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ECONOMICAL UNIFICATION AS A METHOD OF PHILOSOPHICAL ANALYSIS

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Economical Unification as a Method of Philosophical Analysis

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Abstract

This doctoral dissertation introduces economical unification as a method of analysis and shows how it is applied in dealing with some topics that are central in contemporary philosophy. The method resembles a production line that consists of three successive elements which are interconnected by two stages:

$$\text{Economy} \rightarrow \text{Ontology} \rightarrow \text{Applications}$$

In the first stage, an economically unified ontology is explicated by applying the principle of economy as an evaluation criterion of alternative ontologies. An economically unified ontology is an empirically sufficient, metaphysically minimal and generally virtuous world-view or a belief system of a human being. In the second stage everything else is dealt with in terms of the ontology.

The central argument is that economical unification is a more progressive method than plain conceptual analysis which proceeds in the absence of an economically unified ontology and without the principle of economy as an evaluation criterion. Its progressiveness results from having economy as an unambiguous evaluation criterion, which enables explicating a stable and minimal unified ontology which functions as a common base for all topics, and which enables defining and disambiguating meanings of concepts, thereby facilitating their genuine understanding and resolving problems around them, more efficiently than without an economically unified ontology, and without an unambiguous evaluation criterion that would enable explicating it.

The progressiveness of the method is substantiated by applying it in disambiguating some of the central concepts that are dealt with in contemporary philosophy such as time, truth and possibility, and in resolving problems around them. The method works: unification efficiently resolves problems whose central source is disunification itself. In other words, the absence of an economically unified ontology is a central source of problems and ambiguities in contemporary philosophy; in economical unification such problems are resolved by removing their source; their source is removed by replacing the absence of an economically unified ontology by bringing it in the center of the analysis.

The holistic method that handles special topics in the top-down order by relying on an understandable world-view, is very different from traditional conceptual analysis that proceeds in the absence of an economically unified ontology, and even in the absence of having it as the goal, i.e., without economy or the degree of virtuousness as the criterion. Moreover, the method was formulated in order to systematically overcome those limitations of plain conceptual analysis which result from their absence. Traditional conceptual analysis proceeds typically by investigating isolated topics and various angles to them, but this does not manage to interconnect the isolated topics and thus does not resolve problems which are due to the isolation itself.

Although some relevant literature about each topic that is being interrelated via the unified ontology is taken in account, it would be practically impossible to interrelate the topics that will be interrelated in this thesis, and to simultaneously investigate all angles to each topic in the literature, because this would take thousands of pages. Therefore, it is practically impossible to apply the method, if this should be after all done by practicing traditional conceptual analysis about all angles of each topic that is being interrelated. In other words, it is practically impossible to unify many things by concentrating on one thing only.

Moreover, the optimal rate of progress in philosophy and in science in general cannot be achieved if the analysis is limited into investigating isolated fragments. In order to achieve the optimal rate of progress, unification is needed in counterbalancing specialization. By looking at many individual pieces together, one can start streamlining them into a functional totality. In this process much is revealed about what kinds of parts are needed in the totality and what are not. The totality consists of interrelated parts, but in economical unification the overall picture of reality guides the development of its parts at least as strongly as the requirements for the parts guide the development of the totality. Economical unification can thus be seen merely as the project getting hold of the natural order where the totality and its parts interact, and whose alternative is to keep on investigating details of isolated parts blindfolded without worrying about their roles in a totality, for all parts that are applicable do have a role in a totality.

One can and one should scrutinize any suggested totality and replace it when a better one is available, but not before a better one has been presented. This holds for contemporary paradigmatic theories and for everything that comes after them. This brings the focus to the question of what is the objective meaning of 'better.' The suggested answer is: the more economically unified, the better. The most important starting point in the project of economical unification is the acceptance of the principle of economy or the degree of virtuousness as the evaluation criterion, for without a commonly accepted and acknowledged criterion the path towards consensus is unnecessarily long and painful. The easiest way of accepting economy as the criterion is understanding that its general acceptance would accelerate the progress rate of science, including philosophy: virtuousness as the criterion of theories likely results into more virtuous science, faster than without it. Once we have a common criterion, people no longer just agree to disagree about which view is subjectively better, but people have instead leaped forward into evaluating which view is objectively more economically unified or more virtuous. Everything can be scrutinised, including economy, but rejecting it without replacing it with a more progressive criterion means that one does not fully appreciate progress.

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Contents

Basic Information i

Abstract iii

Acknowledgements iv

Table of Contents v

1 Introduction 1

2 Analytical Table of Contents 9

3 Economical Unification in Philosophy of Science 19
- 3.1 Economically Unified Theory as the Goal and the Nexus of Virtues . . . 19
- 3.2 Mach → Verifiability → Neo-Scholasticism → Naturalistic Closure 25
- 3.3 Theory Shifts and Reductions; Pessimistic Induction; Underdetermination; Approximate Truth; Falsifiability; Rational Proliferation 29
- 3.4 Critique of the Simplicity Criterion and Critique of Unified Explanation . 38
- 3.5 Economical Unification vs. Plain Conceptual Analysis 43
- 3.6 Summary 51

4 Ontology I: EUO 54
- 4.1 Axiom: Presentism 54
- 4.2 Definitions: Change; Intrinsic Forward Directed Time 55
- 4.3 Open Selection: Length of the Present Moment 56
- 4.4 Presentism vs. Alternative Theories of Temporal Existence 57
- 4.5 Rejection: McTaggart's Argument 60
- 4.6 Definitions: Classification of Objects; Sameness, Identity, Similarity . . . 61
- 4.7 Axiom: Causality 64
- 4.8 Theorem: Naturalism 66
- 4.9 Rejection: Transcendism and Modal Realism as a Version of Transcendism. The Roots of Naturalisation in Aristotle's Naturalisation of Platonism . . 67
- 4.10 Definitions: Properties; Universals. Theorem: the Principle of Instantiation 72
- 4.11 Theorem: Eternal Universe 74
- 4.12 Axiom: Ontological Realism 76
- 4.13 Theorem: Physicalism. Rejection: Mind-Body Dualism 81
- 4.14 Definition: Abstract 85
- 4.15 Axiom: The Law of Non-Contradiction 89
- 4.16 Rejection: Backward Directed Causation 92
- 4.17 Axiom: Finiteness 93
- 4.18 Rejection: Genuine Self-Reference 98
- 4.19 Summary 102

5 Ontology II: The Dynamic Universe Model 104
- 5.1 The Basic Structure of DU: 4D Geometry and Zero-Energy Balance . . . 105
- 5.2 From Mechanistic Force to Nonmechanistic Energy 109
- 5.3 DU's Expansion Hypothesis and Other Calculations 110
  - 5.3.1 The Rate of the Passage of Time Argument 113
- 5.4 From Newton into SR into GR into FLRW and its Expansion Hypothesis 115
- 5.5 Gravitationally Bonded Systems 118

5.6 The Relativity Principle . . . 119
5.6.1 Atomic Clocks: Contradiction with Absolute Simultaneity . . . 120
5.6.2 Cosmic Time and Relativistic Time: Contradictory or Independent? 121
5.6.3 Eternalism and the Entropy Mapping . . . 123
5.7 Summary: Evaluation of DU and Relativistic Physics . . . 124

6 Definition: Truth **129**
6.1 The Fusion of Object-Based Correspondence and Epistemic Theories . . . 129
6.2 The Solipsism/Comparison/Treadmill Argument . . . 134
6.3 Correspondence of Sensations vs. Theories: Putnam's Arguments . . . 135
6.4 Locating Truthmakers: the Slingshot Argument . . . 140
6.5 An Argument from Abundancy . . . 141
6.6 Truthmaking in Presentism . . . 143
6.7 Funny Fact Arguments . . . 146
6.8 Analytic Truth . . . 147
6.8.1 Correspondence/Truthmaking with Facts and States of Affairs . . . 148
6.8.2 Deflationist Theories of Truth . . . 152
6.8.3 The Identity Theory and the Primitivist Theory of Truth . . . 155
6.8.4 Semantical Problems with Presentism? . . . 156
6.9 Summary . . . 158

7 Definition: Modalities **160**
7.1 Deducing Truthmakers of Modal Propositions . . . 160
7.2 Partial and Total Determinism. Diachronic vs. Synchronic Modalities . . . 164
7.3 Future Contingents, Counterfactuals, Conditionals, Probabilities . . . 167
7.4 EUO vs. Alternative Ontological Foundations for Diachronic Modalities . . . 169
7.5 Lewis, Armstrong and Possible Worlds Semantics . . . 174
7.6 Fictionalist, Epistemic and Logical Considerations . . . 177
7.7 Summary . . . 178

8 Definition: Colour **180**
8.1 Colour Perception, Colour Families, Colour Science . . . 180
8.2 Experience of Similarity . . . 181
8.3 From Behaviour to Structure . . . 183
8.4 Impossible Colours . . . 185
8.5 The Unified Theory vs. Relationalism and Dispositionalism . . . 185
8.6 Summary . . . 187

9 Concluding Remarks **188**

Appendix A: Mereology **190**

Appendix B: References **191**

Appendix C: Glossary and Abbreviations **208**

1 Introduction

The method of economical unification resembles a production line with three inseparable elements that are interconnected in two stages:

Economy → Economically unified ontology → Applications

In the first stage an economically unified ontology is explicated by applying the principle of economy. In the second stage concepts are defined and disambiguated and problems are resolved in terms of the ontology.

The central argument that is defended in this doctoral dissertation is that the method is more progressive than plain conceptual analysis that proceeds in the absence of an economically unified ontology and in the absence of the principle of economy as an evaluation criterion of alternative ontologies. Its progressiveness results from having a stable economically unified ontology that is the same for all derivative topics, and which enables defining and disambiguating meanings of concepts, thereby facilitating their genuine understanding and resolving problems around them, more efficiently than in plain conceptual analysis. This argument is substantiated by applying the method in defining and disambiguating some of the central concepts that are dealt with in contemporary philosophy and in resolving problems around them. The scope of this thesis is on concepts which are directly relevant and applicable in the domains of empirical science and human social behaviour, i.e., the scope is not on language or linguistic philosophy, and not on logic as such, as characterized in §3.5.

The key concepts around the method, the central topics that will be handled in terms of it and some important sources are introduced in the following. The sources behind the method are all authors who have formulated versions of the principle of economy or expressed the preference for unified science, including Aristotle, Isaac Newton, Ernst Mach and many more, as cited in §3.

THEORY AS FUSION OF ONTOLOGY AND CONCEPTS DEFINED IN TERMS OF IT. An ontology is a system of interrelated *ontological commitments* or a world-view of a human being.[1] An ontological commitment is a commitment to the existence of something, i.e., an ontology can be seen as a system of interrelated beliefs of a person about what exists. According to Quine [323, p. 11], ontological commitments of a *theory* are those entities

[1]The term 'ontology' denotes sometimes also a branch of philosophy. *Ontology* derives from the Greek *logos peri ta onta*. *Logos* stands for *word, speech, reason*; *peri* for *around, about*; *ta onta* for *the beings*. *Ontology* can thus be translated as the *study of being* and as the *study of the things that exist*. Aristotle used the term *first philosophy* in the book *Metaphysics* 1004a4. *Metaphysics* derives from the Greek *ta meta ta fysika*, which means *what comes after physics/nature*, which in turn derives from the cataloguing order of Aristotle's works: "When Aristotle's works were collected and catalogued by Andronicus of Rhodes in the first century BC, the collection of writings dealing with substance, causation, and other topics was placed after the book now known as the *Physics*" (Crane and Farkas [95, p. vii]). I used originally the Finnish translations of Aristotle's *Metaphysics* [11], *Physics* [12], and *Of The Heavens* [13]. The English citations are from Ross [10], from *Perseus Digital Library* `http://www.perseus.tufts.edu`, and from *The Internet Classics Archive* `http://classics.mit.edu`. 'Ontology' and 'metaphysics' are used in this thesis with exactly the same meaning when these denote a branch of philosophy. 'Ontology' and 'metaphysics' have also been used with slightly different meanings when these denote a branch of philosophy. In Wolff's [415] distinction of general metaphysics and special metaphysics, ontology denotes general metaphysics. According to Juti [192, p. 15], ontology as general metaphysics is the heart of metaphysics that precedes the questions of special metaphysics. However, as it is in many senses difficult to cleanly separate general and special metaphysics, this dichotomy is not used.

that the theory requires to exist in order for the theory to be true.[2] As even a single ontological commitment can be called a theory, it is often indifferent whether 'ontology' or 'theory' is used.[3] However, theory as a fusion of ontology *and* concepts defined in terms of it, is not exactly the same as ontology *only*. To illustrate, consider a theory of the Solar System. Its ontology covers all that exists according to the theory, including stellar objects such as the Sun and the planets, their orbits and the supposed interactions between the objects which are characterized by mathematical formulas. One may define e.g. the concept of *one year* in terms of the ontology of the theory of Solar System, as the period in which the Earth orbits once around the Sun. The ontology of a theory is thus not exactly the same as the theory, i.e., the ontology with the defined concepts.

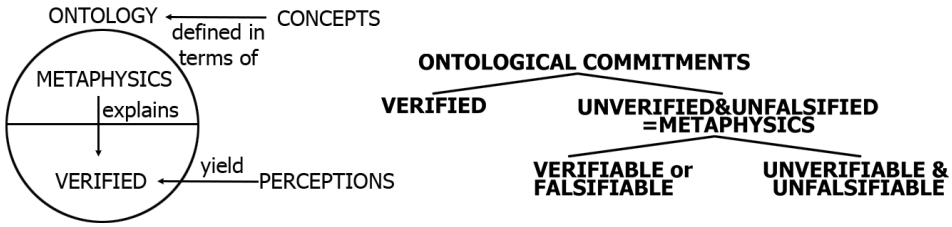

Figure 1: Theory as fusion of ontology and concepts defined in terms of it. Perceptions yield verified commitments. Metaphysics explains the verified commitments. Ontology consists of verified and metaphysical (unverified and unfalsified) commitments, which are classified in two on the right.

As depicted on the bottom left of figure 1, perceptions yield verified commitments, i.e., verified beliefs in the existence of something. For instance, direct perception (§8.1) has yielded the commitments in the existence of trees, houses, people, the Moon, the Sun and the Earth. Beliefs yielded by direct perception are understood as not involved with *interpretation* in any significant sense, i.e., they are understood as not *theory-laden*. When you perceive a tree in front of you and thereby believe in its existence, this is not theory-laden, or it is theory-laden only on a very insignificant level. Likewise, perceiving the outside temperature *indirectly* by perceiving a thermometer reading of 5 Celsius and thereby believing that the temperature outside near the thermometer is about 5 Celsius is not theory-laden, or only on an insignificant level. In the end, not much can be said to hold with absolute certainty, but direct and indirect perceptions are accepted as certain-enough points of departure, for otherwise it would be practically impossible to proceed.[4] As perceptions *yield* verified commitments, 'verified commitment' and 'perception' do

[2]According to Bricker [58]: "The ontological commitments of a theory are, roughly, what the theory says exists; a theory is ontologically committed to electrons, for example, if the truth of the theory requires that there be electrons." According to Cameron [72, p. 250] "the ontological commitments of a theory are what must exist if it is true; the ontological commitments of a theory are what counts against it when judging it for ontological parsimony; the ontological commitments of a theory are those things whose existence its truth entails that have real being." Cameron refers to parsimony which is central to the principle of economy, and which is applied in evaluating metaphysical complexities of theories.

[3]The theory-ontology dichotomy vanishes e.g. in the cases of the axioms of EUO, which are unfalsifiable and unverifiable ontological commitments: presentism is a theory of temporal existence and a metaphysical commitment; ontological realism is a theory of mind-independence and a metaphysical commitment; finite divisibility is a theory of divisibility and a metaphysical commitment; causality is as a theory of interactions and a metaphysical commitment.

[4]What has been taken as certain-enough can always be scrutinised in the search for a higher degree of certainty. For instance, if a physicist says that *dark energy* is an 'empirical fact,' we are dealing with a fully theory-laden metaphysical commitment, not with a direct or indirect observation. See §§3.3,5.4.

not have the same meaning. However, for the sake of convenience 'verified commitment' is often replaced by 'perception.' This convention is analogous to the notion that *seeing is believing* and allows saying that *metaphysics explains perceptions*.

While the verified commitments are not involved with interpretations, metaphysical commitments especially *are* interpretations of the verified commitments. The function of theories or the function of metaphysical commitments of a theory is to explain the verified commitments, i.e., to explain perceptions, to save phenomena, to answer questions that result from perceptions, and to function as generalisations which are induced from perceptions. The structure of the ontology of a theory thus appears as a fusion of verified commitments and metaphysical commitments, where the verified commitments are explained by metaphysical commitments which are themselves unfalsified and unverified by perception. Metaphysical commitments have been called by many names such as *unobservables*, *brute facts*, *primitives*, *axioms*, *first principles*, *premisses*, *postulates*, *hypothetical entities* and *unexplained explainers*. Although metaphysical commitments have especially been deduced by reasoning from perceptions and in this sense *could be seen* as verified, they are best seen as unverified and unfalsified interpretations of perceptions. For, different people interpret the existence of different metaphysical entities from the same perceptions: the very same perceptions have been interpreted to indicate mutually incompatible answers e.g. to the question of what is the center of the Universe.

Metaphysical commitments are classified[5] in two: unfalsifiable&unverifiable commitments; verifiable *or* falsifiable commitments. The unfalsifiable&unverifiable metaphysical commitments are not verifiable nor falsifiable by perception even in principle. Such metaphysical commitments function as eventual answers to questions that perceptions leave over; they are unexplained explainers which cannot be explained in terms of anything else. The *axioms* of the given version of economically unified ontology (EUO) are metaphysical commitments which are in principle unfalsifiable&unverifiable, which are required in explaining perceptions, and which are economical with respect to their available alternatives. The verifiable-or-falsifiable metaphysical commitments are currently unverified and unfalsified, and are either verifiable or falsifiable by direct or indirect perception. For instance, before the planet Neptune and atoms were verified to exist, the commitments to their existence were metaphysical, i.e., Neptune and atoms were *hypothetical entities*. Once Neptune and atoms were verified to exist, the commitments to their existence ceased to be metaphysical. Although these commitments were verifiable all along, this was not strictly speaking known before these were actually verified. All hypothetical entities are thus metaphysical as long as these are verified to exist.

THE PRINCIPLE OF ECONOMY. The principle of economy has also been called *Ockham's razor* and *the principle of parsimony*. Economy favours the theory which gives the most accurate predictions; of two theories with equally accurate predictions, economy favours the one which incorporates the least sum of metaphysics. In other words, of two theories which explain the same phenomenon otherwise equally well, economy favours the metaphysically simplest. Economy evaluates (I) empirical sufficiency and (II) simplicity of metaphysical commitments of theories. As I is always applied first and II only after I has been applied, economy does not favour *over-simplification*, whereas II guarantees

[5]For comparison, Michael Heidelberger (lecture on 17.6.2016, *Ernst Mach Centenary Conference*, Vienna) maintained that according to Fechner [134] physics involves four kinds of metaphysics. (1) Inference to the *best explanation of phenomena*: theoretical entities explaining the phenomena are not given in experience (yet they are of an experiential form). (2) Inference to *possible appearances*: they are not given in actual experience. (3) *Inductive metaphysics*: philosophical 'completion' of physical theories. (4) *Speculative metaphysics*: to assume theoretical entities of no experiential form. (1) and (3) seem to overlap heavily.

that economy does not favour *unnecessary complexity* either. Perceptions or the total sum of verified commitments is considered to be the same for all theories that are being evaluated. Therefore, once two theories have been judged equally accurate by criterion I, their metaphysical simplicities and other theoretical virtues are what *can be* evaluated by criterion II, i.e., criterion I only is troubled by *underdetermination* and related issues, which are effectively resolved by economy (§3.3). The weight of a sum of metaphysical commitments is determined by the number of different types or kinds of metaphysical entities and quantities of each type. The importance of counting in both the number of kinds and the quantities of each kind is emphasised by Nolan [292], and II could be characterized as the criterion of *quantitative and qualitative parsimony*. That both are needed becomes evident e.g. when reviewing David Lewis' arguments for his *modal realism* in §4.9: one can compensate the other, and therefore both must be evaluated. The central justification of applying economy in theory evaluation is the progress that follows. It is shown in §3.1 that empirical sufficiency and metaphysical simplicity are natural allies of other theoretical virtues, including unificatory power, understandability, comprehensiveness and coherence, and there is thus a small step from plain economy into a criterion which favours the most virtuous theory. Common sense indicates that propagation into more and more virtuous total science is progress. Some more specific ways in which the general application of economy would be progressive are pointed out in §§3.3,3.5.

STAGE 1: SELECTING AXIOMS OF AN ECONOMICALLY UNIFIED ONTOLOGY. At this stage, axioms of an economically unified ontology are selected from within mutually exclusive unverifiable&unfalsifiable metaphysical commitments by applying the principle of economy. The given version of economically unified ontology is abbreviated as EUO. Given two mutually exclusive provisional axioms which explain perceptions with an equal accuracy, the metaphysically simpler is selected as an axiom of EUO. The simplicity of a total ontology is always primary with respect to the simplicity of an individual commitment, and therefore the evaluation of two axioms should always be the evaluation of all metaphysics that comes along with them. Some evaluations might turn out to be complex optimisation problems where various alternative collections of provisional axioms and other metaphysical postulates are evaluated. However, the evaluation of individual provisional axioms suffices for selecting the axioms of EUO, because these do not bring along more metaphysics than themselves.

It is not claimed that EUO is in all ways final nor that it is the only correct ontology. It is only claimed that EUO is more economically unified than *its central alternatives*, with respect to functioning as a base for the concepts defined in terms of it, where the concepts are intended to function in the contexts of natural science and human social behaviour. This brings the focus to the inseparability of the elements of the chain: *economy* $\rightarrow$ *ontology* $\rightarrow$ *concepts with a specified range of application*. That EUO is more economically unified than its central alternatives means EUO as a whole contrasted to alternative wholes that *do the same jobs or explain the same scales*, and each axiom of EUO when contrasted one at a time to alternative axioms that explain the same scale. In other words, as the concepts as the end results of applying the method are intended to function in natural science and human social behaviour, also the ontology must sufficiently explain phenomena that are relevant in these contexts; therefore, also economy is applied in evaluating alternative commitments which explain phenomena that are relevant in these contexts.

§4 should be seen as a modest attempt to explicate some extremely basic and economical axioms and interrelate them into a unified whole, i.e., to explicate sufficient and meta-

physically minimal axioms instead of sufficient but metaphysically excessive axioms. The axioms of EUO are *presentism*, *causality*, *finiteness*, *the law of non-contradiction*, and *ontological realism*. *Presentism*: it is supposed that only the present temporal stage of the Universe (TSU) exists, as this is sufficient and simpler than to suppose that also the past and the future exist as strongly as the present. *Causality*: causal influences are supposed in the absence of better alternatives, and these together with presentism imply that there is only one world, which is sufficient and simpler than to suppose that causally isolated worlds and causally inefficacious objects exist. *Finiteness*: it is supposed that the TSUs are finitely divisible and spatially finite as this is sufficient and simpler than infinite divisibility and spatial infinity. *The law of non-contradiction*: it is supposed that the TSUs are not contradictory as there is no need to suppose that they are. *Ontological realism*: the existence of mind-independent reality is supposed in the absence of better alternatives.

It turned out to be straightforward to formulate EUO by starting from presentism and by building everything else around presentism. Presentism became central because an economically unified ontology needs an unambiguous and minimal conception of time in dealing with everything else and such a conception can be built on presentism. The building of EUO was initially oriented by the work of David Malet Armstrong such as [16, 18, 26]. Armstrong's list of accepted and rejected principles in the end of [16, II] functioned as an early orientation to looking at various axioms together, which led to trying to fit them together. Armstrong's naturalism —the doctrine that there is only one world— is a theorem of presentism and naturalism, but e.g. Armstrong's combinatorial theory of possibility ceased to function as the central meaning of possibility in the context of presentism, and Armstrong's states of affairs became unnecessary as objects —such as temporal stages of the Universe and their proper parts— could do their jobs with less ambiguities. The Theory of Relativity contradicts presentism (§5.6). As a priori theorising is insufficient in defending presentism against the Theory of Relativity, an alternative theory that gives verifiably correct predictions had to be found and this was Tuomo Suntola's [384, 386] Dynamic Universe model (DU) that is compatible with presentism. The incorporation of ontological realism was influenced by Ilkka Niiniluoto [289] and Armstrong. The law of non-contradiction came directly from Aristotle (*Metaphysics*, 1005b18-20). Although economy is the greatest source behind EUO, all authors who have defended the axioms of EUO can be counted in the source literature, such as those cited in the main text.

EUO overlaps partially with DU. The fusion of DU and EUO is called an *economically unified theory*, as depicted in figure 2. The aim here is not to argue that the given version is the only correct alternative nor that it is the final or ideal unified theory. However, in order to defend EUO (presentism) it had to be coupled with DU, and in order to defend the fusion of DU and EUO, it must be argued that it fares at least as well as the available alternatives. Therefore, DU is contrasted to relativistic physics in §5, and it is pointed out that DU is in fact a more economically unified explanation of the evaluated scales. Likewise, it is argued in §4 that EUO is more economically unified that its main alternatives. One can thereby evaluate the given approximation of the unified theory against alternative approximations. The unified theory can also be seen as a fusion of various overlapping theories, where the overlap means that the theories share some or all ontological commitments. It is sometimes handy to talk about the *unified theories* of truth and possibility, but these are merely aspects of the full unified theory, as truth and possibility are concepts defined in terms of EUO, which is a proper part of the full unified theory. DU is a theory, i.e., a fusion of an ontology and concepts defined in terms of

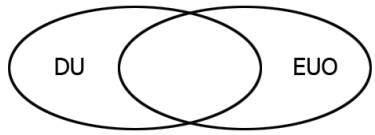

Figure 2: The given approximation of economically unified theory: DU + EUO.

it. The context determines the exact meaning of 'EUO.' 'EUO' denotes sometimes only ontological commitments, sometimes the fusion of the ontology and all concepts defined in terms of it, and sometimes the fusion of the ontology and only some concepts defined in terms of it. For instance, when it is said that the economically unified theory is the fusion of DU and EUO, EUO is meant to include all defined concepts such as truth and possibility. When only some concepts have already been defined in terms of the ontology, 'EUO' denotes the ontology with only those concepts that have already been defined.

STAGE 2: DEFINING CONCEPTS IN TERMS OF EUO. At this stage, concepts such as *truth, possibility, counterfactual, colour, particular, object, abstract* and *property* are defined in terms of EUO. By defining concepts in terms of EUO, they are also disambiguated, which facilitates resolving problems around them. All concepts defined in terms of EUO are derivative and not primitive, as the ontological commitments of EUO are the only primitives. That a concept is defined in terms of EUO has the following meaning: the ontological commitments of EUO together state what exists; the definition of concept X states that when something exists in a certain specific way within the border conditions of EUO, that something is denoted as X. Saying that a concept is defined in terms of an ontology is equivalent with saying that the concept is *grounded* on the ontology or *mapped* to the ontology. Concepts have always been defined in terms of an ontology in natural science, mathematics and in society in general, i.e., basically all science functions as the source literature of this stage. Here, this is done specifically in terms of EUO, focusing on concepts and that are frequently discussed in contemporary philosophy.

Although the distinction of stages 1 and 2 is clarifying in the didactive sense when explaining the method, in practice the building of the unified theory in §4 is a mixture of both stages: first one axiom is postulated; then one concept is defined in terms of it; then another axiom is postulated; then another concept is defined in terms of it or in terms of all the previously postulated axioms, being aided by the previously defined concepts, and so on. However, §4 is clearly different from §§6-8 in the sense that these sections consist almost entirely of defining concepts in terms of EUO, not of postulating any more axioms. The building of ontology and defining concepts are inseparable processes also in another sense. Every openly explicated ontological commitment is a concept: once you define an ontological commitment such as presentism, you have also defined a concept as presentism is a concept. Moreover, even the principle of economy is a concept, and it precedes all ontological concepts and applications. The methodology-ontology-applications trichotomy is clarifying here. Methodological concepts are defined first; they guide the selection and rejection of ontological concepts (commitments); applicatory concepts are defined in terms of the ontological concepts. The central point is that no concepts —except methodological— are defined nor contemplated independently of ontology, whereas the methodological concepts are independent of specific ontological commitments.

On one hand the definition of concept X in terms of EUO yields a theory of X: the definition of the concept possibility in terms of EUO yields a theory of possibility, the definition of the concept truth in terms of EUO yields a theory of truth, and so forth.

On the other hand, and again, the fusion of DU and EUO with all defined concepts is one single theory, but this theory is applied for many different purposes and has many aspects, including the theories of truth and possibility. It is a matter of taste whether expressions such as *unified theory of truth* and *unified theory of possibility* are used or whether *unified concept of truth* and *unified concept of possibility* are used instead. All such theories are in any case aspects of the full unified theory and all such concepts are defined in terms of the ontology of the unified theory. Moreover, as DU and EUO overlap, most clearly in the sense that they both accept the axioms for causality and absolute simultaneity, concepts defined in terms of the overlapping axioms are defined in terms of both DU and EUO.

A unified theory —of truth, possibility, colour— is formulated by starting from the definition of a central concept of the theory in terms of EUO. For instance, the formulation of the unified theory of truth is started by defining the concept *proposition* in terms of EUO. After this, the central concept is complemented by defining further concepts in terms of EUO, being aided by the already defined concept, where all defined concepts are mutually compatible. The concept *proposition* is complemented e.g. by the concepts *true proposition, correspondence, truthmaker, truthbearer, coherence* and *useful belief*. A unified theory is thus EUO together with some central concept that is complemented by further concepts.

The concepts that are added on the top of the main concept may be ingredients of competing theories, or it is shown that a unified theory as such does the jobs that a competing theory does. It is impossible to build a coherent fusion of genuinely incompatible theories, but their applicable ingredients can be incorporated in the unified theory in terms of mutually compatible definitions. All theories that can be interpreted to be mutually compatible are interpreted as such, whereas genuinely incompatible theories which aim to do the same job are rejected. Either way, the end result is the same: applicable ingredients are incorporated in the unified theory by mutually compatible definitions, and thereby the unified theory alone does the jobs that several mutually incompatible theories were separately supposed to do. For instance, the coherence *theory* of truth is rejected as insufficient in the focal contexts, but its useful ingredients are incorporated in the unified theory by deriving the coherence *theorem of correspondence truths* from the unified theory. Likewise, the pragmatic *theory* of truth is rejected as empirically insufficient in the focal contexts, but its useful ingredients or the demand for verifiability is shown to be implicit in the team play of the unified theory and the principle of economy.

A similar procedure is applied in constructing the unified theories of possibility and colour. For instance, the relational theory of colour is rejected, but it is shown that the unified theory does all that the relational theory does at least as well. As the unified theories of truth, possibility and colour are merely aspects of the one and the same theory, they complement one another. As truth is handled first, the unified theory of possibility can be seen to complement it, and the colour theory can be seen to complement their fusion. Therefore, the emphasis may seem to be on the theory of truth, but it is equally on all concepts defined in terms of EUO, as all these are interrelated and support one another. The path of replacing old theories by new ones that are more economically unified and incompatible with the old theories resembles Kuhnian paradigm shifts that are typically characterized in the context of empirical science, whereas the path of defining a concept that was thought to be primitive in terms of primitive postulates or deriving it as their theorem resembles reductionism. Both paths are characterized in §3.3. These resemblances may not be complete but this is not a problem, for any path to more economically unified total science is progressive, disregarding if the path resembles

theory shifts, reductions or their combinations.

The unified theory of truth complements Rögnvaldur Ingthorsson's [182] project of unifying other theories of truth around the correspondence theory of truth. The unified theory or possibility is logically close to Von Wright's [418] *diachronic possibility*, and complements the work of a long line of authors who have attempted to give ontological foundations for possibility, including David Lewis [221, pp. 84-5][223, p. 78] and David Armstrong [18], but more directly the work of Nuel Belnap [46], Storrs McCall [255], and Rachael Briggs and Graeme Forbes [59] who apply the causal structure of the Universe in defining modalities, and simplifies their metaphysical foundations by replacing versions of eternalism and the growing-block theory by presentism. The unified theory of colour complements David Rosenthal's [338, 339] *Double-Property Theory* and is congenial also with Armstrong [20, p. 270].

2 Analytical Table of Contents

This thesis consists of three successive parts: methodology; ontology and indispensable applications; applications only. These are organized as follows.

§§1&3. The method of economical unification and the principle of economy are formulated. Their historical roots are reviewed and they are positioned in the center of philosophy of science.
§§4-5. The axioms of the given version of economically unified ontology (EUO) are explicated by applying the principle of economy, and some indispensable concepts are defined in terms of EUO. The basic structure of the Dynamic Universe model is explicated and evaluated against relativistic physics. EUO and the Dynamic Universe model are compatible and overlap, and form together with the defined concepts an economically unified theory.
§§6-8. Further concepts are defined and disambiguated and problems around the concepts are resolved in terms of EUO and the already defined concepts.

As the sections are intimately interconnected, the method in §1 must be comprehended before investigating the ontology in §4, and the ontology and the indispensable concepts before investigating further concepts in §§6-8. As this analytical table of contents is extensive, the forthcoming sections do not have tables of contents. Also the glossary in appendix C may be helpful.

§1. The method of economical unification and the key concepts around it are introduced. The scope of this thesis is fixed on concepts which are directly relevant and applicable in the domains of human social behaviour and natural science. The two stages of economical unification are outlined: in the first stage an economically unified ontology is explicated by applying the principle of economy; in the second stage concepts are defined in terms of the economically unified ontology. The structure of theories is explained. A theory consists of an ontology and concepts defined in terms of it; an ontology consists of verified and metaphysical commitments where metaphysical commitments explain the verified commitments; perceptions yield verified commitments, but verified commitment are typically abbreviated as perceptions. Metaphysical commitments are further classified in unfalsifiable&unverifiable (such as the axioms of EUO) and those that are verifiable or falsifiable. The principle of economy is introduced: economy favours the theory which gives the most accurate predictions; of two theories with equally accurate predictions, economy favours the one which incorporates the least sum of metaphysics. Empirical sufficiency and metaphysical simplicity are complemented in §3.1 by other theoretical virtues.

§3. The progress of science is characterized as propagation towards more and more economically unified total science. Historical roots of the principle of economy are reviewed, some models of scientific explanation and progress of science are reviewed, examples are given of the indispensability of economy in evaluating theories, and it is pointed out that the identification of the correct roles of economy and the goal towards unified science that builds on an economically unified ontology in the *center* of philosophy of science gives an extremely fruitful point of departure to various focal issues.
§3.1. It is pointed out that the central task of metaphysics since Aristotle has been unification by explication of the simplest first principles that are common to all sciences,

and that the principle of economy is needed as an evaluation criterion that prefers more economically unified theories, thus guaranteeing the progress of science towards more economically unified total science. Formulations of economy are given in a timely order e.g. by Thomas Aquinas, William of Ockham, Isaac Newton, J.B.S Halldane, Eino Kaila and Philip Kitcher. It is pointed out that an ideal economically unified theory brings together all theoretical virtues, and that metaphysical simplicity and empirical sufficiency are natural allies of all other theoretical virtues such as unificatory power, understandability, comprehensiveness, consistency, indispensability and fundamentality. There is thus a small step from economy as a measure of empirical sufficiency and metaphysical simplicity into a measure of virtuousness in general, and the progressive propagation towards more economically unified total science is propagation towards generally more virtuous total science. The principle of economy as the judge of theories is thus justified by the progress that comes along by accepting it as the criterion.

§3.2. Ernst Mach is characterized as a unifier of science who saw relevant metaphysics in the center of a unified world-view and also made suggestions about what the metaphysical core would look like. When Mach openly rejected 'metaphysics,' he only rejected metaphysics that is not needed in unifying science. The transition from Mach to *logical positivism*, from positivism to the rejection of the positivist *verifiability criterion* and the birth of *neo-scholastic metaphysics* is characterized. The positivists' anti-metaphysical verifiability criterion is characterized as a mis-interpretation of Mach's rejection of unnecessary metaphysics, and contemporary neo-scholastic metaphysics is characterized as an over-propagated counter reaction to the verifiability criterion. The *principle of naturalistic closure* by Ross, Ladyman and Spurrett is characterized as a version of economy, as a reaction to neo-scholastic metaphysics and as a guideline whose purpose is to bring philosophical metaphysics closer to empirical science.

§3.3. It is underlined that economy supports all paths to more economically unified total science. Three paths are reviewed which all increase the relative simplicity of total science: theory shifts, reductions and partial unifications. The shift from the Earth-centered into the Sun-centered model is characterized, and it is pointed out that the propagation towards a paradigm shift walks hand in hand with increasing metaphysical complexity of the current paradigm, following Thomas Kuhn. It is shown that economy provides a fruitful viewpoint to resolving the challenges of *pessimistic induction* and *underdetermination*. It is suggested that the difference in *a more truthlike theory* and *a better theory* is terminological for both have practically the same meaning: *a more economically unified theory*. It is shown that the identification of the correct role of economy enables incorporating Karl Popper's *falsifiability criterion* in theory evaluation, that economy it is a mean to prevent unconditional *stagnation* to paradigms, a mean to see what is the rational degree of Paul Feyerabend's *theory proliferation*. It is pointed out that acknowledgement of the role of metaphysics in theories and their constant evaluations would likely make paradigm shifts smoother, which was a challenge for Imre Lakatos. Oppenheim and Putnam's *micro-reduction* and Nagel's *reductionist model* are investigated. Finally, partial unifications are investigated.

§3.4. Some arguments against simplicity evaluations are exhausted. It is underlined that the progress of science is the primary justification of applying virtuousness as the evaluation criterion, and that the order of evaluation is: empirical accuracy; ontological virtues; syntactical or mathematical simplicity. The scheme of explaining in terms of an economically unified theory (EUT) is defended. Economy as an evaluation criterion of theories goes over and above nuances of different models of scientific explanation, in the sense that a more economically unified theory enables a better explanation. EUT is shown to be compatible with Carl Hempel and Paul Oppenheim's *covering-law model*

of explanation, and it is contrasted to Kitcher's *unification model*. When the economically unified theory is fixed as DU+EUO, the scheme of explanation becomes congenial with Wesley Salmon's *causal-mechanical model* of explanation. It is shown that EUT efficiently exhausts critique that has been targeted against Kitcher's unification model. This is critique that stems from causality-related contemplations, heterogeneity of unification, the winner-take-all conception of explanatory unification, and the epistemology of unification.

§3.5. It is emphasised that economical unification is more progressive than plain conceptual analysis which proceeds in the absence of a unified ontology and in the absence of the principle of economy. It is emphasised that logic is applied as a tool but not as an end. Applying the axiomatic method in ontology is analogized with applying it in mathematical logic. It is emphasised that the goal is not on arbitrary semantics, but to map such semantics to EUO which functions in natural science and human social behaviour. It is shown that economical unification provides answers to some of the central question about the methodology of metaphysics. The central reasons why anything like an economically unified theory has not been explicated earlier are pointed out: the Theory of Relativity; the principle of economy is not taken seriously in contemporary metaphysics and there seems to be negative attitudes towards building comprehensive systems. The progressiveness of economical unification is contrasted to the regressiveness of the culture of *uneconomical pluralism*, following Mario Bunge and Jeffrey Poland: synergy of a single unified theory with many interrelated definitions vs. discorded and isolated micro industries with several competing theories in each industry; a functional separation between ontology and the concepts defined in terms of it vs. mixed handling of both; an overwhelming reduction of ontological and terminological redundancy; the counterbalancing of specialization vs. suffering from the defects of redundancy; increase in understandability without an abundant degree of conceptual analysis.

§3.6. A summary is given.

§4 The first stage of the method is executed by explicating the axioms of EUO by applying the principle of economy: presentism, causality, ontological realism, the law of non-contradiction and finiteness. The axioms of EUO are unfalsifiable and unverifiable metaphysical commitments. The aim is to show that EUO as a whole and its axioms individually are at least as economically unified as their central alternatives, and congenial with the Dynamic Universe model which is the empirical foundation of EUO. A synopsis of the basic structure of EUO and the axioms which imply the basic structure are given first. In addition to the axioms, some concepts which are indispensable in handling the axioms and other concepts are defined, some theorems are derived from the axioms, and some rejections are done which show that some axioms of EUO imply that something specific does not exist or that some result does not hold in EUO. The subsections of this section are accordingly classified into axioms, definitions, theorems and rejections. Suppose that axiom A is given first, axiom B after A, and axiom C after B. Those definitions which require axiom A but no other axioms are given after A has been postulated and before B; those definitions which require axioms A and B but no other axioms are given after the postulation of B but before C. Likewise for theorems and rejections: if a theorem or a rejection is implied by the fusion of axioms A and B but not by A alone, it is given after B and before C.

§4.1. The building of EUO is started from presentism and everything else is organized around presentism. Presentism is postulated as the most economical axiom for temporal existence. Presentism is the thesis that only the present temporal stage of the Universe

exists, whose all parts exist absolute simultaneity. It is notable that the only genuine threat to presentism is the Theory of Relativity (§5.6), and the best defence of presentism is its compatibility with a more economically unified theory of fundamental physics, the Dynamic Universe model (§5). The defence of presentism is organized as follows. (i) An argument that builds on the duration of the present is discussed in §4.3. (ii) It is shown in §4.4 that presentism is a more economical theory of temporal existence than its central alternatives. (iii) It is shown in §4.5 that McTaggart's argument does not threaten presentism. (iv) An argument from the rate of the passage of time is discussed in §5.3.1. (v) The incompatibility of absolute simultaneity and the *relativity principle* is discussed in §5.6. (vi) The alleged problems concerning past and future truthmakers and cross-time relations are discussed in §6.6 and an argument that presentism cannot explain the passage of time is handled. (vii) Some linguistically oriented arguments against presentism are reviewed in §6.8.4. The resolutions of these arguments count as a somewhat comprehensive defence of presentism, and it is hard to find more challenges for presentism in the literature. For comparison, Fiocco [144] lists (ii, v-vii), Markosian [249] lists (v-vii) and Markosian [250] lists (ii,iv-vi) as problems of presentism.

§4.2. *Change* is defined in terms of presentism and *intrinsic forward directed time* is defined as the measure of change. Change is defined as a transition from one present temporal stage of the Universe (TSU) into another present TSU. Intrinsic forward directed time is defined by equating the transition from one present TSU into another with the transition from one present time into another present time.

§4.3. The question of what is the length of the present moment is contemplated. Presentism comes with least difficulties by selecting a positive present. However, the selection between a positive and a non-positive present is left open, and therefore this section is characterized as an open selection: positive XOR non-positive present. Analogously, the selection between total and partial determinism is left open in §7.2.

§4.4. Presentism is defended as the simplest axiom for temporal existence, which alone without additional postulates explains the passage of time or embodies change, gives an account of temporal ordering and the direction of time, and is compatible with both partial and total determinism. The most famous alternatives to presentism —*eternalism*, the *growing-block theory* and the *moving spotlight theory*— are more complex and also require one or more additional postulates in one or more of these tasks. More nuanced versions of the alternatives are reviewed in §7.5. The main support for eternalism comes from the Theory of Relativity which entails eternalism (§5.6.3).

§4.5. It is shown that McTaggart's argument does not threaten presentism.

§4.6. A *part of the Universe* is defined as either a single temporal stage of the Universe (TSU) which is realized at one time or proper part of TSU, or a fusion of two or more TSUs which are realized at different times or any proper part of such a fusion. Discrete mereology (appendix A) is applied as the logical foundation for part-whole relations. *Object* is defined as a part of the Universe and *particular* is defined as an object which exists at one time only, i.e., a particular is either a TSU or a proper part of a TSU. It is pointed out that presentism entails *endurantism* and that EUO is thus incompatible with *perdurantism*. The definitions of *sameness*, *identity* and *similarity* are given. Sameness is defined directly in terms of EUO: particular x is the same as x, and no other particular is the same as x. Sameness and identity are interrelated as follows: $\text{same}(x, y) \rightarrow \text{identical}(x, y)$. Identity and similarity of particulars is defined in terms their resemblance.

§4.7. The axiom for causality is postulated and defended. It is expressed as the fusion of three interrelated axioms which are added on the top of presentism: (i) every part of the present TSU realizes energy in an absolutely determinate location in an absolutely

determinate way; (ii) all parts of the present TSU are causally connected; (iii) the present TSU is the consequence of the preceding TSU and the cause of the succeeding TSU. (i) is close to *physicalism* (§4.13) and its defence relies on economicality with respect to its alternatives such as the existence of *bare particulars* and congeniality with the Dynamic Universe model (DU). The defence of (ii) relies on the absence of intelligible alternatives and on physics in general where it is supposed that the laws of nature dictate how spatially separated object interact causally, and specifically on those interactions that are postulated in DU. The defence of (iii) relies on uneconomicality of alternatives in §4.11. (iii) is an expression of the *law of cause and effect* and can also be considered as an explicit acceptance of the primitiveness of ontological causation or the thesis that general causation is merely generalisation of singular causation. It is pointed out that there is a small step from (iii) to the acceptance of the conservation law of energy, which is an axiom of DU.

§4.8. *Naturalism* is the doctrine that all that ever exists is a part of the Universe and all parts of the Universe are directly or indirectly causally connected. Naturalism is shown to be a theorem of presentism and causality.

§4.9. *Transcendism* is rejected as an uneconomical alternative to naturalism and the concept *actual* is defined. David Lewis' *modal realism* is rejected as a version of transcendism. It is shown in §7 that EUO is a sufficient ontological foundation for a theory of possibility —including counterfactual analysis, physical possibilities, fictions and logical possibilities— and thus transcendist foundations are not needed. It is pointed out that the roots of transcendism can be traced back to Plato, that the roots of naturalisation are in Aristotle's rejection of Plato's theory of forms, and that the given naturalisations of transcendist concepts are nothing over and above Aristotle's replacement of Plato's theory. It is suggested that the ontological version of *nominalism* is equivalent with naturalism, and that the rest of nominalism is semantical (or terminological), not ontological.

§4.10. The concepts *property* and *universal* are defined in terms of presentism and causality, and it is shown that the *principle of instantiation* follows as a side product. The dichotomy of properties and *determinable ranges of properties* is defined, following Johnson and Armstrong. Resemblance and identity of properties is defined in terms of the resemblance and identity of particulars. It is emphasised in §4.9 that properties are nothing over and above particulars, i.e., that using the terms 'property' and 'universal' in talking about particulars is merely a terminological selection, for property is defined as a way in which a particular exists. That particulars exist in some ways rather than in no way at all is equivalent with rejecting bare particulars in §4.7.

§4.11. It is shown that the causality axiom entails the theorem that the Universe is eternal: that the past is infinite and the future is potentially infinite. Alternative qualifications of the causality axiom are evaluated.

§4.12. The axiom for *ontological realism* is defended as the most economical version of *mental realism*. In mental realism mental states of human beings exist. Mental realism is postulated as the only alternative that explains experiences. Ontological realism is a version of mental realism where also other parts of the Universe exist in addition to human minds and these are independent of human minds. Ontological realism is defended on the basis that there are no good reasons for rejecting the mind-independence thesis, and on the basis that an empirically sufficient and minimal version of *solipsism* is practically equivalent with ontological realism. Ontological realism is also defended by Niiniluoto's *argument from the past*.

§4.13. Physicalism as the thesis that *all that ever exists is physical* is derived as a theorem from presentism and causality, and all versions of *mind-body dualism* are rejected.

When ontological realism (as a version mental realism) is coupled with physicalism, the result is that some physical particulars have both concrete and mental properties, which resembles the *dual-aspect theory*. It is pointed out that EUO is compatible with Galen Strawson's argument against brute emergence.

§4.14. Naturalisation of transcendism is continued by defining the concept *abstract* as *thought which is realized in a human mind*. It is shown that the given definition disambiguates the concept, and that it manages to classify the paradigm cases of concrete and abstract things. *Naturalist Platonism* is contrasted to *transcendist Platonism*. It is argued that naturalist Platonism does what mathematics and natural science require from it and that it is simpler and thus transcendist Platonism is rejected.

§4.15. The axiom for the *law of non-contradiction* (LNC) is postulated. The ontological version of LNC is defended. It is pointed out that LNC is compatible with the existence of propositions which violate the *law of the excluded middle* and the *principle of bivalence*, and that LNC is compatible with many-valued logics and paraconsistent logics, as long as these remain in the level of semantics/language. It is noted that the compatibility of LNC with *dialetheism* depends on how the range of dialetheism is interpreted.

§4.16. Genuine backward directed causation is rejected on the basis that it either violates the law of non-contradiction (LNC) or requires other uneconomical axioms, namely, transcendism or some naturalist version of branching space-time (§7.4). It is pointed out that van Inwagen's *hypertime framework* sustains LNC but must commit to transcendism or some naturalist version of branching space-time.

§4.17. The axiom for *finiteness* states that all temporal stages of the Universe (TSUs) are spatially finite and consist of finitely many indivisible and positive interrelated parts. Spatial finiteness is defended by economy and compatibility with both models of cosmology that are evaluated in §5. Ontological finite divisibility is needed not only as a pillar of an economically unified world-view, but without it lots of derivative issues would be left ambiguous, for finite divisibility entails that ontological *self-reference* (§4.18) is impossible, and the rejection of self-reference is in turn applied in §§6.1,6.4,6.8.1,6.8.3. Finite divisibility is defended by economy. It is noted that it is compatible with the existence of transfinite idealizations in mathematics, with contemporary physics and with *ontic structural realism* of Ladyman and Ross. Two interpretations of infinite divisibility —the *point-continuum* interpretation and *non-wellfoundedness*— are presented as alternatives to finite divisibility, and it is pointed out that in addition to being uneconomical, these bring in further difficulties. These interpretations are needed in comprehending §§4.3,4.18. *Eliminative structural realism* requires non-wellfoundedness and is rejected as uneconomical.

§4.18. It is shown that ontological *self-reference* is impossible in the context of the finiteness axiom, specifically in the context of finite divisibility. This result is needed in exactifying the definition of a true proposition in §6.1, in rejecting the *slingshot argument* in §6.4, in understanding the difficulties of fact-based correspondence in §6.8.1, and in understanding the difference of correspondence and identity in §6.8.3.

§5. The overall metaphysical structure of Tuomo Suntola's Dynamic Universe model is introduced with the focus on explaining the largest cosmological scale, and contrasted to relativistic physics (RP). The fusion of EUO and DU is characterized. EUO is fully congenial with DU but incompatible with RP which violates presentism (§5.6).

§5.1. The basic structure of DU is explained: the fusion of 4D spherical geometry and zero-energy formulation of the conservation law of energy; the energy balance equation and the notions of mass and the velocity of light; how in DU the energy of motion of an

object moving *in* space is related with the energy of motion of an object moving *along with* the expansion of space, and comparison with RP's *Equivalence Principle*.
§5.2. It is investigated how DU and RP explain the conveying of influences.
§5.3. It is explained how DU's expansion hypothesis is calculated. Some preliminary calculations are done and concepts are explained: the calculation of the present circumference or size of the present TSU; the concepts of *hypothetical homogeneous space* and *mass equivalence* and the calculation of the mass of the present TSU; calculation of the volume and density of the present TSU; deriving the changing velocity of light from the basic structure of DU; calculation of how much time has passed since the singularity. Given all these, DU's hypothesis of decelerating expansion can be calculated.
§5.3.1. The results of §5.3 are applied in exhausting J.J.C. Smart's *rate of the passage of time* argument which has been targeted against presentism.
§5.4. The historical evolution from Newtonian physics into the Special Theory of Relativity into the General Theory of Relativity and into FLRW cosmology is explained, including the role of FLRW's *density parameter* with *dark energy* in the hypothesis of accelerating expansion. It is shown that the standard interpretation of the Planck equation that is incorporated also in FLRW is incompatible with the conservation law, unless further metaphysics is introduced.
§5.5. It is investigated how certain observations about the Earth, the Moon and Mars are explained in the contexts of DU and RP.
§5.6. The *relativity principle* of RP and some of its implications are investigated.
§5.6.1. It is shown how the relativity principle contradicts absolute simultaneity whereas DU builds on absolute simultaneity, and how DU and RP explain the tests with atomic clocks.
§5.6.2. It is explained that cosmologists commit to *cosmic time* which requires absolute simultaneity and thus either contradicts the relativity principle or requires that cosmic time and relativistic time are independent, which is uneconomical.
§5.6.3. It is indicated that the relativity principle entails eternalism, which in turn requires an anchor for the direction of time, where *entropy* is the anchor.
§5.7. DU and RP are evaluated by a modified version of Kaila's criterion of relative simplicity. The predictions of DU match perceptions at least as accurately as those of RP, and the commitments of DU are economically unified with respect to those of RP.

§6. The second stage of the method which concerns almost entirely applications is started by defining and defending a *unified theory of truth* in terms of EUO, complementing the work of Rögnvaldur Ingthorsson.
§6.1. *Proposition* is defined as a thought realized in the mind of a human being, which refers to something else than the thought itself and which states that the object to which the proposition refers exists in some way; mental realism (§4.12) and finiteness which excludes self-reference (§4.18) are thus strongly present in the ontological base of the definition of proposition. *True proposition* is defined: a proposition is true if and only if the object to which the proposition refers exists in the way that the proposition states. This is abbreviated by saying that the *proposition corresponds to the object*. The object-based correspondence theory of truth has thereby been defined. *Truthmaker* and *truthbearer* are defined. It is shown how the central ingredients of the *coherence theory of truth* are incorporated in the unified theory in terms of the fusion of object-based correspondence and the law of non-contradiction which yield the *coherence theorem of correspondence truths*. It is shown how the central ingredients of *Jamesian pragmatic theory of truth*, if it is considered as a theory in the first place, can be incorporated in object-based corre-

spondence, whereas the Pragmatic theory alone without object-based correspondence is empirically insufficient. It is shown that the *non-descriptivist views* are compatible with object-based correspondence.
§6.2. The argument that the requirement of reliable verification leads into solipsism is rejected.
§6.3. It is underlined that the correspondence relation is not vacuous nor mysterious, and that Hilary Putnam's criticism against correspondence is answered. Putnam's *language acquisition argument* is answered by noting that it does not threaten the correspondence of sensations, whereas theories with metaphysical commitments are not considered to be correspondence-true or correspondence-false in the first place, but instead better or worse based on their verifiable predictions and virtuousness, i.e., Putnam's requirement of rational assertability is implicitly incorporated by evaluating theories by the principle of economy. Putnam's *model-theoretic argument* is answered by noting that it does not threaten the correspondence theory that an ideally rationally assertable theory cannot be false. It is noted that Putnam's *internal realism* is incorporated in the sense of acknowledging theory-ladenness, but that it does not affect economy evaluations where all metaphysical commitments of theories are counted.
§6.4. The *slingshot argument* or the *big fact argument* is exhausted.
§6.5. An argument that correspondence truth is an abundant property is handled.
§6.6. Allegations about truthmaking in presentism, cross-time relations, and an argument that presentism cannot explain the passage of time are handled.
§6.7. *Funny fact arguments* concerning *negative, disjunctive, universal, existential* and *subjunctive* propositions are resolved. *Conditional, probabilistic* and *counterfactual* propositions are handled in §7.3 for these are involved with modalities.
§6.8. The analytico-linguistic analysis of truth which started by replacing objects with facts in the early 20th century is contrasted to object-based correspondence. The correspondence theory with *facts* and *states of affairs*, the *deflationist theory of truth*, the *identity theory of truth* and the *primitive theory of truth* and their relations are reviewed.
§6.8.1. Correspondence with facts and states of affairs is reviewed, with the following conclusions. If facts and states of affairs are objects or sufficiently close to objects in EUO, they can function as truthmakers in a correspondence theory and we are dealing with a version of object-based correspondence. If facts are not objects nor in objects, they must be translated as true propositions, but the notion that a proposition corresponds to a proposition does not work, except in a special case. However, we can translate *correspondence with facts as true propositions* into *deduction based on known true propositions* that works in the context of object-based correspondence.
§6.8.2. The deflationist theories of truth are contrasted to object-based correspondence. These are prime examples of linguistically oriented theories of truth which omit objects as well as correspondence and empirical sufficiency along with them. The deflationist theories like Horwich's *minimalism* do not even try to say anything about a relation between a proposition and the mind-independent reality, and thus do not compete with object-based correspondence in being the best empirically sufficient theory of truth. When the status of a theory is removed from deflationism, it can be seen in the context of object-based correspondence as a framework for handling *what is supposed to be true at some time in some context*, disregarding whether it is true in object-based correspondence.
§6.8.3. It is pointed out that the *identity theory of truth* and the *primitivist theory of truth* do not compete with object-based correspondence.
§6.8.4. Some linguistically oriented arguments against presentism are exhausted.
§6.9. A summary is given of the unified theory of truth.

§7. The second stage of the method is continued by complementing the definition of a true proposition by *modalities —possible, contingent, necessary, impossible—* and thereby extending the unified theory of truth into a unified theory of possibility. An unambiguous modal proposition which functions in natural science and human social behaviour states that it is possible, contingent, necessary or impossible from the aspect of one time that an object has certain properties at a target time, and has one of the following truth values: true; false; indeterminate. The unified theory is very close logically to Von Wright's diachronic possibility.
§7.1. Modal propositions with different combinations of aspect and target times are given and it is explained how their truthmakers can be deduced.
§7.2. The mutually exclusive axioms for *partial determinism* and *total determinism* are introduced as qualifications of the causality axiom (§4.7), although the selection between them is left open. Modal propositions are analyzed in both contexts. *Synchronic* propositions are contrasted to *diachronic* propositions. *Asymptotical determinism* is defined.
§7.3. It is shown how the fusion of partial determinism and EUO implies that some propositions are not true nor false but *indeterminate*, that the *principle of bivalence* and the *law of the excluded middle* do not hold for such propositions in EUO, and that *future contingents* are implications of selecting partial determinism. It is shown how *counterfactual* can be defined in terms of EUO, how truthmakers of propositions whose surface structure is involved with counterfactuals are deduced, and that some propositions about counterfactuals are indeterminate in the context of partial determinism. It is shown that the fusion of EUO and partial determinism manages to handle conditional propositions, and provides a straightforward ontological foundation for probabilistic propositions.
§7.4. It is shown that EUO is the most economical available foundation for a theory of diachronic modality that functions accurately in the focal contexts. Alternative ontological foundations are contemplated, including Belnap's *branching space-time*, McCall's *shrinking-tree theory* and the growing-block version of Briggs and Forbes.
§7.5. It is shown that the unified theory *can be seen* as an application of Kripke's *possible worlds semantics* as well as of Hintikka's version, although the unified theory shifts from *possible worlds* into *possible TSUs*. It is noted that any theory of modalities which is applicable in the focal contexts must incorporate temporal mappings, and that logical possibility and Lewis' *modal realism* are inaccurate and uneconomical foundations for such a theory. Armstrong's *combinatorial theory of possibility* is characterized as a half-way solution between possible worlds and possible TSUs.
§7.6. It is shown that the unified theory suffices as a background for epistemic, fictionalist and logical considerations. This is another way of naturalising Platonism (§4.9).
§7.7. A summary is given.

§8. The unified theory is complemented by exactifying the notion of perception in terms of EUO, with colour perception as the case example.
§8.1. The process of perception is defined in terms of EUO, aided by the previously defined object-based correspondence theory of truth. Colour perception is defined by complementing plain perception by colour families: mind-independent colour objects; colour sensations of human agents; lights in the environment. The equivalence of the unified theory with David Armstrong's colour realism and David Rosenthal's *double-property theory* is pointed out and the goal of colour science is defined as the goal of discovering the contents of the colour families and their relations.
§8.2. It is shown how different cases of the experience of similarity of colours fit in the framework of the unified theory, including the experience of similarity of homogeneous as well as heterogeneous objects; *metamers* and the dichotomy of *one-over-many* colour properties and ranges of colour properties are defined in terms of EUO.
§8.3. The chain from a colour sensation of a perceived object to the knowledge of the structure of the object is discussed. The colour behaviour of an object is handled in terms of its *reflectance profile*.
§8.4. It is shown that an argument from *impossible colours* does not compose a threat to the unified theory.
§8.5. The unified theory is contrasted to *relational* and *dispositional* theories of colour. It is shown that all these theories manage to resolve conflicts which follow from interpersonal differences and heterogeneous lightning conditions, but the unified theory resolves them without mixing up the colour families, whereas the relational and dispositional theories especially mix these up. It is noted that the unified theory can be seen to incorporate the applicable ingredients of the relational and dispositional theories.
§8.6. A summary is given.

§9 The progressiveness of economical unification is emphasised and the central contributions of this thesis to the existing body of knowledge are listed.

3 Economical Unification in Philosophy of Science

Economical unification is the process of approaching ideal total science which builds on an economically unified base of metaphysical postulates which is sufficient for explaining all scales of phenomena. Figure 3 represents the transition from disunified total science into ideally economically unified theory which is the nexus of virtues. At the ideal stage where everything is built on an economically unified postulate base, it is indifferent if one talks about economically unified total science or about an economically unified *theory*. In contrast, in the current disunified state, we must talk about different theories because they build on different postulates and even contradict one another.

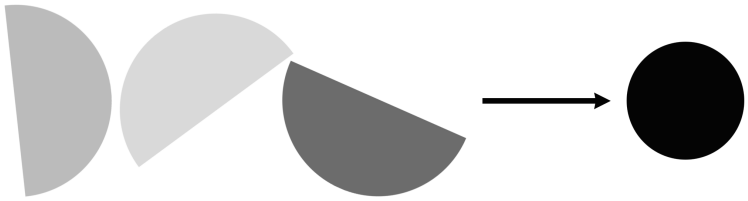

Figure 3: Economical unification as a process where a disunified aggregate of isolated, heterogeneous and incompatible theories is replaced or otherwise transformed into a homogeneous ideally economically unified and in all ways virtuous theory.

The following chain is the key to understanding the nature of unification and the need for it: the progress of science is desirable; all progress of science is not economical unification, but economical unification is progress of science and inseparable from the increase of general virtuousness of total science; in order to efficiently advance economical unification, the principle of economy is needed as an evaluation criterion that favours more economically unified and virtuous theories; it is indifferent whether one arrives at more economically unified theories by rejecting old theories and shifting into new ones, by reducing theories to others or by yet unexplicated paths, for all paths of economical unification are paths to progress; in order to arrive at more economically unified theories, one must explicate their metaphysical postulates; metaphysics is the science of explicating these postulates and their interrelations, i.e., metaphysics is primarily the science of unification. It will be seen that the understanding of the correct role of economical unification in the *center* gives an extremely fruitful point of departure to various focal issues in philosophy of science.

3.1 Economically Unified Theory as the Goal and the Nexus of Virtues

The goal of unified science and the preference for simplest empirically sufficient theories have been present in philosophical and scientific thinking since the antiquity until today. The ideally unified science cannot be had without an economically unified ontology in its center, which consists of metaphysical postulates, or *first principles*. Thales (624-547 BC) may be the earliest documented author who searched for the first principles.[6] For Aristotle (384-322 BC), science starts from first principles, and therefore it is natural that he called the science about them *the first philosophy*:

[6]See Aristotle, *Metaphysics* bk.1, ch.3.

> Clearly then Wisdom is knowledge about certain principles and causes (Aristotle, *Metaphysics*, bk. 1, ch. 1). When the objects of an inquiry, in any department, have principles, conditions, or elements, it is through acquaintance with these that knowledge, that is to say scientific knowledge, is attained. For we do not think that we know a thing until we are acquainted with its primary conditions or first principles, and have carried our analysis as far as its simplest elements. Plainly therefore in the science of Nature, as in other branches of study, our first task will be to try to determine what relates to its principles. Aristotle, *Physics*, bk. 1, ch. 1

There is not much difference in the method of economical unification and in the method Aristotle described, where the task is to explicate the simplest first principles and the rest is a matter of relating applications to them. Their equivalence is substantiated by Schaffer's remark:

> The task of metaphysics is to say what grounds what. That is, the neo-Aristotelian will begin from a hierarchical view of reality ordered by priority in nature. The primary entities form the sparse structure of being, while the grounding relations generate an abundant superstructure of posterior entities. ... The posterior is grounded in, dependent on, and derivative from it. The task of metaphysics is to limn this structure. Schaffer [352, p. 351]

The process of explicating the first principles common to all sciences is also the process of unification, for once the first principles have been explicated, sciences have been unified under them and they have become closer to being the same science. Thus, metaphysics should be primarily seen as the science of unification by explication of the first principles. The following formulations of the task of metaphysics are mixtures of stating that it is the task of unification and that of explicating the first principles. Again, if you unify two sciences you have to explicate the principles that are common to them, and if you do explicate those principles you have unified the sciences:

> [Ontology is] 'the' theory of the most basic and pervasive traits of reality (Bunge [68, p. 4]). [T]he metaphysician ... looks for unity in diversity, for pattern in disorder, for structure in the amorphous heap of phenomena. Bunge [69, p. 1]
>
> [Metaphysics] is concerned with developing a unified picture of all that there is, a picture that succeeds in portraying the fabric in which everything is woven and is connected with everything else. Poland [312, p. 124-5]
>
> Its business is to study the most general features of reality and real objects. Peirce [304, 6.6]
>
> [F]irst philosophy, [is] concerned with the principles, such as they are, that are common to all the sciences. *Britannica* [177, p. 63].

Formulations of the Principle of Economy. The principle of economy is needed as an objective evaluation criterion that favours more economically unified theories. Formulations of economy and formulations that are compatible it can be found throughout the history, including the Aristotle's above formulation, i.e., the given version of economy is merely a restatement of earlier versions.

1225-1274. Thomas Aquinas [9, p. 129] states that something that would violate economy is to be avoided: "If a thing can be done adequately by means of one, it is superfluous to do it by means of several."

1287-1347. William of Ockham likewise states that something that would violate economy is to be avoided: "It is vain to do with more what can be done with fewer."[7] "For nothing ought to be posited without a reason given...." [297, p. 290]

[7] As quoted in Russell [345, p. 472].

1726: Isaac Newton (1642-1727) [284, bk. 3, Rules I, IV] states that something that would violate economy is to be avoided, and also that a good theory ought not be rejected on the basis of a theory that is not better:

> *We are to admit no more causes of natural things than such as are both true and sufficient to explain their appearances.* To this purpose the philosophers say that Nature does nothing in vain, and more is in vain when less will serve; for Nature is pleased with simplicity, and affects not the pomp of superfluous causes. ... In experimental philosophy we are to look upon propositions inferred by general induction from phenomena as accurately or very nearly true, notwithstanding any contrary hypotheses that may be imagined, till such time as other phenomena occur by which they may either be made more accurate or liable to exceptions. Isaac Newton (1642-1727) [284, bk. 3, Rules I, IV]

1892-1964. J.B.S Halldane: "In scientific thought we adopt the simplest theory which will explain all the facts under consideration and enable us to predict new facts of the same kind."[8]

1933. Einstein's [128, p. 165] formulation is very close to the given version of economy: "It can scarcely be denied that the supreme goal of all theory is to make the irreducible basic elements as simple and as few as possible without having to surrender the adequate representation of a single datum of experience."

1935. Eino Kaila's *relative simplicity* of theory h is the fraction $RS(h,e) = \frac{syst(h,e)}{K(h)}$, where $syst(h,e)$ is the number of empirical propositions that are derivable from h based on empirical evidence e, and $K(h)$ is the number of logically independent assumptions of h (Niiniluoto [287, pp. 158-9]). According to Niiniluoto [290, p. 190] "a theory has high relative simplicity, if it explains a multitude of empirical data by means of a few independent assumptions." Kaila [194, p. 83] maintains that "the *explanatory value of a theory is proportional to its relative simplicity*" but as in his analysis direct references to metaphysics are well hidden in the positivistic spirit, it is left open whether 'independent assumptions' can be translated as 'metaphysical postulates.' If they can, then relative simplicity is very close to the principle of economy. For in this case, given two theories which give exactly the same number of empirical propositions (explain the same phenomena), the one with the least sum of independent assumptions (metaphysical commitments) has a greater relative simplicity. Relative simplicity is thus a version of economy. Although relative simplicity could be interpreted in a different way and applied e.g. independently of metaphysics, a modified version of it is applied in §5.7 in evaluating theories with metaphysical commitments.[9]

[8] J.B.S Halldane, Science and Theology as Art-Forms, 1927. As quoted in McAllister [254, p. 105].

[9] According to Kiiskinen [198, p. 5], Kaila left the problem of relative simplicity for Pertti Lindfors to be resolved, who took on the challenge, not seeing how difficult the thus far unresolved problem it was. (The unpublished articles of Lindfors about the topic are in the hold of the Finnish Philosophical Association, Suomen filosofinen yhdistys.) The problem was to define $syst(h,e)$ and $K(h)$, i.e., to define the number of empirical propositions that are derivable from an evaluated theory h based on empirical evidence e or just the magnitude of phenomena explained by h, and the number of logically independent basic assumptions of h, in order to calculate relative simplicities of theories as ratios $RS(h,e) = \frac{syst(h,e)}{K(h)}$. As a proof that this is not an insuperable difficulty, the phenomena explained by a theory and the sum of its metaphysical postulates are explicated in §5.7. It can be speculated what the difficulties might have been. One difficulty might have been the general silencing of metaphysics away in the positivistic spirit which makes it hard to openly explicate metaphysical commitments. An interrelated difficulty might have been not seeing that there are metaphysical postulates in physics in the first place but instead taking a bad reading of Mach and talking only about mathematics that predicts verifiable phenomena and concentrating on the accuracy of predictions only. Another difficulty might have been the absence of alternative comprehensive theories to be evaluated: while in the positivistic spirit scientists were talking about empirical facts within the conceptual schemes of the paradigmatic theories instead of

1945. Bertrand Russell [345, p. 472] states that something that violates economy is to be avoided: "if everything in some science can be interpreted without assuming this or that hypothetical entity, there is no ground for assuming it."

1963. Mario Bunge [67, p. 75] takes in account also the simplicity of alternative *formulations* or *syntactical* simplicity or *descriptive* simplicity and states that something that violates economy is to be avoided: "conceptual entities should not be multiplied *in vain*... but they should be welcomed whenever they lead either to a deeper understanding of reality or to a syntactical simplification of theories."

1974. Michael Friedman commits to a principle that looks very similar to Kaila's relative simplicity: "Friedman's motivational argument suggests a way of working out the notion of unification: characterize $E(K)$ as the set of arguments that achieves the best tradeoff between minimizing the number of premises used and maximising the number of conclusions obtained" (Kitcher [202, p. 431]). Friedman dodges the use of 'metaphysics' by characterizing the unexplained explainers as *brute facts*:

> [T]he phenomenon doing the explaining is not itself understood; it is simply a brute fact. But its ability to explain *other* phenomena is not thereby impaired. ... nor do we have to understand why it occurs. It merely has to explain the phenomenon to which it is related. Friedman [150, p. 11]

1981. Philip Kitcher [201, 202] evaluates three features of a theory: the more general, simpler and stringent, the better, i.e., the greater the unifying power.

Generality: the more general the theory, the greater the number of phenomena explained or the number of conclusions that can be drawn from it.
Simplicity: the simpler the theory, the smaller the number of *argument patterns* in it.
Stringency: the more stringent the theory, the smaller its range of applicability.

The unifying power of a theory is great when a small set of patterns explains much: "the unifying power of a set of argument patterns varies conversely with the number of patterns in the set" (Weber et al [408, p. 15]). When generality and simplicity are considered as a pair without the stringency criterion, Kitcher's unificatory power resembles closely Kaila's relative simplicity. The requirement of saving phenomena is implicit in the generality criterion. The argument patterns cannot be directly equated with metaphysical commitments, and Kitcher aims to make sense of unification "without indulging in the metaphysics" (Kitcher [202, p. 500]). However, an argument pattern contains 'premisses,' and as genuine explanations are based on theories with metaphysical commitments (§3.4), we can apply generality and simplicity in evaluating theories.

The purpose of the stringency criterion is to exclude argument patterns which are irrelevant in explanations and predictions. Consider two irrelevant patters. *God-pattern*: God wants it to be the case that x; what God wants to be the case is the case; it is the case that x. *Pure-chance-pattern*: everything happens by pure chance. One one hand the irrelevant patterns explain everything, but on the other hand they are not applicable in making predictions which are in practice needed and therefore such patterns had to be discluded by the stringency criterion: "If [an argument] pattern sets conditions on instantiations that are more difficult to satisfy than those set by another pattern, then

metaphysical commitments, the existence of an alternative would have revealed alternative 'empirical facts' and pointed out in which respects the evaluated theories differ, thus providing something to be evaluated. Another difficulty might have been the expectation of minute accuracy in the specification of $syst(h, e)$ and $K(h)$, of the same level as is needed in evaluating the accuracy of predictions. This is practically impossible and disoriented, for it does not require a look into the sixth decimal to see e.g. that one theory needs 70% of dark energy and the other needs none.

I shall say that the former pattern is more *stringent* than the latter" (Kitcher [202, p. 433]). The stringency criterion can be seen to be included in the fusion of generality and simplicity. For, irrelevant patterns do not increase the generality of a theory *which is actually needed in natural science*, but as they in any case contain metaphysical postulates, they are not favoured by the simplicity criterion. When the stringency criterion is seen to be implicit in generality and simplicity, Kitcher's degree of unifying power becomes equivalent with Kaila's degree relative simplicity.

1999. Michael Devitt and Kim Sterelny state the simplicity criterion [109, p. 278]: "We should favor here, as in science, simple and economical theories. In ontology, the less the better."

2014. Gonzalo Rodriguez-Pereyra [336]: "Which one of these theories is the best has to be decided by comparing how they score with respect to certain theoretical virtues, like accommodating firm and stable intuitions and common sense opinions, avoiding the unnecessary multiplication of entities, reducing the number of undefined primitive concepts, etc."

Inseparability of Economical Unification and the Increase of Virtuousness. The process of economical unification walks hand in hand with the increase of general virtuousness of total science. Accordingly, there is a small step from economy as a criterion of empirical sufficiency and metaphysical simplicity only, into a criterion that evaluates all virtues of competing theories: empirical sufficiency and accuracy, metaphysical simplicity, unificatory power, consilience, comprehensiveness, the lack of ad hoc features, understandability, coherence, necessity and fundamentality.[10] All these are interrelated with all, and only some of their interrelations are explicated. The central unifying factor behind all interrelations is naturally unification itself, which could be added in all below titles.

EMPIRICAL SUFFICIENCY, METAPHYSICAL SIMPLICITY, UNIFICATORY POWER. In figure 3 the three half-circles represent isolated theories of different scales —such as the scales of particles, planetary systems, galaxies, and the present state of the Universe as a whole— and the circle represents an ideally unified theory of all scales. By explaining all scales with a unified postulate base, the overall quantity of postulates and parameters is minimised, whereas in isolated theories their quantity is maximised, proportionally to the degree of isolation. Even if an isolated one-scale theory were individually simpler than a unified theory of all scales, the unified theory would be relatively simpler than the isolated theories together. The fusion of wide or comprehensive empirical sufficiency, metaphysical simplicity and coherence is close to great *unifying power* (p. 22), great *relative simplicity* (p. 21) and great *explanatory power* (Psillos [317, p. 171]). The greater unificatory/explanatory power and greater relative simplicity, the more economically unified is the theory, i.e., all these terms have basically the same meaning.

UNDERSTANDABILITY AND COMPREHENSIVENESS. When the minimal sum of metaphysical commitments and their interrelations are explicated and as they explain all scales, the whole is understandable and its minimal size facilitates understanding it, whereas

[10] Psillos [317, p. 171] lists external coherence, consilience, completeness, unifying power, lack of ad hoc features, capacity to generate novel predictions and explanatory power. Chakravartty [80]) lists simplicity, consistency and coherence (both internally, and externally with respect to other theories and background knowledge), scope and unity (pertaining to the domain of phenomena explained) as theoretical virtues. Nolan [293, p. 224] lists internal consistency, external coherence, simplicity, explanatoriness, fertility and unificatory power. Quine (1960) [324, p. 276] characterises the method of an ontologist: "He can scrutinize and improve the system from within, appealing to coherence and simplicity; but this is the theoretician's method generally."

understanding several isolated theories individually requires more work, and these in any case fail to catch the unified picture of reality. Understandability and comprehensiveness are interrelated, as a comprehensive theory does not leave central aspects of nature unexplained, and as these are explained these are also understood. This is congenial with Poland [312, p. 29]: "A unified picture of nature provides more and deeper understanding than does a view of nature that represents it as a disunified aggregate of isolated and disconnected facts." The incorporation or explication of common-sensible metaphysical commitments —such as the axioms of EUO— contributes to the understandability of the unified theory, for once these are clearly explicated, there are no ambiguities about whether these are incorporated or not.

INTERNAL AND EXTERNAL COHERENCE, CONSILIENCE. Internal coherence is a basic requirement for an economically unified theory, for an incoherent theory cannot genuinely explain perceptions. Internal coherence means mutual consistency of all ontological commitments of the theory and of all concepts defined in terms of them, plus internal consistency of each individual commitment and concept. Coherence and understandability walk hand in hand whereas an incoherent theory cannot be genuinely understood. 'External' coherence is misleading in the context of an *ideally* unified comprehensive theory that explains literally all scales, as there is nothing external to it. However, in the path towards it, a sum of compatible theories of different scales is more virtuous than an otherwise equal sum of incompatible theories, where isolated theories may naturally have conflicting commitments. A comprehensive and coherent unified theory is consilient, as independent points of view conform to it. This is congenial with Whewell:

> [O]nce a theory is invented by discoverers' induction, it must pass a variety of tests before it can be considered confirmed as an empirical truth. These tests are prediction, consilience, and coherence. These are characterized by Whewell as, first, that "our hypotheses ought to fortel [sic] phenomena which have not yet been observed" (1858b, 86); second, that they should "explain and determine cases of a kind different from those which were contemplated in the formation" of those hypotheses (1858b, 88); and third that hypotheses must "become more coherent" over time (1858b, 91). Snyder [367] quotes Whewell [410, pp. 83-96]

NECESSITY AND FUNDAMENTALITY. Necessity is exemplified by using EUO. The *aim* is to show that the axioms of EUO are simultaneously sufficient *and* necessary, and thereby metaphysically minimal. (a) A theory may commit to the existence of several causally isolated worlds (transcendism), but all sufficient theories must commit to at least one world; at least one world is necessary and the aim is to shown that (naturalism) the commitment to exactly one world is also sufficient. (b) A theory may commit to whatever combination of the existence of past, present and future but all sufficient theories must commit at least to the existence of the present; the aim is to shown that (presentism) the commitment to the existence of the present only is also sufficient. (c) A theory may commit to spatial infinity and infinite divisibility, but all sufficient theories must accept at least finite space and finite divisibility; the aim is to shown that these only are also sufficient. (d) A theory may commit to the existence of physical contradictions but all theories must accept that some objects are non-contradictory; the aim is to show that it is sufficient to suppose that all objects are non-contradictory. (e-f) The aim is to show that all sufficient theories must commit to causal interactions and some form of mind-independence.

It is natural to consider everything necessary as fundamental. The fundamentality of a theory that consist of necessary and optional commitments can be measured by economy: the more economical, the more fundamental. Further, in the light of the indispensability of metaphysics in theories, economical unification functions as a point of departure to

demarcation. It is not asked whether a theory is metaphysical or scientific, but it is asked which of two 'scientifico-metaphysical' theories is better, i.e., more economical: the more economical, the more 'scientific.'[11] Bunge's and Quine's characterizations fit in this picture:

> But the two concerns are not mutually exclusive and, in fact, sometimes they are indistinguishable: an extremely general scientific question may be a special ontological one (Bunge [69, p. 1]). There is not even a gap, let alone an abyss, between them: *ontology is general science* and *the factual sciences are special metaphysics* (*ibid*, p. 16). [E]very scientific theory, if extremely general, *is* ontological; and every ontological theory, if exact and in tune with science, *is* scientific (*ibid*, p. 21).
>
> Naturalistic philosophy is continuous with natural science. ...The boundary between naturalistic philosophy and the rest of science is just a vague matter of degree. [325, p. 257] Quine

3.2 Mach → Verifiability → Neo-Scholasticism → Naturalistic Closure

Ernst Mach (1838-1916) is best seen as a unifier of science, whose work was in line with general positivism or empiricism, which was in turn natural continuation of the 18th century Age of Enlightenment where the common world-view was no longer given by the church but by science, and where unnecessary mysticism needed to be banished from science. As an illustration of the spirit of positivism, Auguste Comte (1798-1857) characterized [91, p. 29] three stages of mental development of the human kind —the religious stage, the metaphysical stage, the scientific stage— where the scientific stage is the final and the most perfected stage. Mach's anti-metaphysical aspect is best seen as derivative from his project of unification: that metaphysics which is not needed in this project was only in the way. Thus, when Mach rejects 'metaphysics' he aims to reject unnecessary metaphysics, not metaphysics that is needed in unifying science.[12] Mach coined in the term 'the principle of economy of thought' and emphasised it role in unifying science in various works such as [236, 240, 237, 241].[13] Consider Mach's characterisations of the goal of economically unified science which does not incorporate excessive metaphysics, and of his own view of science:

> It is the object of science to replace, or save, experiences, by the reproduction and anticipation of facts in thought. ... any stock of knowledge worthy of the name is unattainable except by the greatest mental economy. Science itself, therefore, may be regarded as a minimal problem, consisting of the completest possible presentment. [237, pp. 481, 491].

[11] For comparison, Juti [193] concludes that theories in neither class —metaphysics and other sciences— should be considered as primary or more fundamental with respect to one another. Juti notes that e.g. Lowe [232] and Tahko [390] seem to promote the primary status of philosophical metaphysics, whereas Ross, Ladyman and Spurrett [213, p. 30] take contemporary institutional science as primary and give metaphysics the role of advancing its unity (§3.2).

[12] E.g. Peirce's [304, 1.129], Planck's [311, pp. 26,52] and Feigl's [136, pp. 14-5] criticism against Mach should be seen as criticism against the supposed over-propagated anti-metaphysics or against Mach's personal suggestions about the correct metaphysics, not against economy as a mature methodological principle that in practice unites all scientists: "If we handle our concepts responsibly, we can avoid metaphysical perplexities" (Feigl [135, pp. 50-1]).

[13] Charles Sanders Peirce first wrote about the *economy of research* a few years before Mach (Rescher [330, p. 71]). The basic idea was that in practice, the simpler the hypothesis, the easier it is to test it. A very similar idea was expressed by Quine and Ullian [326, pp. 408]: "At each stage... when choosing a hypothesis subject to subsequent correction, it is still best to choose the simplest that is not yet excluded. ... the more complex the hypothesis, the more and wilder ways of going wrong; for how can we tell which complexities to adopt?" See also Pietarinen [307, pp. 60-1].

> The goal which it has set itself is the simplest and most economical abstract expression of facts. Mach [236, p. 207]
>
> All living creatures who may study physics in the future will be obliged, like us, to provide for their own survival and therefore to pay attention to whatever in nature is economically important and permanent for them. Mach [242, p. 36]).
>
> [E]very *metaphysical* and every one-sided *mechanical* view of physics were kept away, and an arrangement, according to the principle of economy of thought, of facts—of what is ascertained by the senses—was recommended. Mach [241, p. 9]

Again, the basis of an intelligible interpretation of what he meant by *keeping metaphysics away* is Mach's goal to unify science, which can never succeed without metaphysics as some metaphysics must be in the very center of a unified world-view. Moreover, in addition to the general preference for unification, Mach gave suggestions about what the metaphysical core of the unified physics looks like, which makes it clear that Mach did not intend to banish metaphysics *completely*: "Mach did not totally reject metaphysics (as some of Vienna Circle tried). He looked through Kant's ideas and accepted *unavoidable* metaphysics. As a scholar of Beneke and principally a Neokantian, he tried to extract the metaphysical errors of Kant."[14]

Mach [243, pp. 361-2] [242, p. 39] explicity stated that he is not a solipsist or an extreme idealist and therefore Mach's metaphysics is compatible with ontological realism which is an axiom of EUO; however, Mach concentrated heavily on psychology and on the perceiver, and this tendency can be easily misinterpreted to be some version of extreme idealism, when looking at Mach's [237, pp. 482-3] passages such as: "Nature is composed of sensations as its elements" and "the world is not composed of "things" as its elements, but of colors, tones, pressures, spaces, times, in short what we ordinarily call individual sensations." Also, when Mach's (*ibid*, p. 481) notion that "the object of science to replace, or save, experiences, by the reproduction and anticipation of facts in thought" is combined with his statements which reject 'metaphysics,' it can be misinterpreted and applied in defending any theory of physics as the 'correct description of facts' without seeing that it has a metaphysical base and without seeing that it has alternatives.

Mach's views about the atomic theory are nuanced (cf. Brush [64]). His primary goal in the anti-atomistic hypothesis was to reach a non-mechanistic description of the atomic scale, i.e., to not to explain phenomena in that scale solely in terms of mechanistic movement of particles; however, Mach also presented the falsifiable hypothesis that there are no atoms e.g. in [239], a hypothesis which was also falsified, i.e., he was persistent in both non-mechanicism and in the rejection of atoms (Blackmore [52]).

Mach [241] devoted a book for the conservation law of energy. Mach [237] suggested a shift away from Newtonian absolute space and time, where time and space are independent of particulars *in* space, and where a particular in space can move with respect to the absolute space. The rejection of absolute space is interrelated with Mach's view of the Universe as a total gravitational system, where the principle "that links inertia of mass to the total mass in space" (Suntola [385, p. 267]) has become to be called *Mach's principle*. According to Siemsen [360], by Mach's principle "the movement of any object would be dependent on the totality of mass in the universe." In this view, when a mass particular moves, its movement is always relative to and affected by the rest of the mass in space, i.e., there is no such thing as 'absolutely free movement' that would not be affected by the rest of the mass. Mach notes that the idea of absolute space is unneces-

[14]Karl Siemsen, personal communication. This interpretation is found from Hayo Siemsen, *The Genesis of Central Ideas of Ernst Mach*, working paper.

sarily metaphysical, whereas experience testifies that all moving bodies are affected by other bodies:

> No one is competent to predicate things about absolute space and absolute motion; they are pure things of thought, pure mental constructs, that cannot be produced in experience. All our principles of mechanics are, as we have shown in detail, experimental knowledge concerning the relative positions and motions of bodies. Mach [237, p. 229, cf. pp. 542-3].

Some of Mach's ideas are deployed in relativistic physics (Norton [295]) and some in the Dynamic Universe model (DU) (§5). The analysis of Lichtenegger and Mashhoon [227] shows that Mach's principle is practically rejected in the General Theory of Relativity. The relativistic standard model of cosmology is mechanistic and it violates the conservation law or its role is at least ambiguous (§5.6.2). DU incorporates the conservation law and "gives an unambiguous explanation and an exact mathematical expression for inertia, in full agreement with Mach's principle" (Suntola [385, p. 137]). DU is especially holistic and not mechanistic (§5.2). Both models shift into intrinsic time from absolute time but in different ways: while the Theory of Relativity incorporates intrinsic time in the form of relativistic time, DU couples intrinsic time with absolute simultaneity.[15]

1924-1950's POSITIVISM IN PHILOSOPHY. The anti-metaphysical turn was conveyed to philosophical thinking through the classical logical positivist clubs —the Vienna Circle and the Berlin Circle— which were active during the period 1924-1936. These clubs set the path of 20th century analytical philosophy on logic, logical analysis and language, drawing from the work of Russell, Frege and Wittgenstein. Mach was the biggest single figure behind their extreme empiricism. This becomes clear from Uebel's remarks about the Vienna Circle:

> [L]ong before the verification principle proper entered Circle's discourse in the late 1920s, the thought expressed by Mach's dictum that "where neither confirmation nor refutation is possible, science is not concerned" (1883 [1960, 587]) was accepted as a basic precept of critical reflection about science. Uebel [402] and Mach [238]

According to the logical positivists' *verifiability criterion* or the *verifiability theory of meaning*, only verifiable commitments qualify as scientific. Therefore all unverifiable and unfalsifiable metaphysical commitments are unscientific: e.g. all axioms of EUO are unscientific according to the verifiability criterion. This full-blown anti-metaphysical statement could have been a misinterpretation of Mach who did not aim to eliminate metaphysics completely. Again, although Mach [237, p. 490] clearly declared that "where neither confirmation nor refutation is possible, science is not concerned" he also proposed unrefutable metaphysical principles. Although Mach seems to be inconsistent here, he can also be interpreted to have taken his suggestions about metaphysics as verified, or in any case as clearly 'scientific' in the sense that had great unificatory power? The high point of the positivist movement was perhaps in the 1950's (Aliseda and Gilles [7, p. 436]). Philosophers such as Popper understood that the verifiability criterion is unbearable because some metaphysics is present in theories in any case.

> My criticism of the verifiability criterion has always been this: against the intention of its defenders *it did not exclude obvious metaphysical statements; but it did exclude the most*

[15]It is notable that absolute time, or God's time as Newton called it, was never needed nor applied in giving predictions when applying Newtonian physics. Also, the focal periods of time were defined intrinsically (§4.2), disregarding any God's time whatsoever: one day was defined exactly as today as the period of time during which the Earth rotates once around its own axis; one second was derived by dividing the day; one year was defined exactly as it is defined today as the period in which the Earth rotates once around the Sun.

> *important and interesting of all scientific statements,* that is to say, the scientific theories, *the universal laws* of nature. Popper [313, p. 281]

The rejection of the verifiability criterion did not lead into a consensual positioning of the goal towards economically unified science with a minimal metaphysical core, right into the center of philosophy of science where it belongs to. Instead, the analysis proceeded with a strongly formal, logical and linguistic outlook, without the most obvious unifying goal. Several examples are given in §3.3 of how the unifying goal indeed unifies various focal issues in philosophy of science. That is, although philosophers of science made great contributions, the progress rate would have probably been lot greater with the commonly accepted unifying goal. To illustrate the lack of the unified goal, consider the project of giving meaning to approximate truth or truthlikeness of theories. The central approach to truthlikeness has been the formal approach which only evaluates accuracies of predictions, and the informal approach to truthlikeness means the evaluation of virtues of theories, whereas in the unified approach the principle of economy evaluates both: accuracies of predictions and virtues. As another example, the term *metaphysics* was replaced during and after the reign of the verifiability criterion e.g. by *logically independent basic assumptions* (p. 21), *experimental laws*, *theoretical assumptions* (p. 37), *brute facts* (p. 22), *premisses* (p. 22) and *unexplained explainers* (Sellars [355]). Perhaps the reason behind the hiding of the term 'metaphysics' even after the rejection of the verifiability criterion was that although full-blown anti-metaphysics had been rejected, metaphysics was still some kind of a taboo that did not have a respectable role among philosophers of science who continued the research line conveyed to them by the logical positivists? Whatever the reason, an overwhelming terminological redundancy does not help in catching the unified goal.

1960's and on: neo-scholastic metaphysics. After the rejection of the verifiability criterion, when philosophers started to openly contemplate about metaphysics again in the 60's and 70's, the principle of economy had very little importance. The absence of the simplicity criterion in contemporary analytical metaphysics can be seen as an over-propagated counter reaction to the positivists' anti-metaphysics. The rejection of positivism meant the tumbling down of a flood wall which prevented unnecessary metaphysics from filling the valley. Ross, Ladyman and Spurrett characterize the transition[16] from positivism into *analytical* or *neo-scholastic metaphysics*:

> Initially granting themselves permission to do a bit of metaphysics that seemed closely tied to, perhaps even important to, the success of the scientific project, increasing numbers of philosophers lost their positivistic spirit. The result has been the rise to dominance of projects in analytic metaphysics that have almost nothing to do with (actual) science. Hence there are now, once again, esoteric debates about substance, universals, identity, time, properties, and so on, which make little or no reference to science, and worse, which seem to presuppose that science must be irrelevant to their resolution. Ross et al. [213, pp. 9-10]

Recall that the greatest orientation behind the method of economical unification is to function as an alternative to plain conceptual analysis that goes hand in hand with neo-scholastic metaphysics (§3.5).

2007 the principle of naturalistic closure. Ross, Ladyman and Spurrett presented the principle of naturalistic closure (PNC) as a reaction to and as a mean to restrain excessive neo-scholastic metaphysics, and as a guideline whose purpose is to bring philosophical metaphysics closer to empirical science:

[16]For comparison, see Williamson's [411] account of the transition.

> Any new metaphysical claim that is to be taken seriously should be motivated by, and only by, the service it would perform, if true, in showing how two or more specific scientific hypotheses jointly explain more than the sum of what is explained by the two hypotheses taken separately, where a 'scientific hypothesis' is understood as an hypothesis that is taken seriously by institutionally *bona fide* current science. Ross et al. [213, p. 30]

Unification and economy are implicit as PNC accepts only those new hypotheses which explain more than previous hypotheses separately. When two previous theories are replaced by such a theory, the new theory has a higher relative simplicity. When a theory is transformed by such hypothesis the resulting version has a higher relative simplicity. PNC favours partial unifications (p. 38).

Although PNC is on the right track, it is in certain senses too strict. First, in PNC two or more hypotheses should jointly explain *more* than the sum of what is explained by the two hypotheses taken separately. Economy is increased already if postulate C explains *as much* as A+B, but is simpler than A+B, i.e., the replacement of A+B by C is progressive even if C does not explain *more* than A+B. Then again, if always when C explains at least as much as A+B, it is also the case that C explains more than A+B, then PNC could be sustained as such in this respect. A clear difficulty is that PNC accepts only hypotheses that are taken seriously by current institutional science, and therefore PNC functions solely within the current paradigms. Melnyk [268, p. 94] notes that this would stall attempts to renew the current paradigms. That is, if Ross et al. accept all paths of progress including reductions, theory shifts and partial unifications, they should also accept that it is always institutional theories that are being shifted into new theories. The exaggerated restriction can be removed by transforming 'institutionally bona fide current science' into 'theory that gives the most accurate predictions.' When transformed into a form congenial with the given version of economical unification, PNC becomes:

> Any new metaphysical postulate or a system of postulates that is to be taken seriously should explain more than the best earlier system, or explain as much with less metaphysics.

In the given version of economical unification and EUO as its product, no new metaphysical hypotheses are made in the first place; instead, the goal is to identify an economically unified theory with openly explicated metaphysical postulates. Axioms such as the law of non-contradiction, causality and ontological realism are in any case implicit in the thinking of scientists and in theories even if these are not written out, and these must be explicated in order to make the evaluation of comprehensive theories objective.

3.3 Theory Shifts and Reductions; Pessimistic Induction; Underdetermination; Approximate Truth; Falsifiability; Rational Proliferation

Theory shifts, reductions and partial unifications are paths into a more economically unified total science. In a theory shift (or paradigm shift) that is favoured by economy, theory A is replaced by theory B which does all that A does and is economically unified with respect to A and incompatible with A. In a reduction which is complete and favoured by economy, theory A is derived from theory B, where A and B are compatible and where B is more economically unified than A. In a partial unification, postulate C is found which is common to both A and B, but A and B also have non-overlapping postulates. The characterization of these three paths and their relations is very inconclusive, but

it suffices for expressing the central point: all paths towards the ideally economically unified science are paths to progress.

THE SHIFT FROM THE EARTH-CENTERED INTO THE SUN-CENTERED MODEL. As with all theories, the ontology of a model of cosmology consists of the verified part and the metaphysical part. The metaphysics of a model of cosmology can be characterized as the fusion of the *central unifying idea*, *laws of nature*, *regularities* and *hypothetical entities*.[17] Of all models with the most accurate predictions, economy favours the model with the simplest sum of the central unifying idea, laws of nature, regularities and hypothetical entities, or just the simplest sum of all metaphysics.

The central unifying idea of the Sun-centered model is that the Sun[18] is the center of the Solar System, and the central unifying idea of the Earth-centered model is that the Earth is the unmoving center of the Universe. In both cases the central laws of nature are the conservation law of energy, and gravitation that is expressed by some formulas. In both cases the central unifying ideas are coupled with regularities. When a human agent who is equipped with the idea that the Earth is the center of the Universe, makes measurements M from the surface of the Earth[19] with a telescope, the result is the following: while the orbits of the Sun and the Moon around the Earth are circular, the orbits of the planets around the Earth are *epicyclic*, as depicted in figure 4. In contrast,

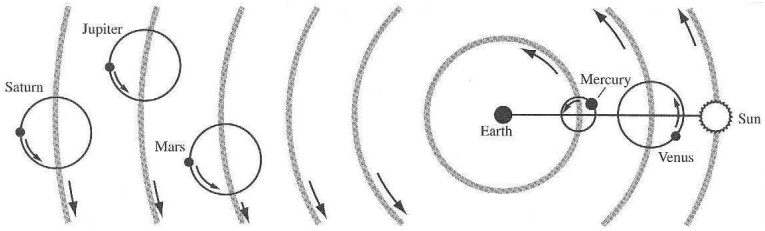

Figure 4: A visualization of the Earth-centred model that requires the epicycles. The figure is from pallisaard.com/blog

when a human agent who is equipped with the idea that the Sun is the unmoving center of the Universe, makes the same measurements M, the conclusion is that all planets of the Solar System circulate the Sun in elliptical orbits. Economy favours the Sun-centered model because its uniform elliptical orbits are simpler than the epicyclic orbits of the Earth-centered model. Therefore, when the Earth-centered model had been replaced by the Sun-centered model, a shift into a metaphysically simpler model had taken place.

In both models, predictions —such as what will be the future positions of the planets— are calculated by giving verified existents such as the present positions of the planets as inputs to formulas which characterize the laws of nature and which are fitted around the central unifying idea and regularities. One of the central notions of Kuhn [209] was that when the predictions of a model do not match perceptions, the model may be complemented with extra regularities or hypothetical entities, by which its predictions can be made to match perceptions. Extra regularities and hypothetical entities may be jointly called *experimental parameters*. These are by definition metaphysical entities, as these are supposed to exist but these have not been verified to exist by perception. The

[17]The laws of nature postulated by the model could as well be considered to be implicit in the central unifying idea, and vice versa.

[18]More accurately, the barycenter of the Solar System which is close to the center of the Sun.

[19]The point of measurement is in principle indifferent, as long as it is either the Sun or one of the objects in a regular orbit in the Solar System, such as the planets, moons and comets.

central reason why also metaphysical postulates need to be evaluated, i.e., the central reason why the principle of economy is needed is to prevent an unconstrained explosion of parameters; when the quantity of parameters increases, the theory gets less relatively simple, which paves the way to a paradigm shift into a more economically unified theory, which is progressive. This issue is handled below from the aspect of *falsifiability*.

UNDERDETERMINATION, PESSIMISTIC INDUCTION, APPROXIMATE TRUTH. Economy would favour the Sun-centered model even if the Earth-centered model would give as accurate predictions. Moreover, any other stellar object with a regular orbit could in principle be selected as the center point. For instance, the idea that the Moon is the center of the Universe and that everything else circulates the Moon would also suffice, but it would have to be coupled with even more complex regularities than the Earth-centered model. This raises the challenge of underdetermination: when "different, conflicting theories are consistent with the data; ... the choice of which theory to believe is underdetermined by the data" (Chakravartty [80]). Economy suggests that the metaphysically simplest of all theories which are equally accurately consistent with the data is to be preferred. Thus, the challenge of underdetermination is exhausted by the basic formulation of economy. The paradigm shifts also raise the challenge of pessimistic induction:

> If one considers the history ... what one typically finds is a regular turnover of older theories in favour of newer ones, as scientific knowledge develops. From the point of view of the present, most past theories must be considered false; indeed, this will be true from the point of view of most times. Therefore, ... surely theories at any given time will ultimately be replaced and regarded as false from some future perspective. Thus, current theories are also false. Chakravartty [80]

Even if the current theories were false, they are still the best approximations we have got and there are no good alternatives for relying on them in the epistemic sense, except than to replace them by even better theories. Pessimistic induction is thus not a threat to economical unification, but it underlines that economy is needed in evaluating theories in order to lubricate shifts into more economically unified theories. According to Niiniluoto [289, p. 10]: "The best explanation for the practical success of science is the assumption that scientific theories in fact are approximately true or sufficiently close to the truth in the relevant respects." Pessimistic induction indicates that the current theories are not true, but as scientific realists wish to sustain *some* notion of a true theory, the concept *approximately true* or *truthlike* does the job. In turn, explicating what *approximately true* means is perhaps the most central challenge of scientific realism. Scientific realists have had two broad strategies: "attempts to quantify approximate truth by formally defining the concept and the related notion of relative approximate truth; and attempts to explicate the concept informally" (Chakravartty [80]).

The formal approach can be characterized in terms of Niiniluoto's [286, p. xii] *similarity approach* where "the truthlikeness of the statement h depends on the similarities between the states of affairs allowed by h and the true state of the world." The basic idea is that a theory gives predictions, and the better the predictions match perceptions, the closer to truth is the theory. For comparison, Tambolo [393, p. 19] maintains that "a theory T is highly verisimilar ... if it says many things about a target domain, ... and if many of these things are (almost exactly) true." Niiniluoto [286] does not openly talk about metaphysical postulates, and Agassi [4] characterises Popper's and Niiniluoto's approaches to truthlikeness as *halfway pro-metaphysical*. Niiniluoto has got nothing *against* metaphysics, but does not take it in account in evaluating theories either, i.e., Niiniluoto has perfected the notion of what it means that a theory gives accurate predictions, but has left metaphysics for others. When commenting the principle of

economy, Niiniluoto[20] maintains that the "definition of verisimilitude fits in principle for all theories, i.e., also for theories with existential claims. In practical applications we must do some kinds of evaluations of the weights." Niiniluoto[21] confirms that he accepts the idea that we first apply the similarity approach in picking out theories with the most accurate predictions, and after this evaluate the aesthetic features of the theories, like simplicity of metaphysics. Economy can thus be characterized as a fusion of the formal and informal[22] approaches to theory evaluation. Psillos' remarks show that equating 'closer to truth' with 'more economically unified' and 'more virtuous' is not a new idea:

> As is well known, scientific realists typically suggest that when it comes to assessing the support which scientific theories enjoy, we should not examine only their empirical adequacy. This may be necessary but not enough on its own to make a theory well supported. We also need to take into account several *theoretical virtues* such as coherence with other established theories, consilience, completeness, unifying power, lack of ad hoc features and capacity to generate novel predictions. These virtues capture the *explanatory power* of a theory, and explanatory power is potentially confirmatory. Psillos [317, p. 171]

Accordingly, the fullest notion of economy should unify all applicable ingredients of both approaches: the formal approach which was characterized in terms of Niiniluoto's similarity approach should be complemented by an as well finalised measure of the informal approach which was characterized as the measure of virtuousness, a project which is advanced in this thesis. Kaila's relative simplicity is modified in §5.7 so that it takes in account some other theoretical virtues in addition to empirical sufficiency and metaphysical simplicity. Even this version is not all-pervasive. For instance, how to select between two sums of metaphysics which are otherwise equal, but where one sum posits existence to a greater quantity of one type of a metaphysical entity and less types of metaphysical entities, whereas the other posits a smaller quantity of that type of a metaphysical entity but more types of metaphysical entities? Although more nuanced versions will be needed in the future, the given version is sufficient for the needs of this thesis and the current state of the field where the differences in metaphysical complexities of competing theories are absolutely obvious: precision instruments are not needed in telling that a theory which incorporates 70 % more unperceived energy and a stack of other commitments is metaphysically more complex than another theory. Once we have arrived at two comprehensive theories which require a more nuanced evaluation criterion, we have already taken a leap forward: once everything that is clearly excessive has been shaved away, we can concentrate on more nuanced criteria. Moreover, the greatest problem today is that the role of metaphysics in physics is not very well understood. Accepting the existence of metaphysics in physics and explicating it is of course a prerequisite for objectively evaluating theories. It is not surprising that many physicists have extreme difficulties in accepting that a better theory is available, when it is difficult for them to accept that there are alternatives to standard physics in the fist place.

It is important that in the light of the current investigation the terms 'better' and 'more truthlike' have the same meaning: more economically unified. That is, the selection is only a matter of terminology. Consider the main reason that supports 'better.' Theories have unverifiable and unfalsifiable metaphysical commitments whose correspondence

[20]Personal communication, 4.4.2015.

[21]Personal communication, 21.5.2016.

[22]Chakravartty [79, p. 222] suggests another informal account: "Consider all of the causal properties and relations relevant to the nature or behaviour of a particular system or class of target systems. Degrees of approximate truth are determined ... by the extent to which theories incorporate the properties and relations." This approach seems to be implicit in relative simplicity as the ratio: the extent of how widely a theory explains the focal phenomena, divided by its postulates.

cannot be known even in principle and which in the light of pessimistic induction may be rejected in the next turn. There are reasons to suppose that an *ideally* economically unified theory is true (p. 138), but still all theories on the path towards it are strictly speaking false, and it is awkward to call one false theory more 'truthlike' than another false theory, whereas the term 'better' does not have this problem. I cannot find a better support for 'more truthlike' than repeating Niiniluoto's [289, p. 10] statement: "The best explanation for the practical success of science is the assumption that scientific theories in fact are approximately true or sufficiently close to the truth in the relevant respects." How to explain why a more economically unified theory indeed 'agrees' with nature better than others, if it does not somehow reflect how nature works, better than others? In the following, the terms 'better' and 'more economically unified' are used.

STRENGTHENING THE SUN-CENTERED MODEL. Newton [284] fused the inverse-square law of gravitation with the elliptical orbits of the Sun-centered model in 1687. This enabled predicting the whereabouts of the planets of the Solar System with a yet unseen accuracy. A problem was confronted in 1781 and in 1821. While the other planets conformed to the predictions, the measured orbit of Uranus deviated from the predictions. There were two alternative conclusions: either there is something wrong with the fusion, or there is something concrete that causes the deviations. As the fusion was the best one available, it was natural to suppose that a stellar object was the cause of the deviations. The search for the object started; as a result of the search the planet Neptune was measured to exist in 1846. During the period of time [t 1846], where t is the time when the hypothesis about Neptune was made, Neptune was a hypothetical entity. The existence of Neptune was verifiable, but this was not known before it was measured. After its discovery, Neptune ceased to be a hypothetical entity, and the commitment to its existence became verified. The discovery of Neptune further confirmed the Sun-centered model.

The following pattern may be excavated from the success story of discovering Neptune. Model F initially gives more accurate predictions than any earlier model and F becomes the paradigm. Later, a conflict is found between the predictions of F and new perceptions. Since the hopes are still high for F, the proponents of F aim to explain the deviations away in terms of a hypothetical entity h, which is supposed to correspond to a mind-independent object. Since the correspondence of h is unverified, h becomes a part of the metaphysics of F, i.e., F becomes $F + h$. As h is supposed to correspond to a mind-independent object, the search for the object is initiated, i.e., attempts are being made to measure the object. Eventually the object is empirically verified to exist. In effect, h ceases to be a hypothetical entity and $F + h$ is transformed back into F. The commitment in the existence of h ceases to be a metaphysical and becomes verified. Model F is further confirmed.

FALSIFIABILITY. If the currently prevailing paradigm of cosmology were ideal or perfect, the future of cosmology would be only about what Kuhn [209] calls *normal science*: about building more and more on the central metaphysical commitments of the paradigm — which Kuhn calls the *disciplinary matrix* of the paradigm— and about success stories of making existence hypotheses based on deviations from predictions and always making more and more discoveries by empirical confirmations. However, if the paradigm fails to give correct predictions or if its metaphysical weight keeps on increasing, then it is not at all clear that the paradigm is optimal. This is congenial with Newton and Kuhn:

> In experimental philosophy we are to look upon propositions collected [or inferred] by general induction from phenomena as accurately or very nearly true, notwithstanding any contrary hypothesis that may be imagined, till such time as other phænomena occur, by

> which they may either be made more accurate, or liable to exceptions. Newton [284, bk. 3, rule IV]
>
> Failure of existing rules is the prelude to a search for new ones. Kuhn's [209, p. 68]

Economy is crucial: if the paradigm does not give correct predictions as such, it can be fixed by incorporating extra hypothetical entities and/or regularities by which its predictions can be made to match perceptions. That is, if the model does not match reality, the reality can be forced to match the model by additional metaphysics. Again, it is insufficient to look only at the accuracy of predictions, for this sets no kinds of constraints to metaphysics, and clashes Karl Popper's [313, p. 281] [315] *falsifiability criterion*, which Popper introduced in the place of the positivists' verifiability criterion: "For Popper, a theory is scientific only if it is refutable by a conceivable event. Every genuine test of a scientific theory, then, is logically an attempt to refute or to falsify it, and one genuine counter-instance falsifies the whole theory" (Thornton [397]). The function of the falsifiability criterion is not to render all theories with metaphysical commitments as unscientific, but it is satisfied only by falsifiable predictions of theories. However, and again, when the predictions of a theory do not match perceptions, it can be saved from falsification by introducing more metaphysical commitments: "theories shape and order facts and can therefore be retained come what may" (Feyerabend [139, p. 5]).

Unless metaphysical complexities of theories count in evaluating them, scientific metaphysics can practically flow free. This underlines the importance of economy, which guarantees that metaphysical parameters cannot be swept under the rug by maintaining that they are merely 'empirical facts' or 'observational terms' after all, nor by trying to downplay them as merely 'philosophical' or 'ideological.'[23] Economy as the evaluation criterion thus incorporates falsifiability as far as possible: as falsifications are compensated by adding metaphysics, the relative simplicity of the theory reduces, i.e., the theory gets less economical. Kuhn teaches that the metaphysical weight of theories has increased as a function of time in the past, and a look at relativistic physics (§5) testifies that the weights have been increased also recently. Feyerabend's worries about universal theories underline the need to explicate metaphysical commitments of theories and evaluate them by economy:

> But if one accepts the pervasive character of universal theories, then one must ask oneself how this kind of theory could be empirically tested at all. This gives rise to the suspicion that these theories, by influencing the observation language, exclude the possibility of articulating falsifying observational sentences. ... Feyerabend suggests that a theory is not, as previously believed, tested by confronting it with empirical data, but that much more serious tests require confronting at least two theories that are incompatible with each other. The weaknesses of a theory often do not appear if the theory confronted with the facts as seen from its own perspective, but may only appear if facts as seen from the perspective of an alternative theory are allowed. Hoyningen-Huene [176, p. 10]

As always, the accuracies of two universal theories or collections of theories are evaluated first. If they are equally accurate, their openly explicated metaphysical commitments are evaluated. The most economically unified theory wins. This shows that Feyerabend's

[23] Quine's [323] distinction of ontological and ideological commitments is not used because it is difficult to distinguish commitments in the two classes, and because all metaphysics is any case taken in account in economy evaluations. According to Cowling [92, p. 3890], ideological parsimony concerns primitive concepts and ontological parsimony concerns existential commitments. This underlines the difficulty of distinguishing the classes: What is the difference of a primitive concept and an existential commitment? According to Sider [359, p. 230] ideological commitments are "as much commitments to metaphysics as are ontological commitments."

worries are exhausted by explicating metaphysics in physics and by giving economy the role of judge.

STAGNATION TO PARADIGMS VS. RATIONAL PROLIFERATION. If the paradigmatic theory fails to give correct predictions or if its metaphysical weightload keeps on increasing, it is natural to start searching for a more optimal theory. Given that a new theory is available and if economy clearly favours it, the path should be open for a paradigm shift. The shifts should happen in orderly fashion so that they would not be treated as *revolutions* as Kuhn calls them, but more like something that must be accepted since the old theory has been objectively evaluated to be worse than a new one. Unfortunately, history and the present both show that 'revolution' characterises paradigm shifts very well, and the enlightened state of science where theories can be evaluated objectively is currently only a dream of a better future. The typical case is that a scientist takes the commitments of the current paradigm as articles of faith and is not willing to consider alternative commitments no matter what. The commitments of current paradigms of physics and their implications are often not considered as metaphysical postulates but as 'empirical facts,' just as Feyerabend saw. People who suggest new commitments are treated as unscientific rebels, and stagnated environment effectively prevents paradigm shifts as it prevents taking better theories seriously, despite objective evaluations:[24]

> [E]mpirically minded scientists at once confront it with *status quo* and announce triumphantly that 'it is not in agreement with facts and received principles'. They are of course right, and even trivially so, but not in the sense intended by them. For at an early stage of development the contradiction only indicates that the old and the new are *different* and *out of phase*. It does not show which view is the *better one*. A judgement of *this* kind presupposes that the competitors confront each other on equal terms. How shall we proceed in order to bring about such a fair comparison? Feyerabend [141, p. 113]

Economy is the suggested evaluation criterion. Economy is needed also in tackling *dogmatism*: an extreme form of stagnation which prevents a more economical theory from becoming the new paradigm. Economy thus paves the way to a more enlightened state of science where the proposed changes would no longer be considered as 'rebellions' which are always opposed until a revolution replaces the current paradigm, but instead as suggestions which can be objectively evaluated. Perhaps the only long-term solution to stagnation is to teach philosophy of science to the students of physics and of all other disciplines, instead of teaching them the current paradigms as final truths. Moreover, it is not enough to teach that the current paradigms may not be final, for the optimal progress rate of science requires systematically encouraging students to seek out alternatives, and to openly bring into light the problems of the current paradigms:

> [C]onsider the role science now plays in education. Scientific 'facts' are taught at a very early age and in the very same manner in which religious 'facts' were taught only a century ago. There is no attempt to waken the critical abilities of the pupil so that he may be able to see things in perspective. At the universities the situation is even worse, for indoctrination is here carried out in a much more systematic manner. ... In society at large the judgement of the scientist is received with the same reverence as the judgement of bishops and cardinals was accepted not too long ago. ... Pursue this investigation further and you will see that science has now become as oppressive as the ideologies it had once to fight. ... In this case it is of paramount importance to strengthen the minds of the young and 'strengthening the minds of the young' means strengthening them against any easy acceptance of comprehensive views. Feyerabend [139, pp. 4, 7]

[24]The discussion during 2010-2014 in the *Tieteessä Tapahtuu* journal about the nature of relativistic physics and its alternatives is a good example of the unwillingness to consider alternatives.

Feyerabend [138, p. 26] suggests the replacement of indoctrination by *proliferation* of theories that are inconsistent with the paradigms: "Invent and elaborate theories that are inconsistent with the accepted point of view, even if the latter should happen to be highly confirmed and generally accepted." Obviously, the invention of competing theories is a prerequisite for coming up with a better theory:

> [O]ne should let them compete with each other in the very same manner in which party lines are competing in politics. The invention of "contrary hypotheses" is the first step towards such competition, and never is their invention more necessary than when it seems that certain ideas have been confirmed beyond doubt and that matters have been settled once and for all. Feyerabend [137], as cited in Achinstein [1, p. 45]

Proliferation leaves over the question that on what basis ought an alternative theory be accepted. The suggestion at hand is that economy ought to be accepted as the criterion. Achinstein's notions are compatible with this view:

> Scientists ... don't just aim at "inventing and elaborating" theories for the sheer joy of it. They want to discover true theories, or ones that are probable, or ones that yield reasonably good predictions, or at least theories that are good in some important way (e.g. they are unifying or simple). ... why should we regard a theory as true, or probable, of good in some way simply because it is inconsistent with the accepted point of view? Achinstein [1, p. 38]

RATIONALITY OF PARADIGM SHIFTS? Aliseda and Gilles [7, pp. 466-7] propose "that philosophers of science have to develop not only a theory of the growth of science, but also a theory of the appraisal of scientific hypotheses. ... we need a theory of the appraisal of scientific hypotheses which does not involve detailed considerations of how those hypotheses are discovered." Economy is a suggestion of exactly this kind of a 'theory' or a criterion of fitness. Aliseda and Gilles (*ibid*, p. 468) also conclude that "Lakatos did not solve the problem he set out to solve, that is the problem of whether scientific revolutions can be rational." Lakatos maintains that there are no standards for evaluating two paradigms:

> There are no rational standards for their comparison. Each paradigm contains its own standards. The crisis sweeps away not only the old theories and rules but also the standards which made us respect them. The new paradigm brings a totally new rationality. There are no superparadigmatic standards. The change is a bandwagon effect. Thus *in Kuhn's view scientific revolution is irrational, a matter for mob psychology.* Lakatos [214, pp. 90-1]

Against Lakatos, it is suggested here that economy indeed is a rational superparadigmatic standard for comparing theories. Each paradigm does have its own standards —metaphysical commitments or Kuhn's disciplinary matrix or Lakatos' *hard core*— but these standards themselves can be evaluated by economy. The new standards do bring new rationality in the sense that it is different to work with new metaphysics, but economy still functions as a superparadigmatic standard. On one hand, it is hard to avoid some kind of a bandwagon effect when people see that it is time to withdraw the money out of the bank before it goes bankrupt, but it is still better to constantly evaluate competing theories than to hold on to one unconditionally. On the other hand, if competing theories are *constantly evaluated*, the transition into a new one is more likely to be smooth.

REDUCTIONIST MODELS. The reductionist models of Oppenheim-Putnam and Nagel share the unificatory character of Aristotle and Mach. Were the reduction of sciences

fully completed in the way characterized in their models, everything would have been explained in terms of some basic unified postulate base. Metaphysics is thus in the center of the reductionist models, although their creators systematically silenced away direct references to it. Oppenheim and Putnam [300, p. 4] maintain that unity of science refers to "first, to an ideal state of science, and, second to a pervasive trend within science, seeking the attainment of that ideal." They also ask whether unitary science can be attained at all, and if then how, but these questions do not need to be answered in order to know that science can get *more* economically unified than it is now, and that even a coherent postulate base for all sciences would be a major advancement. The idea of explaining everything in terms of an economically unified postulate base does not match practices of today's disunified institutional physics and the characterizations of reductionism by Oppenheim-Putnam and by Nagel are imperfect accounts of how the ideal state of science can be attained. But science and philosophy of science are both works in progress and proceed through trial and error: we should not reject the goal towards ideally economically unified science, no more than the goal towards correctly characterising just what kind of reduction works and what is the role of reduction in unification. It is suggested in §3.6 that perhaps the age of reductionism can fully start only after overall coherence has been first established.

In Nagel's [281] [282, p. 352] *reductionist model* a theory is explained by a more fundamental theory: "A reduction is effected when the experimental laws of the secondary science ... are shown to be the logical consequences of the theoretical assumptions ... of the primary science." Whenever a secondary science is indeed reduced to a more primary science, unification has taken place and the commitments of the secondary science are seen to be commitments of the primary science, i.e., it is seen that two branches of science belong to the same tree. However, if this were the only path to the progress of science, then progress of science would have very limited prospects. For this kind of reductionism does not take place in shifts where theory A is *replaced* by another theory B: A cannot be reduced into B when A and B are incompatible. Feyerabend [140, pp. 44-5, 57-9] points out that Nagel's principle that secondary science is explained in terms of primary science and Hempel and Oppenheim's [166, p. 321] scheme of explanation where the explanandum is derived from the explanans, do not apply e.g. when trying to reduce Galilean science to Newtonian science, as these are incompatible. However, the phenomena that were explained in terms of Galilean science can be explained in terms of Newtonian science, and as Newtonian science explains more, the transition is favoured by economy, i.e., although reduction does not apply in this case, economical unification is certainly implemented. Ross et al. [213, p. 49] maintain that although the derivations are not perfect, e.g. some of Galileo's laws can be derived from Newton's, and some of Newton's from the Special Theory of Relativity, "given suitable additional assumptions and restrictions in each case." So, some kind of imperfect reduction has taken place in physics, although paradigm shifts do not proceed by such reduction. In Oppenheim and Putnam's [300] *micro-reduction* a lower-level branch of science is reduced into a more fundamental higher-level branch, and the reducing theory explains all that the reduced theory explains. Ross et al. criticise Oppenheim and Putnam's supposition that even biology and social science are reducible to physics, but they see that reductions are progressive:

> [T]his hunch has been displaced by a widespread emphasis on 'emergence' and inter-level feedback loops. Hence in many respects the inappropriateness of Oppenheim and Putnam's most crude background assumptions is not even controversial nowadays. ... We reject micro-reductionism but not Nagelian reductionism, because we think that there are real examples of Nagelian reductions (though not of caricatures of Nagelian reductions involving

> bridge laws) that are significant contributions to science, and steps toward unification. Ross et al. [213, pp. 47,49]

PARTIAL UNIFICATION. It is certain that the reduction of e.g. biology to physics has not been achieved, but it is another question that can biology and physics ever be even partially unified. In partial unification of theories A and B, postulate C is found that is common to A and B, but A and B have non-overlapping postulates even after the partial unification. Suppose that one day evolution is derived from *entelecheia* or the actualization of potentiality as a law of nature (p. 110), i.e., it is established somehow that given entelecheia, the birth of life and further evolution are asymptotically determined (§7.2). Were this unification achieved, evolution would have ceased to be a separate postulate, and biology would have been unified with *that* physics where some version of entelecheia is postulated. If physics and biology would still have non-overlapping postulates, we would be dealing by definition with a partial unification, which can also be characterized as 'partial reduction.' This is just an example of a desired step which would make science more economically unified, but it is another question that can it be achieved. Partial unification was inspired by the Principle of Naturalistic Closure (p. 28).

3.4 Critique of the Simplicity Criterion and Critique of Unified Explanation

Consider allegations against the simplicity criterion of the principle of economy:

> A common concern is that notions of simplicity appear vague, and judgements about the relative simplicity of particular theories appear irredeemably subjective. Thus, one problem is to explain more precisely what it is for theories to be simpler than others and how, if at all, the relative simplicity of theories can be objectively measured. Fitzpatrick [145]

> In order to judge that one theory furnishes a better explanation of some phenomenon than another, one must employ some criterion or criteria on the basis of which the judgement is made. Many have been proposed: simplicity... consistency and coherence ... unity ... and so on. One challenge here concerns whether virtues such as these can be defined precisely enough to permit relative rankings of explanatory goodness. Chakravartty [80]

Given that the domain of application of the evaluated theories has been explicated and it has been established that these give equally accurate predictions, it is hard to see why the evaluation of their metaphysical complexities should be vague or subjective. The evaluation works e.g. in the case of the Earth-centered vs. Sun-centered model as well as with the case of relativistic physics vs. the Dynamic Universe model in §5.7. It is not hard to see that epicycles are more complex than elliptical orbits, nor to see that 70% of hypothetical dark energy is more complex than 0%, nor that massive hypothetical greenhouse effects on Earth and Mars are more than no greenhouse effects at all. Precision instruments are not needed in evaluating such differences in metaphysical complexities, i.e., simplicity and other virtues can be defined and evaluated accurately enough for the needs at hand. The real problem is to get scientists and philosophers to genuinely respect virtues and to understand the role of metaphysics in physics. Consider some queries about the justification of virtues:

> In addition, even if we can get clearer about what simplicity is and how it is to be measured, there remains the problem of explaining what justification, if any, can be provided for choosing between rival scientific theories on grounds of simplicity. For instance, do we

> have any reason for thinking that simpler theories are more likely to be true? Fitzpatrick [145]
>
> Finally, there is the question of whether these virtues should be considered evidential or epistemic, as opposed to merely pragmatic. What reason is there to think, for instance, that simplicity is an indicator of truth? Chakravartty [80]
>
> There is no prima facie reason to believe that a theory that endorses a smaller number of things, or kinds of things, or employs a smaller number of primitives, is ... likelier to be true or likely to yield more insight than another. ... If, in a given case, considerations of this kind do make one theory better than another, then that point should be made, and the particular reasons should be given. Parsons [302, p. 660]

There are good reasons for respecting theoretical virtues, and these are restatements of what has been said in the previous sections. (1) It has been pointed out that once two theories are established to be equally accurate, there are in practice no other pragmatic and heuristic means available for evaluating theories than to evaluate their metaphysical simplicities and degrees of other virtues, i.e., we must do what we can. The terms 'more truthlike' and 'better' are used with the same meaning. It is not argued that a stepping stone towards an ideally unified theory is true, but the terms 'more truthlike' and 'better' fit for characterizing more economically unified theories better than less economically unified theories. (2) Giving virtuousness the role of judge feeds progress. By negation, if virtues do not count then whatever goes as long as the theory gives correct predictions, and this is regressive and feeds unconditional stagnation. (3) For some, plain common sense reveals that virtuous theories are in all relevant senses more favourable than vicious theories: "I think that we apply many of these criteria in assessing philosophical theories, and that it is an important part of our job as philosophical theorists" (Nolan [293, p. 224]). Consider two theories, A and B, which are equally accurate in doing the very same thing. Theory A is simpler, easier to understand, easier to use, coherent and consilient, whereas B is a more complex disunified aggregate of incoherent theories that is harder to understand and harder to use and requires more and more parameters in explaining new data. Which one would you choose? (4) The classical paradigm shifts have been shifts into more virtuous theories. (5) Economical unification is not progressive only in science, but also in topics typically discussed in the context philosophy, as exemplified in §3.5. (6) Perhaps the main reasons of why it seems to be difficult to some to accept virtuousness as the judge are (i) the failure of identifying the correct role of metaphysics in science and the tendency to consider metaphysical commitments of theories as 'empirical facts,' (ii) the fear of simplicity as a counter reaction to logical positivism, and (iii) the current disunified institutional physics is so full of vices that this state of affairs may have created an atmosphere where it is difficult to support virtues. Consider further worries about the virtues:

> Another challenge concerns the multiple meanings associated with some virtues (consider, for example, mathematical versus ontological simplicity). Another concerns the possibility that such virtues may not all favour any one theory in particular. Chakravartty [80]

The worry about multiple meanings —mathematical versus ontological simplicity— is exhausted by the notion that the evaluation of syntactical or mathematical simplicity of theories can be postponed to the third place after the accuracies of predictions have been measured first and other virtues second. Unless this order is followed, it becomes very hard to evaluate theories. To illustrate, McAllister [254, pp. 107-8] maintains that as different measures of a theory's syntactical simplicity —magnitude of exponents, number of variables and the criterion of integer exponents— are of equal intrinsic worth "any judgment that one theory is simpler than another is arbitrary. Simplicity considerations—this

argument concludes—are thus not suited to picking from among a number of competing theories the one that is the closest to truth." Newton-Smith [285, p. 231] agrees: "The case for simplicity is pragmatic. It is simply easier to calculate with simpler theories. There is no reason to see greater relative simplicity of this sort as an indicator of greater verisimilitude." McAllister and Newton-Smith both disregard the role of metaphysics in 'closeness to truth' and 'verisimilitude' for they talk solely about syntactical simplicity in the above passages. Moreover, it is quite obvious that a metaphysically simpler theory structure requires simpler mathematics, and does not need or needs less parameters in the equations.

When we have reached the stage where we have equally accurate and equally complex theories, a great leap has already been taken forward. The fear that all virtues do not favour any one theory are in vain at this stage of development, at least when it comes down to models of fundamental physics, which are just the ones that are relevant with respect to the goals if this thesis. At some point in the future we might need a more nuanced criterion which takes in account mathematical simplicity, but the future need for such criterion should not prevent the primary evaluation of the accuracy of predictions and the degree of virtuousness. McAllister discusses the argument from the simplicity of phenomena:

> The argument from the simplicity of the phenomena takes the following form: since the phenomena are simple, a theory about a given phenomenon is more likely to be empirically adequate if it too is simple. This argument has two principal defects. First, since judgments of simplicity are relative rather than absolute, the claim that the phenomena are simple, like the related claim that nature is uniform, is not well formulated. One would have to claim rather that the phenomena are simple compared to some other entity, but it is difficult to see what entity could act as a worthwhile term in this comparison. Second, our only ground for believing that a given phenomenon is to some degree simple are our theories about that phenomenon. Therefore, it is illegitimate to cite the belief that the phenomena are simple in support of the claim that a given theory is empirically adequate. McAllister [254, pp. 106]

First, when evaluating metaphysical complexities of theories which explain specific ranges or scales of phenomena —such as the scale of cosmology or the scale of particles— the relativeness vanishes: the theories are evaluated with respect to the same scales. Second, it is not claimed here that simple and sufficient theories show that nature is simple: we have theories and nature that the theories aim to describe. One can believe that nature is more complex than needs to be supposed and another may believe it is just as simple as needs to be supposed: the question is reduced into the question of why suppose that nature is more complex than needs to be supposed?

CRITIQUE OF UNIFIED EXPLANATION. The basic Aristotelio-Machian scheme of explaining in terms of an economically unified theory (EUT) gets over the critique targeted at unified explanation, and it is compatible with specific models of scientific explanation. The principle of economy as an evaluation criterion of theories goes over and above the nuances of different models of scientific explanation. For, if in a model that characterizes the logic of scientific explanation, explaining is about explaining *with some theory*, then it in any case holds that a more economically unified theory enables a better explanation.

Kitcher's *unification model* [201, 202] is in certain senses similar to EUT, but in another sense crucially different. In Kitcher's model, explaining is about unifying or deriving disparate phenomena or a diverse set of facts under a small number of basic principles or patterns. In Kitcher's model, unification *is* explanation, whereas in EUT unification is just unification, not explanation, although unification results into better theories

and thus into better explanations. Despite mixing unification and explanation, the progressiveness of unification in science is the driving force behind Kitcher's [202, p. 431] thought: "Science supplies us with explanations whose worth cannot be appreciated by considering them one-by-one but only by seeing how they form part of a systematic picture of the order of nature." There is much good in Kitcher's model, and there are no reasons to throw the child away with the washing water.

EUT and Kitcher's model are both compatible with Hempel and Oppenheim's [166, p. 321] classical *covering-law model* of explanation whose core principle is that "the explanandum must be logically deducible from the information contained in the explanans." In EUT the explanans is understood as a unified theory, and the explanandum as something that is explained in terms of it.

Plain EUT can be understood without having to commit to any particular economically unified theory, but when actual explanations are given, the theory must naturally be explicated. The unified theory in EUT is DU+EUO in the following. In effect, EUT is congenial with Wesley Salmon's [347, p. 269] causal-mechanical model, where explanation of a phenomenon "involves the placing of the explanandum in a causal network consisting of relevant causal interactions that occurred previously and suitable causal processes that connect them to the fact-to-be-explained." For, causality is postulated in §4.7 as an axiom of EUO. Explaining in terms of DU+EUO could be characterized e.g. as conservation-law-causal rather than just causal-mechanical.

EUT has now been characterized clearly enough to show that it is untouched by the following critique from Woodward [416]. Woodward targeted the critique against Kitcher's unification model, but here it is pointed out only that it does not threaten EUT. The first critique stems from causality-related contemplations:

> Call derivations of the state of motion of planets at some future time t from information about their present positions (at time t_0), masses, and velocities, the forces incident on them at t_0, and the laws of mechanics predictive. Now contrast such derivations with retrodictive derivations in which the present motions of the planets are derived from information about their future velocities and positions at t, the forces operative at t_0, and so on. It looks as though there will be just as many retrodictive derivations as predictive derivations, and each will require premises of exactly the same general sort—information about positions, velocities, masses etc. and the same laws. Thus the pattern or patterns instantiated by the retrodictive derivations look(s) exactly as unified as the pattern or patterns associated with the predictive derivations. However, we ordinarily think of the predictive derivations and not the retrodictive derivations as explanatory and the present state of the planets as the cause of their future state and not vice-versa. It is again far from obvious how considerations having to do with unification could generate such an explanatory asymmetry. Woodward [416]

It is misleading to say that considerations having to do with unification generate an explanatory 'asymmetry' for the 'asymmetry' is merely the result of the supposed causal structure of the Universe. The derivation of the position p_{-1} of the Moon at t_{-1}, from its position p_0 at t_0 is in one sense retrodictive, but in another sense predictive. In the unified theory, it is supposed that the Moon must have moved from location p_{-1} to location p_0. Thus, the instead of considering the explanation retrodictive, it can be considered as predictive, where the task is to give such coordinates of the Moon at t_{-1} that make it possible in the unified theory to find it from position p_0 at t_0, so that the state of affairs at t_{-1} could have caused the state of affairs at t_0. Both retrodictive and predictive explanations are given under DU+EUO, where causality is forward-directed, and where the present causes the future and where the past caused the present. The famous flagpole-shadow example is not a threat either: the sun and the flagpole cause a shadow and not

vice versa, but we can still deduce from the perception of the shadow that something caused it, i.e., we are dealing here with nuances of scientific explanation which compose no threat to EUT. Woodward (*ibid*) maintains that the above example "casts doubt on Kitcher's contention that one can begin with the notion of explanatory unification, understood in a way that does not presuppose causal notions, and use it to derive the content of causal judgments." This does not threaten EUT which incorporates causality on the level of axioms. The second critique stems from heterogeneity of unification:

> Is Kitcher's account of unification sufficiently discriminating or nuanced to distinguish those unifications having to do with explanation from other sorts of unification? The worry is that it is not. The conception of unification underlying Kitcher's account seems to be at bottom one of descriptive economy or information compression—deriving as much from as few patterns of inference as possible. Many cases of classificatory and purely formal unification involving a common mathematical framework seem to fit this characterization. Consider schemes for biological classification and schemes for the classification of geological and astronomical objects like rocks and stars. If I know that individuals belong to a certain classificatory category (e.g. Xs are mammals or polar bears), I can use this information to derive a great many of their other properties (Xs have backbones, hearts, their young are born alive etc.) and this is a pattern of inference that can be used repeatedly for many different sorts of Xs. But despite the willingness of some philosophers to regard such derivations as explanatory, it is common scientific practice to regard such schemes as "merely descriptive" and as telling us little or nothing about the causes or mechanisms that explain why Xs have backbones or hearts. Woodward [416]

It is not a problem of EUT if Kitcher's model does not distinguish between derivations from a theory and derivations from a classification scheme, for EUT explaining is done with a theory. The main contribution of this critique might be the notion that two types of derivation must be distinguished: derivations from classification schemes in the absence of a theory; derivations from a theory that is entangled with a classification scheme. As a theory incorporates metaphysics, the explication of the metaphysical commitments of the theory that does the explaining is again seen to have central importance: the causes or mechanisms that explain e.g. why Xs have backbones or hearts, or in general the eventual answers to such why-questions are metaphysical. Perhaps the reason why Kitcher's account of unified explanation does not distinguish between the two types of derivations is that metaphysics was silenced away too strictly:

> I have been trying to show that we can make sense of scientific explanation and our view of the causal structure of nature without indulging in the metaphysics. The aim has been to develop a simple, and, I think, very powerful idea. The growth of science is driven in part by the desire for explanation, and to explain is to fit the phenomena into a unified picture insofar as we can. What emerges in the limit of this process is nothing less than the causal structure of the world. Kitcher [202, p. 500]

This attitude is very strange in the sense that a unified theory must have metaphysics in its center. One way to make sense out of this is the hypothesis that Kitcher took the anti-metaphysics conveyed by the logical positivists too seriously. But this does not help understanding how one could make sense out of fitting phenomena into a unified picture —that is built on a metaphysical core— without especially indulging in metaphysics. Further, a characterization of the causal structure of the world cannot escape metaphysics either. The third critique stems from the *winner-take-all* conception of explanatory unification:

> [G]eneralizations and theories can sometimes be explanatory with respect to some set of phenomena even though more unifying explanations of those phenomena are known. For example, Galileo's law can be used to explain facts about the behavior of falling bodies

> even though it furnishes a less unifying explanation than the laws of Newtonian mechanics and gravitational theory.... If we reject this idea, we must adopt the conclusion that in any domain only the most unified theory that is known is explanatory at all; everything else is non-explanatory. Call this the winner-take-all conception of explanatory unification. Woodward [416]

Economy judges less economically unified theories as worse, but still sustains explanations done in terms of them as explanations. Therefore, one can commit to EUT, without committing to the winner-take-all conception. The fourth critique stems from the epistemology of unification:

> Assume, for the sake of argument, that it is desirable to have a unified belief system in Kitcher's sense—whether because unification is connected to explanation and the latter is intrinsically valuable or because unification is connected to other goals (e.g., confirmation) that are desirable. It is still not obvious why it would be valuable to have a set of beliefs that are a smallish proper subset of the beliefs that comprise such a unified system, which is what most people seem to have, given Kitcher's views about the transmission of causal knowledge. Recall Kitcher's basic picture: when I acquire the belief that, say, whether salt is hexed is causally irrelevant to whether it dissolves and that whether it is placed in water is causally relevant, I acquire a fragment of the community's overall systemisation S. But adding a fragment of S or even a number of fragments of S to my belief store may not result in *my* having a belief system that is unified, or that facilitates whatever epistemic goals are associated with unification. Of course if I end up adding all or most of S to my belief store, I will have at that point a set of beliefs that is unified and that brings with it all of the benefits of unification. But, as Kitcher agrees, it is unrealistic to suppose that most people possess anything like the full systemization S that best unifies all of the beliefs in their community. Woodward [416]

The critique is restated in steps. (1) Communities such as today's community of physicists have some overall systemization S. (2) Individual people typically acquire only fragments of S by cultural transmission. (3) Unification is cognitively or practically valuable only in the sense of unified belief systems of individuals and not just of the community. (4) There is thus a major problem with the story of cultural transmission of a unified picture. This critique does not threaten the goal towards a unified world-view nor EUT. Perhaps it only testifies how disunified the contemporary science is and how this disunification has influenced the thinking of philosophers. For, if the scientific community were in the hold of a genuinely unified theory that is based on few mutually compatible postulates, including the conservation law of energy and understandable conceptions of time and geometry of space, it would not be hard for individuals to grasp the overall world-view. But as contemporary theories of different scales come with different postulates, people in practice acquire only fragments of the unsystematic and fragmentary aggregate of isolated theories S, and there has been no such thing as an understandable unified world-view to be grasped. Of course, EUO+DU is the given suggestion.

3.5 Economical Unification vs. Plain Conceptual Analysis

It is emphasised that economical unification is more progressive than plain conceptual analysis in dealing with topics that are typically dealt with in metaphysics as a field of philosophy. Economical unification as the production line of economy $\rightarrow$ ontology $\rightarrow$ applications is best seen as a reaction to plain conceptual analysis which proceeds in the absence of a unified ontology and without economy as an evaluation criterion. Their basic difference is illustrated in figure 5. In plain conceptual analysis, one isolated

concept is taken under investigation and various angles to it are reviewed. This does not manage to unify all concepts and they do not communicate, as intimately as they should. In economical unification, the unified ontology gives the understandable structure where individual concepts can be placed, their correct roles can be found, and they communicate through the ontology.

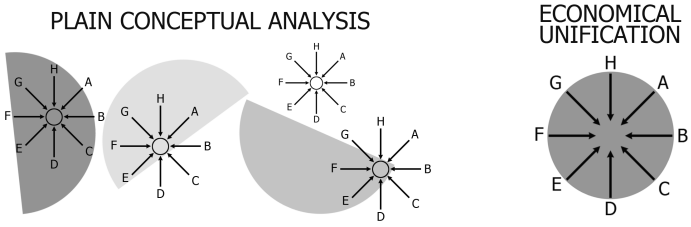

Figure 5: The half-circles on the left denote isolated and often mutually incoherent ontological commitments, which are replaced on the right by a unified ontology. The alphabets denote different angles to individual concepts. In plain conceptual analysis some of these concepts are grounded on ontology but some are not, whereas in economical unification all concepts are grounded and conceptual redundancy is diminished.

DEFINING THE SCOPE; THE ROLES OF LOGIC AND SEMANTICS. Explication of the scope of the defined concepts that are the end results of the analysis is of utmost importance, for this is a prerequisite for evaluating alternative definitions. In this thesis, the scope is on concepts which are applicable in the contexts of human social behaviour and natural science. The defined concepts thus do not compete with concepts whose intended scope is different, but only with concepts whose scope is the same. Although all sciences in the end investigate the same nature, the scope of this thesis is very different from the scope of analytical philosophy that typically concentrates on language, logic and semantics *as such*. The focus is not on linguistic philosophy or language as such, but language or words or concepts are mapped to the unified ontology in order for them to be applicable in the focal contexts. The scope is not or semantics as such, but on applying such semantics which is helpful in the focal contexts. For instance, the focus is not on *possible worlds semantics* as such, but in fitting it to serve the focal contexts in terms of EUO (§7.5).

The focus is not on logic as such, but logic is applied as a very helpful tool in two central ways. First, specific logical systems can be applied in exactifying ontology. For instance, classical extensional mereology is applied as a logical foundation for talking about part-whole relations between objects that is sufficient for the needs of this thesis (§4.6, appendix A); further logical machinery can be incorporated along the need. As another example, that there are future contingents is a theorem of EUO + partial determinism; after the theorem has been derived, various logical or semantical approaches can be applied in handling future contingents (§7.3). Second, as a unified ontology is a coherent axiomatic system, i.e., a logical system, economical unification enjoys from the benefits that mathematics has had for millennia, yet without having to suffer from difficult formalism. The axiomatic method as applied in this thesis is contrasted to applying it in set theory.

In both cases some axioms are taken as the foundation for everything else and the axiom base contributes to making the analysis systematic: Thomas Jech starts his book *Set Theory* [188] by listing the axioms of Zermelo-Fraenkel set theory with the axiom of choice (ZFC); the axioms of EUO are listed in the beginning of §4. The axiomatic nature of ontology makes it easy to see that various axioms need to be incorporated

in EUO, for otherwise it would be crippled, i.e., none of the axioms can be 'taken away' but they are all needed for the overall axiomatic system to work as intended; by analogy, ZFC would be crippled if e.g. the axiom of pairing were deleted, and Euclidean Geometry would be crippled if any of its axioms were deleted. Therefore it is senseless to demand a practitioner of economical unification to concentrate on one isolated axiom in the absence of everything else; as the axioms and definitions are especially intended to function together, it is not by accident that some of the axioms and definitions are not given in a form in which these are typically given or handled in the philosophical literature. The axioms of ZFC as well as the ontological commitments of EUO state what exists. While the axioms of ZFC postulate purely abstract (§4.14) entities (sets), the ontological commitments of EUO postulate the existence of physical objects. In both cases, theorems —which like axioms state what exists— are proved from the axioms by applying traditional rules of inference, although it is not explicitly stated in this thesis nor in Jech's book just which rules are used when using them, for this would amount to very cumbersome use of language. In set theory e.g. the natural numbers, rational numbers and real numbers are defined to be analogous to certain sets whose existence is implied by the axioms of ZFC, whereas in this thesis concepts such as truth and possibility are defined in terms of what EUO states that exists, or has existed or will exist. *Lemmas* are used in set theory as well as in economical unification, although the term 'lemma' is not used elsewhere in this thesis. A lemma is a proven proposition or a *helping theorem* which is used as a stepping stone to a larger result rather than as a statement of interest by itself. For instance, the result that there are no *bare particulars* in EUO could be called a lemma: it is used as a stepping stone to statements of interest in §4.10. To substantiate the axiomatic nature, §4 is organized into axioms, theorems, definitions and rejections (of commitments which violate the axioms and arguments which lean on such commitments).

Explication of the scope and working with an economically unified ontology with-respect-to-the-scope thus provides a point of departure for logic and semantics to be applied within the specified scope. This is very different to plain conceptual analysis. First of all, the scope of the defined constructions is often not explicated, which leaves one pondering about where they are intended to be applied. There is a crucial difference in a construction intended to function e.g. in natural language understanding vs. natural science, but without a specified scope the function of the construction hangs in the air. If the scope is not explicated, it is natural that the ontology with-respect-to-the-scope is not explicated either. In the absence of an explicated ontology, logical systems are built as purely formal-abstract constructions, analogous to the non-grounded concept on the left side of figure 5. There is of course nothing wrong in logic or mathematics as such, but practicing these without intending to apply them in ontology must be separated from metaphysics as a science that aims to make sense out of nature. In other words, logic-without-ontology is only logic, and should not be considered as metaphysics, but should only compete with other purely logical constructions. If the intended scope of logic is nature, which is a reasonable supposition if we are dealing with metaphysics, the analysis typically proceeds without economy as the criterion. Without economy, logic or mathematical idealizations can be promoted on the level of ontology, i.e., ontological answers can be sought from logic and formalism instead of asking first what is the minimal ontology where logic and formalism can be applied. For instance, contemplations about infinite divisibility are largely logic-driven (§4.17). Excessive rigor has been widely present, whereas economical unification marks a shift from excessive logic to finding application for logic that is sufficient and minimal:

> [M]ost of the contemporary essays on possible worlds, temporal logic, and causality, though often exact, are far removed from science and sometimes even incompatible with it. . . . *Strive for rigor but do not allow it to curtail vigor*: exactness is a means not an end — a mean to attain clarity, systemicity, cogency and testability. Insisting on rigor for its own sake and at the price of giving up deep intuitions is a mark of sterility. Bunge [69, p. 8-9]

ANSWERING QUESTIONS ABOUT METHODOLOGY. Consider Sider's [358, p. 385] questions and their suggested answers. (a) *Are the criteria that are commonly used in scientific theory choice (for example, simplicity and theoretical integration) applicable in metaphysics?* Economy is applicable in evaluating theories. Moreover, the inseparability of metaphysics from theories guides one from the distinction of metaphysics and science into accepting that theories are scientifico-metaphysical. (b) *How can these criteria be articulated clearly? And what hope is there that that criteria will yield a determinate verdict?* Economy has been articulated clearly enough for it to yield adequately determinate verdicts in §§3.3, 4, 5.7.

Consider Manley's [245, p. 1] questions and their suggested answers. (a) *What is the best procedure for arriving at the answers to the questions of metaphysics? Common sense? Conceptual analysis? Or assessing competing hypotheses with quasi-scientific criteria?* Economy is the suggested quasi-scientific criterion for assessing competing metaphysical hypotheses, and economical unification is the suggested procedure for arriving that the answers. (b) *Are the answers substantive or just a matter of how we use words*? If one defines concepts in terms of an economically unified ontology that is sufficient in the contexts of human social behaviour and natural science, then the answers are especially substantive and not just a matter of how words are used; the defined concepts are understandable and match the needs of people in these contexts. In contrast, if concepts are defined in terms of an uneconomical ontology, their meanings may be understood but it is often hard to say how these meanings connect to what is important to people in the given contexts. For instance, if possibility is defined in terms of transcendent worlds (§7.5), this leaves people pondering how such a definition is applicable. Given that concepts are not mapped to an ontology at all, then it is very hard to tell what are the meanings of the answers: non-grounded concepts hang in the air, which results in ambiguities in all that follows.

ECONOMICAL UNIFICATION VS. UNECONOMICAL PLURALISM. The idea of founding everything else on an economically unified ontology has been present from Aristotle to Mach, and such an ontology is needed in tackling problems of metaphysics as a branch of philosophy. The problem is that this goal is absent in contemporary philosophy, or not in the center as it should be. It is not claimed that the given approximation of the unified theory (DU + EUO) is final or the only correct version, but it is economically unified with respect its central contemporary alternatives, as shown in §§4,5.7,7.4. The given suggestion can be rejected at once you come up with a more economical version that does the same jobs. But it should not be rejected without showing what is wrong with it, and it should be taken as a progressive step instead of an attempt to force a one-eyed solution to everything. For comparison, Tahko [391, p. 235] concludes a book on the methodology of metaphysics with the remark that "contemporary analytic metaphysics can go at least some way towards meeting the challenge of combining science and metaphysics. . . ." It has not only been testified that we can go some way towards meeting the challenge of combining science and philosophical metaphysics, but a suggestion of just this kind of a fusion has been given.

The greatest obstacle for any satisfiable unified theory has been the Theory of Relativity. A genuinely unified theory is understandable and applies same postulates in explaining

all scales or in all areas of physics. This is not the case in relativistic physics, which makes it a blockade for a unified theory. For instance, the conception of time in relativistic physics is not understandable as a whole, for two conceptions of time are applied: absolute simultaneity or cosmic time is applied on the largest cosmological scale; however, absolute simultaneity is more like an exception, whereas relativistic time is the central notion of time in relativistic physics (§5.6). As another example, the relativistic cosmology model with *dark energy* as a parameter makes role of the conservation law of energy completely ambiguous, and the standard interpretation of the Planck equation as an intrinsic property of radiation violates the conservation law of energy for radiation propagating in expanding space (§5.4). Conservation laws are the primary laws e.g. in particle physics and concerning planetary systems, but as the conservation law makes no sense in relativistic cosmology, it is hard to see what is the common base under which these are unified. Therefore, there are no prospects for a genuinely unified theory in the context of relativistic physics. In contrast, DU builds on the conservation law and an understandable conception of time.

Another obstacle on the way of a unified theory is that economy is not taken seriously by philosophers, and thus the goal of explicating an economically unified ontology is not taken seriously either. Perhaps economy is seen as some form of the anti-metaphysical verifiability criterion? Even if we ideally had all metaphysical possibilities at hand, some criterion would be needed in selecting between them. If empirical sufficiency is the only criterion, we end up either with isolated postulates, or with a family of combinations of mutually coherent postulates that together explain all scales. There are 4096 combinations[25] even with the axioms of EUO, some of their well-known alternatives, and with the given open selections (§4). Consider the negation of EUO: spatially infinite, infinitely divisible and contradictory actual and transcendent worlds, with an ambiguous conception of time where future and past exist as strongly as the present if there even is a present, where time travel is possible, where all that exists is mind-dependent or just your mind, where minds and bodies can be detached, and where abstract things and universals exist in a transcendent realm. The main problem with such a metaphysical swamp is that it gives very bad prospects for clarifying anything at all, for clarification of other things requires a clear base.

Instead of aiming at a consensual economically unified ontology, many analytical philosophers seem to have inherited from the positivists the idea that "the task of philosophy is the clarification of meaning, not the discovery of new facts (the job of the scientists) or the construction of comprehensive accounts of reality (the misguided pursuit of traditional metaphysics)" (Kosciejew [206, p. 620]). Consider how Russell [345, p. 834] embraces what can be characterized as the negation of economical unification: "Modern analytical empiricism ... has the advantage, in comparison with the philosophies of the system-builders, of being able to tackle its problems one at a time, instead of having to invent at one stroke a block theory of the whole universe." Russell was essentially wrong: instead of managing to clarify meanings and tackling problems one at a time, more than 100 years of analysis without an economically world-view as the base has resulted in the contemporary absence of consensus about the meanings of virtually all focal concepts

[25]Finite vs. infinite divisibility; spatial finiteness vs. spatial infinity; the length of the present is positive vs. nonpositive; presentism vs. growing-block vs. eternalism vs. moving spotlight; the law of non-contradiction applied to nature vs. there are contradictions in nature; total vs. partial determinism; the eternal Universe theorem vs. the three alternatives; naturalism (as a theorem of presentism and causality axiom) vs. transcendism; physicalism (as a theorem of presentism and causality axiom) vs. mind-body dualism; ontological realism vs. everything is dependent on your mind. This leaves $2 \times 2 \times 2 \times 4 \times 2 \times 2 \times 4 \times 2 \times 2 \times 2 = 4096$ combinations.

such as truth, possibility and time. As there is no consensus about ontology, there is no consensus about anything that follows either.

100 years in the state of disunification seems to have resulted in many philosophers considering the disunified state as natural and desirable. The fusion of the culture of disunification, negligence of economy and unconstrained theory proliferation can be called *uneconomical pluralism*,[26] where any coherent combination of axioms which explains perceptions is equally worthy. In economical unification, proliferation of empirically sufficient metaphysical possibilities is good in the sense that we can select the most economically unified combination. In the culture of pluralism, these are good as such, for this is what pluralism is: embracing the plurality of metaphysical possibilities, proliferation by free association, the let-all-flowers-bloom attitude or the freedom of concentrating on whatever one finds interesting in 'metaphysics,' without having to point out where it should be applied. Contemporary pluralism may have been influenced by Feyerabend's notions about proliferation, whose central function was to overcome stagnation in science (p. 36). It is quite different to try to come up with a more virtuous theory than to start with metaphysical possibilities such as infinite divisibility and transcendent worlds that are not even needed by best contemporary science. If the pluralists are genuinely searching for better theories, then in these cases their search for them starts from worse foundations. But if there is no criterion of fitness, anything goes.

The selection between pluralism and economical unification should be made based on their progressiveness. Economical unification effectively blurs the borders of philosophy and natural science, while pluralism keeps these apart, proliferating neo-scholastic metaphysics which begs the question of how should it be used. There is no problem in demarcating economically unified metaphysics. For, the necessary commitments (p. 24) are implicit in theories in any case. After the necessary commitments have been identified, they can be complemented by minimal and sufficient optional commitments when needed. This brings the focus right back to the classical formulations of economy (§3.1): Why postulate more if you can make do with less? What other reasons are there for such postulations than pluralism itself? The pluralists' challenge becomes to demarcate the excessive pluralistic metaphysics, i.e., to explain why it is useful and in what respect.

This is where the pluralist disagrees, for queries about utility are against the pluralist culture, i.e., the pluralist more likely searches for ways to avoid answering the utility question and maintains that such questions should not be asked because this is suppressive. The unificationalist can only appeal to progressiveness and maintain that progressive tools are more likely created by having the goal of creating usable applications in mind than by dodging questions about applications. Certainly, proliferation of theories by free association is better than nothing, but there is statistically a very big difference between the most optimal and whatever at all that is better than nothing. In practice, without economy as the criterion and without a clearly specified intended function of the defined concepts, the philosophical corpus itself becomes the primary measure of relevance. This means that quoting the corpus widely is at least as important a sign of good philosophy than arriving at economically unified solutions with clearly specified functions. The obvious problem is that this is not optimally progressive, and the reason is the same as why 100 men aiming at a designated target more likely hit it than 100 men shooting at the forest.

THE BENEFITS OF WORKING WITH A UNIFIED ONTOLOGY. The benefits of economical unification are revealed clearly in the stage of working with an economically unified

[26]This is not exactly the same doctrine as what Turner [401] calls *ontological pluralism*: "According to ontological pluralism, there are different ways, kinds, or modes of being."

ontology, and the difficulties that result from its absence are proportionally cumulated at this stage. The following characterizations of the progressiveness of the method were originally inspired by Mario Bunge [68, preface, pp. 1, 3, 6-7, 238, 296-7] and Jeffrey Poland [312, pp. 26, 29, 32, 35].

The fusion of DU and EUO is one single theory. There are no separate theories but only definitions of different aspects of one theory, such as the definitions of the concepts of truth, possibility, colour, time, property and abstract. Applicable ingredients of competing theories are incorporated by defining these in terms of EUO in a way that these are compatible with the previously defined concepts. The resulting concepts are mutually compatible and understandable and they manage to resolve arguments targeted against them. Unification does not stop on the level of individual concepts. Literally every concept defined in terms of EUO is interrelated with every other concept, directly or indirectly via EUO. This is congenial with Juti's conclusion:

> On the whole, it can be said that in metaphysics the sentence "everything is involved with everything" expresses a profound truth. In this sense, the building of a traditional metaphysical system is not at all old-fashioned, but only if it is founded on carefully analyzed suppositions about the contents and character of reality. Juti [192, p. 348]

The given suppositions about the contents and character of reality are the metaphysical commitments of EUO, which are carefully derived by economy and interrelated. It is clarifying to change the *building of a traditional system* into *identification of commitments and their interrelations that are present in any case*. It is old-fashioned to do this only when it is not seen that the hands are attached to the body in any case, or analogously when it is not seen that e.g. causality and temporal existence are interrelated in any case, disregarding if one wishes to acknowledge the interrelations or not. Identifying connections between specialized domains of inquiry and applying them in resolving problems is merely an alternative to working blindfolded without acknowledging connections that exist in any case: the necessary commitments and their relations can only be meditated away.

Unification yields inter-field synergy and helps coping with increasing specialization and growth of knowledge. According to Oppenheim and Putnam [300, p. 3]: "the metascientific study of major aspects of science, is the natural means for counterbalancing specialization by promoting the integration of scientific knowledge." (Unfortunately, philosophers typically throw away the child with the washing water and only note that reductionism does not work as Oppenheim and Putnam characterized.) No matter how specialized a branch is, it is connected to the ontology. Conceptual and terminological redundancy are reduced when all concepts are defined in terms of a unified ontology. A unified ontology enables seeing what can and what cannot be omitted, what presupposes what, what entails what, which concepts are wrongly supposed to play any role at all, what are the roles of different concepts and which concepts are redundant. This way, a unified ontology avoids uncontrolled introduction of arbitrary vocabulary and concepts, it supplies a way to understand what has been achieved, what are the relevant challenges or the advanced questions and what is the range of application of a concept, for all these unfold when it is understood how things hang together.

It is practically impossible to discover these interrelations by concentrating on one topic only. The aim is naturally to take relevant literature about each topic in account, but apparently, details are not needed in unifying concepts on the top level. Ingthorsson notes that there is a great plurality of nuanced version of different theories of truth, and underlines that it is practically impossible to achieve unification if all details should be taken in account at one stroke:

> It is important to note that I focus on the core ideas of various truth-theories rather than the details of the views of particular thinkers. This is partly a practical necessity for the big picture approach attempted here, but also a consequence of the fact that there is no canonical version of any particular truth-theory. Ingthorsson [182, ch. 1]

Further, *unification enables* handling various concepts within a short space: once the basic structure is understood, all the rest can be defined in terms of it shortly; the short definitions make sense and can be understood sufficiently only by understanding their places in the context of the ontology. In traditional conceptual analysis, literature about individual and isolated topics drives the discussion. The left side of figure 5 depicts e.g. truth, possibility and time as isolated stand-alone theories, or as isolated *industries* or fields of various competing theories of truth, various theories of possibility and various theories of temporal existence, whereas the right side depicts their unified fusion. The results of the *PhilPapers survey*[27] show that the current disunification is not a myth.

Time: A-theory or B-theory? 34.7% insufficiently familiar with the issue; 22.6% accept or lean toward B-theory; 16.0% accept or lean toward A-theory; 9.8% agnostic/undecided.
Truth: correspondence, deflationary, or epistemic? 48.9% accept or lean toward correspondence; 23.0% accept or lean toward deflationary; 10.9% accept or lean toward epistemic.
Abstract objects: Platonism or nominalism? 40.8% accept or lean toward nominalism; 36.3% accept or lean toward Platonism.

From the aspect of economical unification the above questions about truth and abstract objects are similar to asking "Do you select hands or feet?" and "Do you prefer head or body?" whereas the progressive starting point is that the limbs and the head are attached to the body. It is suggested in §4.4 that economy favours the presentist A-theory and therefore it is selected as an axiom of EUO. It is suggested in §6 that object-based correspondence is the most straightforward basis for a unified concept of truth in EUO, and it is shown how the applicable ingredients of epistemic theories and deflationism are incorporated by definitions in terms of EUO. The issue with abstract objects requires settling first the ontological case between naturalism and transcendism. Naturalism is shown to be a theorem of EUO in §4.8, transcendism is rejected as an uneconomical alternative to naturalism in §4.9, and abstract is defined in §4.14 in terms of EUO so than the job of Platonism is done and compatibility with nominalism is sustained.

In economical unification the difference of ontology and applications is crystal clear. Without a consensual ontology, there is no consensus about anything that depends on the missing ontology either. As a result, the difference of ontology and applications is blurred: it is not known whether a concept is defined in terms of ontology or whether the it is meant as an ontological commitment. Concepts which are defined and disambiguated in terms of the ontology are not mixed with the ontology. For instance, once finite divisibility is postulated (§4.17), everything that violates it is automatically rejected, such as genuine self-reference (§4.18). This guides one into interpreting away cases which seem to be involved with self-reference, whereas without a unified ontology and economy as a criterion, one may freely suppose that genuine self-reference takes place and accept infinite divisibility of nature as an implication.

Again, the unified ontology is a stable and consistent base for defining concepts unambiguously, which reduces conceptual and terminological redundancy and confusion, which

[27]The biggest ever survey of professional philosophers on their philosophical views was carried out in November 2009. The percentages are calculated based on answers given by 1803 philosophy faculty members and/or PhDs.

in turn allows moving forward and investing efforts to more advanced questions. Without economy as the criterion, conceptual and terminological redundancy and multiplicity explodes and ambiguities emerge proportionally: even one ambiguity is enough to muddify all that follows, but when many things are open, debates wallow without effectively culminating in consensual conclusions. Two concepts which are mapped to unexplicated ontologies may unknowingly contradict one another. When one does not consciously recognise the foundations, one may unknowingly map different concepts on incompatible ontologies, whereas concepts or semantical constructions which are not mapped to any ontology in any case hang in the air. The openly explicated unified ontology makes the analysis avoid pseudo-problems which result from its absence. Without an openly explicated ontology, it is not known whether some debate is about ontological commitments, about different terminology, different semantics or about conflicting definitions of concepts in terms of the same ontology; the ontological background of a statement has to be guessed. In effect and again, debates wallow without *effectively* converging into consensual conclusions. To illustrate, arguments against presentism in §6.6 rely on committing to a truthmaking principle that is practically incompatible with presentism, but this is not seen as the rejection of presentism is not written out in the surface structure of that truthmaking principle; the semantical or linguistic arguments against presentism in §6.8.4 result from circulating around the surface structure of language instead of taking presentism seriously; the funny fact arguments in §6.7 amount to blaming a theory of truth for ambiguous formulations of truthbearing propositions. The existence of such pseudo problems is the reason why Devitt [108, pp. 29-30] insists that "our semantics should be driven by our metaphysics and not vice versa."

3.6 Summary

It can be concluded without exaggeration that the idea of economical unification genuinely unifies the philosophy of science, and that the failure to see this results from the currently disunified science. The goal of seeking out the simplest first principles common to all science has always been a central goal of first philosophy, from Aristotle to Mach. The greatest source of difficulties is the logical positivists' misinterpretation of Mach, which resulted in the verifiability criterion that rejects metaphysic. What is more wrong-headed than the project of unifying science without metaphysics that is needed in the center of unified science? The verifiability criterion was naturally rejected, but this did not lead into a consensual picture of having the goal of economically unified total science in the center of philosophy of science. Although the idea of unification and the criterion of simplicity have been implicit in philosophy of science all along the 20th and the 21st centuries, where philosophers of science made valuable contributions to understanding of scientific explanation, progress of science and evaluation criteria of theories, the goal towards unified science with an economically unified metaphysical core was not openly placed in the *very center* where it belongs and functions as the unifying nexus.

Economical unification is not the only path to the progress of science. Even plain new data and development of devices are progressive, and it is better to give correct predictions by being aided by parameters than to fail to give correct predictions at all. But this does not change the fact that the most desirable state is to give correct predictions without parameters, i.e., economical unification is progressive without a question. Theory shifts and reductions are paths to more economically unified science and thus paths to progress. However, instead of taking in the unificatory picture and holding it for good, it seems that the unificatory picture has been shaking in the minds of philosophers always

when somebody who has understood the nature of economical unification has failed in some sense.

To illustrate, take Kitcher's unification model. Maintaining that unification is explanation is one thing. Seeing that unification is progressive and that a more economically unified theory enables a better explanation is another thing. That someone has identified unification as explanation, should not mislead anyone into thinking that now the unificationist project is somehow threatened. Alas, when you talk about unified explanation, philosophers are ready to remind you that unification is not explanation. As another example, many seem to take the failure of Oppenheim and Putnam's characterization of micro-reductionism as the path towards unified science as a proof of the failure of the whole unificationist project, and as something that shows that all unifiers want to reduce social science to particle physics. This picture is almost completely false. Everybody now hopefully understands that incompatible theories cannot be reduced to one another, but this should not prevent anyone from attempting to reduce mutually compatible theories to one another whenever this is possible, nor from advancing unification by theory shifts, nor from finding a postulate that unifies two or more theories. For all paths of economical unification are progressive.

It is hard to predict just what are the detailed paths in which economical unification of science will be advanced, but given that the tools are theory shifts, reductions, partial unifications and their mixtures, it is a matter of implementing these in some order. The path of theory shifts must be first traversed far enough, so that we have arrived at mutually coherent theories. Once coherence has been achieved, it has become possible to look at the theories together and to try to figure out which axioms can be derived from which, i.e., there are no obstacles to fully traversing the paths of reduction and partial unification. Once these have also been traversed, we are no longer dealing with different sciences but with one and the same economically unified theory which explains all scales of phenomena. While the road towards the ideally economically unified theory is long, this does not prevent us from enjoying from more and more economically unified theories.

Even though the greatest thinkers have expressed their consent to economical unification, although this is in line with the large-scale historical progression of theories, and although the progression towards more and more virtuous total science with increased explanatory power, simplicity, understandability, usability, coherence and consilience makes sense to most people, still many are not convinced about economical unification. One asks: How can science be disunified now, if the progress of science is propagation towards more economically unified science? In the Kuhnian picture, the evolution of theories walks hand in hand with the increase of data; the more new data, the more parameters the theory requires, which is a prelude to a paradigm shift. The 20th century development fits perfectly in the Kuhnian picture as relativistic physics has developed along with a growing parameter structure (§5.4). Its evolution has been progressive and unificatory in the sense that it explained more than earlier, but not optimally economical unification, for its explanations require the parameters. All that is needed in perfectly matching the Kuhnian picture is the replacement of relativistic physics with a more economically unified theory. Instead of seeing the big picture, many note that contemporary science is disunified and conclude that this is also how things should be, i.e., their picture of disunified science matches how science is practiced. These people forget progressiveness and Hume's guillotine: how things are should not indicate how things should be. One should not bury the goal towards ideal science because science is currently not ideal.

The need for the principle of economy is best understood by the chain: progress is desir-

able; economical unification is progress and inseparable from the increase of virtuousness of total science; in order to efficiently advance economical unification, economy is needed as an evaluation criterion that favours more virtuous theories. Evaluating the accuracy of predictions alone is toothless in the face of underdetermination; the only alternative to taking metaphysical commitments in account in theory evaluation is to accept that failures of the current paradigms can be fixed by an increasing heap of parameters, which is counter-progressive. Economy is the alarm bell which gives a signal that it is the time to start searching for a better theory, it is a mean to tackle unconditional stagnation which stalls shifts into better theories, and it incorporates falsifiability. Without economy, increased metaphysical complexity does not matter, the alarm bells do not ring, stagnation is left untackled and the current paradigms are practically unfalsifiable.

Philosophical metaphysics *should be* primarily the science of unification: the science of explicating metaphysical postulates of applicable theories and their interrelations, in order to facilitate the process of economical unification. But this is not what it currently is. Analytical or neo-scholastic metaphysics became a somewhat independent field of inquiry where the principle of economy and applicability in natural science and society had and still have very little importance. The principle of naturalistic closure is a version of economy and a counter reaction to neo-scholastic metaphysics which rose after the rejection of the verifiability criterion. The principle of naturalistic closure merely tries to unite philosophical metaphysics with empirical science. This thesis continues on the same lines, except that the preference for institutional science is changed into the more general preference for economically unified science.

The progressiveness of economical unification in dealing with topics that are typically discussed in the context of philosophy has the same cause as the progressiveness of economical unification everywhere else: once you have a unified ontology, many things become much easier. Everything else can be handled efficiently in terms of it: problems can be efficiently resolved, meanings of concepts can be clarified and ambiguities can be disambiguated. This is progressive and also releases efforts to dealing with more advanced questions, i.e., progress by unification is not just progress but it also means an accelerated rate of progress. In contrast, the absence of a unified ontology makes almost everything hard, leading into great difficulties and preventing achievement of the optimal progress rate in physics as well as in philosophical metaphysics. In order to arrive at a unified ontology, a criterion is needed for evaluating metaphysical commitments, for otherwise we are left with equally relevant metaphysical possibilities. The initiative of searching for mutually compatible sums of metaphysical commitments enables organizing them together, instead of looking at individual and isolated commitments. The unified ontology is the key to progress, but it cannot be had in the context of relativistic physics which especially keeps theories disunified, nor without having it as a goal, i.e., without having economy as a criterion. The absence of a unified ontology is not surprising in the light of relativistic physics, pluralistic tendencies, negligence of economy and the cosmetic logico-linguistic basic touch.

4 Ontology I: EUO

Axioms of the given version of economically unified ontology (EUO) are derived by applying the principle of economy. The aim is to show that the traditional alternatives to the axioms of EUO, if any, are either insufficient, metaphysically more complex or at best equivalent with the axioms of EUO. In addition to the axioms, some concepts are defined in terms of the axioms, some theorems are derived from the axioms, and some rejections are done which show that some axioms of EUO imply that something specific does not exist or that some result does not hold in EUO.

THE BASIC STRUCTURE OF EUO. The Universe is a single non-branching sequence of consecutive temporal stages (TSUs) which are in a forward directed temporal and causal succession. Only the present TSU exists, the past TSUs did exist, and future TSUs become into existence one at a time. All parts of a single TSU exist absolutely simultaneously, they are causally connected and realize energy in an absolutely determinate location in an absolutely determinate way. Every TSU is non-contradictory, spatially finite and consists of a finite number of positive parts. Human beings with their mental states are proper parts of the Universe, and the other parts of the Universe are independent of human minds.

PRESENTISM. Only the present temporal stage of the Universe (TSU) exists.

CAUSALITY. All parts of the present TSU are causally connected and realize energy in an absolutely determinate location in an absolutely determinate way. The present TSU is the consequence of the preceding TSU and the cause of the succeeding TSU.

ONTOLOGICAL REALISM. A proper part of the Universe is independent of human minds.

THE LAW OF NON-CONTRADICTION. The present TSU is non-contradictory.

FINITENESS. The present TSU is spatially finite and consists of finitely many indivisible and positive parts.

4.1 Axiom: Presentism

Presentism is postulated as the most economical answer to the question of what exists temporally. Presentism is the thesis that only the present temporal stage of the Universe (TSU) exists.[28] Presentism is to be taken literally. That only the present exists means that the past does not exist and that the future does not exist: the past *did exist*; the present *exists now*; future TSUs will become into existence one at a time.[29] In words of Dummett and Putnam:

> The present forms the substance of the world; the past consists of what *has been* present, the future of what *will be* present. Hence all that now exists is what is *now* present. Dummett [116, p. 73-4]

> Future things (which do not already exist) are not real (on this view); although, of course they will be real when the appropriate time has come to be the present time. Similarly, past things (which have ceased to exist) are not real, although they were real in the past. Putnam [319, p. 240]

[28] This definition is compatible with Sider [356, p. 325] who defines presentism as the thesis that only the present is real, with Markosian [249] who defines presentism as the view that only present objects exist, and with Pezet [306] who defines presentism as the thesis that all and only present things exist. Fiocco [144, pp. 197-8] calls the given version *primitive presentism*.

[29] The reason why the expression 'future TSUs' is used instead of '*the* future TSUs' is explained in §4.11.

As only the present TSU exists, the present is the ultimate viewpoint in terms of which everything is analyzed. As only the present exists, it should strictly speaking be always qualified whether a particular *exists* or *did exist* or *will exist*. It should be said that something holds for a particular *when it exists* which is *when it is the present*. Such expressions are not typically added in order to facilitate the use of language, and the context hopefully fixes the meaning of *exists*.

The present TSU is a single unchanging particular whose all parts exist absolutely simultaneously. The expression 'particulars X and Y exist at time t' means that X and Y are parts of the TSU which is realized at time t. If X and Y would not exist at the same time, they would not be parts of the same TSU either, for all parts of a TSU exist at the same time. The Dynamic Universe model (DU) requires absolute simultaneity, and therefore the postulation of presentism unifies DU and EUO in this sense; in contrast, the *relativity principle* violates absolute simultaneity (§5.6). The organization of the defence of presentism is given in the analytical table of contents.

4.2 Definitions: Change; Intrinsic Forward Directed Time

CHANGE. Perception testifies that change is taking place. As only the unchanging present TSU exists, change is defined as a transition from one present into another.

INTRINSIC FORWARD DIRECTED TIME. The transition from one present into another is equivalent with the transition from one present time into another present time that succeeds the preceding time. All transitions of time are thus in the forward direction. Intrinsic forward directed time has thereby been defined, where 'intrinsic' means that time is merely the measure of change. By intrinsic time, e.g. the concept of one day can be defined as the period of time during which the Earth rotates around once its own axis, and one year as the period in which the Earth rotates once around the Sun.

Leibniz [119, pp. 25-6] was a proponent of intrinsic time:[30] "As for my own opinion, I have said more than once, that I hold space to be something merely relative, as time is, that I hold it to be an order of coexistences, as time is an order of successions." In contrast, Newton[31] was a proponent of *absolute time* where time is independent of the changing particulars in space. There is no need for absolute time in EUO and thus intrinsic time is the only notion of time that is needed. Absolute simultaneity ought not be confused with absolute time, although these are compatible.

Time is a measure of change also in the Dynamic Universe model (DU). There is thus no need to define the direction of time in the fusion of DU and EUO in terms of the increase of *entropy* as is done with relativistic physics; time and change are coupled also in relativistic physics, but in a crucially different way, as explained in detail in §5.6. While in relativistic physics time is especially an independent entity —the fourth dimension— in EUO/DU time is not an independent entity, but merely the measure of change: a figure of speech that is used in talking about TSUs and about transitions from one TSU to another. Thus, we may talk about time t as well as about TSU t, and about the period of time $[x\ y]$ as well as about the sequence of TSUs which starts from x and ends to y. Consider the sequence of consecutive TSUs 1,2,3. The transition from 1 to 2 and from 2 to 3 can be characterized as follows, where $P(x)$ means that x is the present TSU:

[30] E.g. Rundle [341, ch. 1.1] calls intrinsic time *relational time*, but this term is not used in order to avoid confusions with the conception of time in relativistic physics.

[31] In *General Scholium* of *Principia Mathematica* [284].

$P(1)$,2,3: 1 is the present TSU; 2 and 3 are future TSUs.
1,$P(2)$,3: 1 is a past TSU; 2 is the present TSU; 3 is a future TSU.
1,2,$P(3)$: 1 and 2 are past TSUs; 3 is the present TSU.

The fusion of presentism, the perceived change and the definition of intrinsic forward directed time implies that the past TSUs *did exist in the past*, the present TSU *exists now*, and the future TSUs *will become into existence* one at a time. The present divides the Universe strictly in past, present and future: future and past do not overlap.

4.3 Open Selection: Length of the Present Moment

Again, time p is equivalent with TSU p. That TSU p is unchanging is equivalent with saying that time p is *discrete*. Given that hybrids are discluded, this leaves the following mutually exclusive options open. (1) The length of the present is positive, i.e., denoted by a real number greater than zero; this does not imply that the discrete duration of every TSU is the same. (2) The length of the present is non-positive; this option can be subdivided in a version where the present is zero and in version where it is infinitesimal, but only the zero-option is handled here. In both (1) and (2) all times are strictly ordered.[32] Although (1) is in a certain senses easier than (2), there are no forcing reasons to explicitly select between them and therefore the postulation is left open. However, (1) is applied in the other sections as a provisional figure of speech. Consider some implications and dependencies which follow from the selection between (1) and (2).

(1) implies that a positive period of time consists of finitely many (two or more) TSUs. Therefore, (1) implies together with the rest of EUO (especially the finiteness axiom) that only finitely many changes take place within a finite period of time. A single TSU is not called a *period* of time, although its discrete duration is given a positive numeric value. (1) entails that the TSUs are ordered one after another and thus enables talking about sequences of consecutive TSUs $p, p+1, p+2$ and so on. This facilitates talking e.g. about future possibilities in §7. (1) gets by with very simple logical foundations, for times can be seen to be logically equivalent with integers. Given (1), the eternal Universe theorem (§4.11) can be stated as: there are infinitely many TSUs in the past and potentially infinitely in the future. Consider the following remarks in the context of (1):

> If we conceive of some point of time which cannot be divided even into the minutest parts of moments, that is the only point that can be called present: and that point flees at such lightning speed from being future to being past, that it has no extent of duration at all. For if it were so extended, it would be divisible into past and future: the present has no length. St Augustine [296, pp. 272-3]
>
> The present has no duration: it is a mere boundary between past and future. Dummett [116, p. 74]

Against Augustine and Dummett, in (1) the present is especially considered to have a positive duration. Against Augustine, in (1) the present is not divisible in past and future, but congenially with Dummett, (1) preserves the role of the present as the boundary between the past and the future.

Given that it is impossible to build anything positive out of *finitely many* zero-width instants, (2) must be coupled e.g. with point-continuum (§4.17) where a positive period

[32]The strict ordering of times can be characterized as follows. Irreflexivity: $a < a$ does not hold for any time a in past, present or future. Asymmetricity: if $a < b$, then $b < a$ does not hold. Transitivity: $a < b$ and $b < c$ implies $a < c$.

of time consist of infinitely many zero-width points. Given (2), the eternal Universe theorem (§4.11) appears as: the length of the past (as an interval) is infinite, and the length of the future (as an interval) is potentially infinite. Given two real numbers $x > y$, there is a real number in between them. This entails that there is no such thing as the *next* TSU $p + 1$ which is realized after p. Therefore, (2) entails that sequences of TSUs such as $p, p + 1, p + 2$ strictly speaking cannot be realized. Accordingly, expressions such as 'TSU p partially determines TSU $p + 1$' must either be translated as 'TSU p partially determines TSUs which follow p' or interpreted so that $p + 1$ does not denote the 'next' TSU but some TSU that is assigned and is after p. (2) faces Zeno's next-point paradox, also called *dichotomy*, which is familiar from Aristotle's *Physics*, bk. 6: if time consists of points, but there is no next point of time after the present, then how can time go forward? By selecting (1), this paradox never raises.

Dorato [114] presents an argument against both (1) and (2): if the present is discrete (zero or positive), we cannot have direct experience of it; therefore "presentism has no direct phenomenological evidence in its favor and its only force can come from its explanatory power." This is not a problem, for presentism has been postulated especially as the simplest axiom for temporal existence that explains perceptions.

4.4 Presentism vs. Alternative Theories of Temporal Existence

The complexities of presentism and its alternatives are evaluated, and it is evaluated how they manage to embody change or the passage of time, and to give an account of temporal ordering and the direction of time.

The central theories of temporal existence which all accept the existence of the present are depicted in figure 6: presentism, eternalism, the moving spotlight theory, the growing-block theory and the shrinking-block theory. Eternalism is sometimes called a *block theory*, but this convention is not used here in order to distinguish eternalism from the growing-block and the shrinking-block theories, which are called jointly block theories here. Presentism, the block theories and the moving spotlight theory are A-theories,

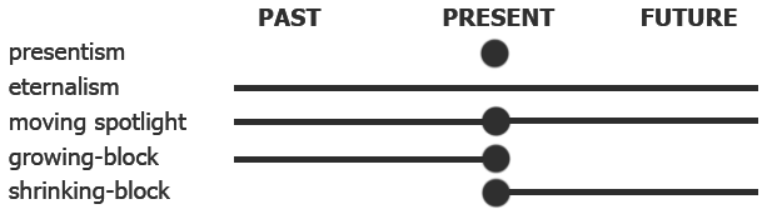

Figure 6: Presentism and its basic alternatives.

whereas eternalism is a B-theory. According to Deasy [104]: "A theory of time is an A-theory just in case according to that theory, there is an absolute, objective present moment; otherwise, it is a B-theory." According to Zimmerman [425, p. 402], the A-theorists "posit an objective distinction between what is present and what is past and what is future" whereas the B-theorists "deny the objectivity of any such distinction."

In presentism the present exists while the future and the past do not. It is quite difficult to point out the origins of presentism as it is the common-sensical view of temporal existence. In eternalism past, present and future exist equally (cf. Baron and Miller [43, p. 32]). Although no such thing as an objective present exists in eternalism, all points

of time still exist, and that what is typically considered as the present is one of these. The Theory of Relativity is the greatest threat to presentism and the main support for eternalism,[33] as it entails eternalism and is incompatible with presentism (§5.6.3). In the growing-block theory the present is equivalent with the tip of the existing block which grows as time goes by. C.D. Broad [60] is credited for introducing the growing-block theory.[34] In the shrinking-block theory the present is equivalent with the tail of the existing block which reduces as time goes by. The shrinking-block theory is kept along for the sake of conclusiveness; I have not found defenders of it in the literature, but it is acknowledged as a logical option by Merricks [269, p. 103] and Hare [163, p. 17]: "Some imagine that the future exists but the past does not." In the moving spotlight theory past, present and future exists, but there is also the objectively changing present. Deasy [103, p. 2075] credits Broad [60, pp. 59-60] for its early description and characterises the moving spotlight theory as follows: "Some instant of time is absolutely, non-relatively present (A-THEORY) and it is always the case that everything exists eternally (PERMANENTISM)."

In presentism all existing things are of the same type: present. In the growing-block theory there are two types of existing things: present and past. In the shrinking-block theory there are likewise two types of existing things: present and future. In the moving spotlight theory there are two or three types of existing things, depending on the interpretation: there are three types of things if past, present and future are all interpreted to be of different types; there are two types of things if past and future are both interpreted to be of the same type, non-present. In addition to more types of existing things, the other theories are also quantitatively heavier, as the past or future or both is quantitatively more than the present. Eternalism must be complemented by an indexical wrapping or something equivalent, in order to account for the experience of the present moment. Lewis characterises the indexicality:

> Our present time is only one time among others. We call it alone present not because it differs in kind from all the rest, but because it is the time we inhabit. The inhabitants of other times may truly call their own times 'present', if they mean by present what we do; for the meaning we give to 'present' is such that it is indexical, and refers at any time t to that time t itself. Lewis [221, p. 86]

Thus in eternalism there exists the indexical present that you experience right now when reading this text, plus the indexical past and the indexical future. Although the past, present and future indexicals are all of the same type —indexical time— their sum is quantitatively more than in presentism. In sum, economy favours presentism: eternalism is only quantitatively uneconomical, whereas the block theories and the moving spotlight theory are both quantitatively and qualitatively uneconomical with respect to presentism.

EMBODYING CHANGE OR THE PASSAGE OF TIME. A sufficient theory of temporal existence must explain the perceived change or the experience of the ever-changing present. In presentism the perceived change is explained as a transition from one present 1 into another present 2: when the transition from 1 to 2 has occurred, 2 has become into existence and 1 has ceased to exist. In the growing-block theory, when 1 is the present 1 exists whereas 2 does not exist because 2 is in the future at 1; when the transition from 1 to 2 has occurred, 2 has become into existence and 1 remains existing: "to become past is merely to cease to be on the 'cutting edge' of the growing four-dimensional manifold of events" (Zimmerman [425, p. 403]). In the shrinking-block theory, when 1 is the present

[33]Eternalism has been defended e.g. by Putnam [319], Mellor [267] and Sider [357].

[34]The growing-block theory has been defended e.g. by Forrest [146], Tooley [399] and Button [70].

1 exists and also 2 exist because 2 is in the future at 1 and the future exists; when the transition to 2 has occurred, 1 has ceased to exist.

In eternalism, change cannot be explained in terms of becoming to exist or ceasing to exist, because all times exist equally and there are initially no such things as past, present and future. Therefore, eternalism must incorporate some additional postulate which embodies change, or alternatively an eternalist can consider the perceived change as an illusion. On one hand, maintaining that the perceived change is an illusion does not help in any way, for the function of metaphysics is to explain perceptions and not to maintain that they are illusions; on the other hand, the commitment to the idea that change is an illusion is a metaphysical postulate; either way, eternalism is uneconomical because it either fails to embody change or must appeal to some additional postulate. The indexical wrapping does not seem to help, for it does not explain why I seem to constantly jump from one indexical present to another. In sum, presentism and the block theories suffice as explanations of the perceived change in terms of ceasing to exist and/or becoming into existence, but eternalism must incorporate something additional.

TEMPORAL ORDERING AND THE DIRECTION OF TIME. A sufficient theory of temporal existence must provide a foundation for placing different times in before-after relations. Given two arbitrarily assigned times x and y, a theory of temporal existence must provide the ontological foundation for saying that one is before, after or the same as the other. In presentism present *exists*, past *did exist* and future temporal stages of the Universe *will become into existence* one at a time. The before-after-same relations can be defined in terms of all A-theories, for these incorporate the objective present: x is before $y \equiv$ when x is the present, y has not been the present yet; x is at the same time as $y \equiv$ when x is the present, y is the present; x is after $y \equiv$ when x is the present, y has already been the present in the past. For instance, take instantial times in the years 1000 and 2000. When 1000 was the present, 2000 had not been the present yet and therefore 1000 is before 2000; when 2000 was the present, 1000 had already been the present and therefore 2000 is after 1000. Likewise, the direction of time is merely a definition in the A-theories: when the present has changed —when something has become into existence or has ceased to exist or both— time has gone forward.

In eternalism all times exist equally and there is no objective present. Therefore in eternalism the direction of time and the before-after-same relations have to be incorporated as additional parameters or founded on additional parameters. This reminds that the greatest support for eternalism comes from the Theory of Relativity, where the mapping to entropy gives the direction to time: the increase of entropy is equivalent with time going forward (§5.6.3). The entropy mapping can be also used as the basis of the before-after relations by equating these with lower-higher entropy states.

SUMMARY. Theories of temporal existence are answers to the question of which of these exist: past, present, future. Presentism is a more economical answer than the initial versions of eternalism, the block theories and the moving spotlight theory. All A-theories postulate the objective present, and are therefore sufficient explanations of change, whereas eternalism requires an additional postulate in this task. The direction of time and temporal ordering relations can be given as definitions in the A-theories, whereas eternalism has been coupled with entropy as the additional anchor. With respect to these tasks, presentism is most economical of the sufficient theories. Further difficulties of the growing-block theory, the moving spotlight theory and eternalism —which need to be explained away by further metaphysics— are contemplated in §7.5.

4.5 Rejection: McTaggart's Argument

McTaggart [259, 261] coined in the terms *A-series of time* and *B-series of time*. The A-series is "that series of positions which runs from the far past through the near past to the present, and then from the present through the near future to the far future, or conversely" and B-series is the "series of positions which runs from earlier to later, or conversely" (McTaggart [261, p. 10]). The *A-theory* and *B-theory* of time are analogous to taking the A-series and B-series ontologically.

Presentism is a version of the A-theory. McTaggart concluded that the A-theory is needed as the ontological base which does embody change or the passage of time, whereas the B-theory does not embody change. McTaggart's [261, pp. 14-22] argument about the unreality of time aims to show that the A-theory contradicts itself, and because the A-theory is anyhow needed to embody change and the passage of time, the passage of time is an illusion. According to Ingthorsson [179] there is a consensus that McTaggart does not manage to show that time is unreal, *unless* one commits to McTaggart's ontology, which appears to be some version of eternalism based on Ingthorsson's (*ibid*, ch. 6) as well as Broad's [61, p. 307] analysis. As eternalism is clearly uneconomical with respect to presentism (§4.4) the appeal to eternalism cannot be used to support McTaggart's argument. Therefore it is only show that McTaggart's argument does not hold in the context of presentism. The argument can be given in two steps:

STEP I. Time t is in the future when the present is before t; t is the present when t is the present; t is in the past when the present is after t. As t being past, present and future is contradictory, and as the A-theory leads into this contradiction, the A-theory is contradictory, and therefore the passage of time is an illusion.
STEP II. The resolution that t is strictly either past, present or future from the aspect of a single assigned present time p fails, for step I applies to p as well. "Thus, according to McTaggart, we never resolve the original contradiction inherent in the A series, but, instead, merely generate an infinite regress of more and more contradictions" (Markosian [250]). Therefore, the passage of time is an illusion.

Presentism remains standing in the face of McTaggart's argument because there is no contradiction to start with. Consider the law of non-contradiction: *the same attribute cannot at the same time belong and not belong to the same subject in the same respect.* The attribute 'future' belongs to t when the present is before t; the attribute 'present' belongs to t when the present is t; the attribute 'past' belongs to t when the present is after t. Thus, the attributes 'future,' 'present' and 'past' do not belong to t *at the same time*: they belong to t *at different times*. Therefore, there is no contradiction to start with. Broad made the same conclusion already in 1938:

> I cannot myself see that there is any contradiction to be avoided. When it is said that pastness, presentness, and futurity are incompatible predicates, this is true only in the sense that no one term could have two of them simultaneously or timelessly. Now no term ever appears to have any of them simultaneously. ... Thus, there is nothing in the temporal appearance to suggest that there is a contradiction to be avoided. Broad [61, p. 313]

Especially, the first step of McTaggart's argument is invalid, i.e., there is no contradiction to start with, given presentism. This is crucial, for if you first get lulled into thinking that the first step reveals a genuine contradiction, then you have already stepped into the trap. Once you have accepted that the first step reveals a contradiction, all counter arguments are rejected by saying that McTaggart anticipated just these arguments. Consider one such argument:

> Thus, according to the A Theorist, there is no contradiction in the A series — i.e., no contradiction in saying of a time, t, that t was future, is present, and will be past — and, hence, no contradiction to be passed along to the different times at which t was future, is present, and will be past. In effect, then, the typical A Theorist makes exactly the move in response to McTaggart's argument that McTaggart anticipated, and explicitly rejected. Markosian [250]

It seems that Markosian fails to see that step II of McTaggart's argument is irrelevant, because step I never shows any contradiction in the first place, although Carroll and Markosian [78, p. 165] especially note that "when A Theorists reject the first premise of McTaggart's argument... they are not merely passing a contradiction along from one set of times to another, thereby generating an infinite regress of contradictions. Instead, they will claim, there is no contradiction in the first place." Making one understand that McTaggart's argument is forceless against presentism requires two steps:

STEP X. Step I of McTaggart's argument never manages to show that there is a contradiction in the A-series to start with, and therefore there is no need to look at step II.
STEP Y. If you think that step X is exactly what McTaggart anticipated in step II, then you have not understood step X, for step X exhausts step I of McTaggart's argument. If you insist on looking at step II you have not understood that the intelligibility of II requires that I is intelligible; as I is not intelligible, II is not intelligible either.

The conclusion about McTaggart's argument should be seen in the overall context of EUO and economical unification: presentism is the most economical axiom for temporal existence; McTaggart's argument has no force in the context of presentism.

4.6 Definitions: Classification of Objects; Sameness, Identity, Similarity

Observe figure 7. A denotes the whole circle. There is a smaller circle inside A, which is denoted by B. B is a *part* of A: $B \preceq A$. B is not the whole A, and therefore B is a *proper part* of A: $B \prec A$. By analogy, the hand is only a proper part of the body, because the body has other parts in addition to the hand. It is usually said that the hand is a *part* of the body, as it is known from the context that 'part' in this case means 'proper part.' A is a part of A, but A is not a proper part of A: $A \preceq A \& A \not\prec A$. A part of A is either a proper part of A or the whole A, but not both: $x \preceq A \rightarrow (x \prec A \quad \text{XOR} \quad x = A)$. All proper parts of A are parts of A but a proper part of A is not the whole A: $x \prec A \rightarrow x \preceq A \& x \neq A$. E.g. mereology (Appendix A) is a formalization of such part-whole relations and a sufficient logical foundation for part-whole relations for the topics discussed in this thesis.

Figure 7: B is a *proper part* of A.

When mereology is mapped to EUO, a part of the Universe is either the Universe as a whole or a proper part of the Universe. As the Universe is the sum of all that ever exists,

the Universe is not a proper part of anything. Further, by the finiteness axiom (§4.17) *discrete* mereology suffices as the logical foundation for part-whole relations between parts of the Universe in EUO. The collections of discrete mereology are called *aggregates*. An aggregate is either a single indivisible *ur-element*, or a composite of two or more ur-elements. Ur-elements are mapped to elementary particulars; aggregates which consist of two or more ur-elements are mapped to structural particulars and other objects. For example, suppose that a chunk of iron at time t is composed of the elementary parts $e1, e2, e3, \ldots, ek$, where the relations between the elementary parts are not written out. The elementary parts are considered logically as ur-elements, and the chunk of iron is modeled as the aggregate $e1e2e3 \ldots ek$. To illustrate that discrete mereology suffices for talking about all kinds of parts of the Universe, consider the Universe as a single aggregate U which consists of all elementary particulars which are ever realized in the past, present or future. Then consider any arbitrary part of the Universe X. As every part of X is a part of U, it follows that X is a part of U.

As the Universe is a sequence of consecutive temporal stages (TSUs) and as every TSU consists of proper parts, a part of the Universe is either a part of a single TSU which is realized at one time, or a part of two or more TSUs which are realized at different times. All parts of the Universe are objects and all objects are parts of the Universe, i.e., 'object' and 'part of the Universe' are interchangeable. 'Object' is applied for the sake of convenience. Objects are classified in *particulars*, *sequences of particulars* and *temporally scattered objects*. The intention here is not to give an exhaustive classification, but to come up with a classification that is sufficient for the purposes of this thesis.

PARTICULARS. A particular is either a single TSU or a proper part of a single TSU, i.e., a particular is realized exactly at one time in one location. Therefore, in the context of presentism particulars are strictly speaking all that ever exist. 'Particular' is equivalent with what Simons and Melia [363] call 'continuant' whereas other objects fall under what they call 'occurrent': continuant/particular exists at one time only and thus does not have temporal parts (or a particular is itself its only temporal part); an object that is not a particular exists at two or more times and thus has two or more temporal parts. Again, as particular X exists at exactly one time only, X is the only temporal part of X, i.e., a 'temporal part' of an object covers all spatial parts of the object which exist at one specific instant. For instance, you at time t is the only temporal part of you at time t, although you at time t has several spatial parts.

SEQUENCES OF PARTICULARS. A sequence of particulars is an unbroken sequence of parts of two or more consecutive TSUs. As a part of a TSU is either the whole TSU or a proper part of the TSU, all the following qualify as sequences of particulars: a sequence of consecutive TSUs which are realized within a period of one year; a person during a period of one minute; an electron during a period of one millisecond; a tree in your backyard during a period of ten years; the Universe. Individual particulars are temporal parts of such sequences. Thus $p1$ is a particular and a temporal part of the sequence of two consecutive particulars $p1, p2$ which are realized at consecutive times 1, 2. Also sub-sequences of $p1, p2, p3, p4$ such as $p1, p2$ and $p3, p4$ could be called temporal parts of $p1, p2, p3, p4$, but in the following 'temporal part' denotes only particulars.

TEMPORALLY SCATTERED OBJECTS. Some objects are not particulars nor sequences of particulars. Consider the sequence of three consecutive particulars $B = b1, b2, b3$. $b1$ is a particular; $b2$ is a particular; $b3$ is a particular; $b1, b2, b3$ is a sequence of particulars; $b1, b2$ is a sequence of particulars; $b2, b3$ is a sequence of particulars; $b1, b3$ is not a particular nor a sequence of particulars, but a temporally scattered object. For instance, but the sum of the Eiffel tower at the first instant of the year 1900 and at the last instant of the

year 1999 is not a particular nor a sequence of particulars, but a temporally scattered object. As another example, the sum of Barack Obama at the first instant of the year 2015 and the Eiffel Tower during the whole 20th century is not a particular nor a sequence of particulars, but a temporally scattered object.

ENDURANTISM AND PERDURANTISM. One could in principle start building an ontology by selecting either perdurantism or endurantism, but as these are partially redundant with the straightforward theories of temporal existence from which the building of EUO was started, it is convenient to handle them in terms of temporal existence, not the other way around. Consider Hawley's definition:

> Perdurantists believe that ordinary things like animals, boats and planets have temporal parts (things persist by 'perduring'). Endurantists believe that ordinary things do not have temporal parts; instead, things are wholly present whenever they exist (things persist by 'enduring'). Hawley [165]

Presentism entails endurantism, and thus perdurantism is automatically incompatible with EUO: a particular is wholly present when it exists, and a particular exists without exceptions at the present; only the present temporal part of an object exists, the past parts existed and future parts will exist. Perdurantism is compatible with eternalism, the growing-block theory and the moving spotlight theory (§4.4), as in these theories all temporal parts of an object may exist. Although EUO is incompatible with perdurantism as theory, perdurantism can be considered as a mere figure of speech. The perdurantist way of talking is used frequently in the context of EUO, as objects that are not particulars 'have' by definition two or more temporal parts. However, and again, as presentism is an axiom of EUO, only the present temporal part of an object exists.

SAMENESS, IDENTITY, SIMILARITY. Recall that a particular is realized in exactly one location at exactly one time. Particular x is the same as x, and no other particular is the same as x. Sameness and identity are interrelated as follows: $\text{same}(x, y) \rightarrow \text{identical}(x, y)$. Sameness of particulars x and y implies that they are identical, but the identity of x and y does not imply that they are the same. As identity does not imply sameness, in principle two particulars which are realized at different times may be identical, i.e., two particulars which are not the same may be absolutely identical. Sometimes the term 'numerically different' is used instead of 'same.' Identity and similarity of particulars is defined in terms their resemblance; as the resemblance of particulars is nothing over and above the particulars in their environments, identity and similarity of particulars is nothing additional to the particulars in their environments either (cf. Armstrong [19, p. 56]). If the resemblance of x and y is absolute, they are identical; if the resemblance of x and y is partial but not absolute, they are similar but not identical.

Similarity (or partial identity) is mostly sufficient for the needs of this thesis: e.g. two iron atoms in different states of motion and gravitation resemble in some degree and are therefore at least partially identical. However, both identity and sameness are needed, and it is implausible to maintain that two non-same parts of the Universe cannot be absolutely identical, given any sustainable requirements for their external relations. Consider two examples. (i) Two absolutely resembling temporal stages of the Universe (TSUs) which are realized at different times; these have no external relations and thus their absolute intrinsic resemblance suffices for absolute identity. (ii) Two absolutely resembling halves of a single TSU which has the form of a sphere (cf. Black [51, p. 165]); such halves share all external relations.

Consider some disambiguations of the predicate 'same.' The expression 'particulars x and y instantiate the same property P' indicates nothing about the times when and locations

where x and y are realized, but only means that x and y resemble absolutely with respect to the range of properties where P belongs to (§4.10). The expression 'particulars a and b belong to the same range [length]' means that a and b resemble partially or totally with respect to length. The expression 'I had the same idea as you' means that two ideas which are realized in different locations (in different minds) resemble as ideas. With expressions 'the same person has lived in that house for 10 years' and 'the same electron has occupied several locations in the cloud chamber' we are dealing with sequences of functionally identical particulars; it is not known whether the temporal parts of the electron are also identical. The expression 'one cannot step twice into the same river' manifests the strongest sense of sameness as defined above, whereas in 'one can step twice into the same river' the term 'river' denotes a sequence of functionally identical particulars: "A river replaces its water all the time and thus is functionally rather than materially genidentical" (Reichenbach [329, p. 64]).

4.7 Axiom: Causality

The axiom for causality can be expressed in terms of three interrelated axioms that are formulated on the top of presentism: (i) every part of the present TSU realizes energy in an absolutely determinate location in an absolutely determinate way; (ii) all parts of the present TSU are causally connected; (iii) the present TSU is the consequence of the preceding TSU and the cause of the succeeding TSU. Although the axioms explicitly state what holds for the present TSU, the axioms hold for all TSUs which are ever realized, for all that is ever realized is present when realized.

I AXIOM FOR ENERGY-ENDOWED PARTS, OR PHYSICALISM: every part of the present TSU realizes energy in an absolutely determinate location in an absolutely determinate way. As the TSUs are all that ever exist, it follows that all that ever exists without exceptions realizes energy at some absolutely determinate time in some absolutely determinate location[35] in some absolutely determinate way, which is equivalent with *physicalism* (§4.13). As all parts of the Universe or all objects are endowed with energy, there are no energy-free objects. Objects in EUO are equivalent with *energy objects* in DU. DU and EUO are seamlessly unified also in this respect, as energy objects are all objects there are in both DU and EUO. The ways of realizing energy are defined as properties in §4.10.

Economy favours this axiom as the explanation of perceptions requires supposing the existence of energy-endowed objects which are located in space, but does not require supposing that in addition to the energy-endowed objects, there should be energyless objects located in space, or objects which are not located in space. The *rejection of bare particulars* (RBB) is implicit in this axiom, for RBB is in the ontological sense equivalent with accepting that *every particular which ever exists, exists in some absolutely determinate way.* The acceptance of bare particulars (ABB) in the ontological sense is equivalent with accepting that *one or more particulars at one or more times exist without existing in some absolutely determinate way.* Consider the economy of RBB vs. ABB. As every perceived particular has some absolutely determinate form and size and so forth, it suffices to suppose that *all* particulars —those which are perceived and those which exist at some time but are not perceived at that time— exist in some absolutely

[35] A TSU does not exist in any location in the sense that location can be defined only in relation to another location, and the location of a TSU cannot be defined in relation to anything else. In DU the location of a TSU can be defined in terms of the distance from the abstract center point of the TSU and vice versa, but the location of the fusion of the center point and the TSU cannot be defined.

determinate ways, i.e., RBB suffices. In ABB it is supposed that in addition to the non-bare particulars, some bare particulars exist at some times somehow as propertyless substances. Economy favours RBB over ABB, for the commitment that all particulars are of the same type (non-bare) is simpler than the commitment that there are two types of particulars (bare and non-bare). Therefore RBB is postulated and ABB is rejected. Bare particulars can be applied as useful fictions if needed, but fictions are nothing over and above mental states (§§4.12, 7.6). In Bunge's [69, p. 26, 57] words, "there are no bare individuals except in our imagination" and "there is no formless substance except as a useful fiction." See Bailey [38] for an in-depth attack on bare particulars.

II AXIOM FOR LAWS: all parts of the present TSU are causally connected. Perceptions testify that the Moon stays on its orbit around the Earth, that the Earth stays on its orbit around the Sun, that parts of smaller objects such as rocks and atoms somehow remain attached to one another, and so forth. This raises the metaphysical question of why is this so. The hypothesis that all parts of a TSU are causally connected by gravitation, chemical bonds, nuclear bonds and other influences suffices as an explanation, and this is postulated as an axiom of EUO in the absence of other explanations. This axiom is thus an explicit postulation of the laws of nature that dictate what relations hold between particulars. DU is applied as the provisional model of physics which is coupled with EUO, i.e., DU's descriptions of the laws of nature are applied, i.e., DU's metaphysical postulates are applied. The form of this axiom conforms to Armstrong's formulation of laws of nature as relations between universals: properties instantiated by a particular.[36] To illustrate, the Earth and the Moon instantiate mass properties, and the relation of gravitational attraction between the Earth and the Moon is an instantiation of a law of nature as it is a realized relation between realized properties.

III AXIOM FOR CAUSAL SUCCESSION OF TSUS: the present TSU is the consequence of the preceding TSU and the cause of the succeeding TSU. This axiom is an expression of the *law of cause and effect*, i.e., the principle that each event has its cause, fitted in the context of presentism in the cosmological scale. This axiom was formulated already in the Ancient Greece e.g. by Hippocrates of Cos:[37] "Every natural event has a natural cause." Various modern formulations are available.[38] The need for this axiom can be understood by looking at the basic structure of DU, where all parts of the Universe move and there are two kinds of movement: movement *in* space and movement *of* space (expansion of the Universe). The parts of TSU t with their energies of motion are the cause of TSU $t + 1$ and the consequence of TSU $t - 1$. It is a small step from the axiom for cause and effect to the conservation law of energy (CLE), for it is only the step of adding that every cause has an equal effect. These are connected in William Whewell's axioms:[39] "(1) nothing takes place without a cause, (2) the magnitude of an effect is proportional to the magnitude of its cause, and (3) to every action there is an equal and opposed reaction." (1) is compatible with the axiom for causal succession of TSUs whereas (2) and (3) seem to be expressions of CLE or very close to it. In DU the axiom for cause and effect is accepted, and explicitly complemented by the *zero-energy* formulation of CLE, which finds roots in G. W. Leibniz (§5.1).

This axiom can be considered as an expression of *general causation*, whereas an expression of *singular causation* would be the statement that the 1st TSU of the year 2016 caused the 2nd TSU of the year 2016. Consider two characterizations of the dichotomy:

[36] See Armstrong [17], [19, p. 76] and §4.10.
[37] As quoted in Meadows [262, p. 12].
[38] See Bugajak [66, p. 90], Losee [231, p. 129], Meadows [262, p. 12] and Bergman and Collins [47].
[39] As quoted in Losee [231, p. 129].

> Singular causation applies to cause-effect relations that occur in a single fragment of the world's history. Examples of singular causal claims include, "The collapse of the Tacoma Narrows Bridge was caused by wind," and "The cholera outbreak was caused by a contaminated well." General causation addresses the kinds of events that can cause some chosen kind of effect. Examples of general causal claims include, "Smoking causes cancer," and "Bribes encourage corruption." Kutach [212, ch. 1.4]
>
> Singularist theories of causation deny that general relations between types of events (like the relation expressed in "Electrons repel other negatively charged particles") are more basic than singular relations between particulars (like the relation expressed in "This electron is repelling that electron"). Singularism, finally, is just the thesis that some singularist theory of causation is true. Rota [340]

In Mellor's view [266, pp. 6-7] general causation is merely generalisation of singular causation and according to Broadbent [62, p. 54] general causation is reduced to singular causation: both of these views certainly seem to be plausible in the light of this axiom, for the postulate that all TSUs are in a causal succession is equivalent with a conjunction of postulates concerning particular TSUs; in this sense there is no decisive difference in general and singular causation. This axiom can thus be considered primarily as an explicit acceptance of the primitiveness of causation. Rota characterizes primitive causation:

> Ontological primitivism with respect to causation, then, would be the view that the relation of causation is a basic or primitive relation; it cannot be reduced to any other relation, or set of relations, or any other ontological items whatsoever. Rota [340] especially

The attempt to somehow reduce causation ontologically to something even more fundamental seems to be equivalent with the attempt to reduce movement to something more fundamental, and therefore I do not even try to do so. This is also the starting point of Rota [340]: "Perhaps the reason that we haven't yet found a successful reductionist analysis... is simply that there isn't one to be found—perhaps causation is primitive." In sum, as there seems to be no prospects of reducing causal succession of TSUs to something else, it is accepted as an axiom. Alternative versions of this axiom are evaluated in §4.11.

4.8 Theorem: Naturalism

Naturalism can be formulated as the doctrine that *everything that ever exists is directly or indirectly causally connected to everything else that ever exists.* This definition conforms to Popper's [314, p. 10] *causality principle* and is analogous to Armstrong's [16, I, p. 138] use of 'naturalism' in the sense of one-world ontology. Naturalism contradicts the existence of causally isolated or *transcendent* things and the function of naturalism is to explicitly reject these from EUO.

Naturalism can be derived as theorem from the axioms for presentism and causality, as follows. (i) Presentism states that everything that exists is a part of the present TSU. (ii) Causality states that all parts of the present TSU are causally connected. The fusion (i-ii) runs as: everything that exists is a part of the present TSU and all parts of the present TSU are causally connected. (iii) Causality also states that the present TSU is the consequence of the preceding TSU and the cause of the succeeding TSU. The fusion (i-iii) determines cumulatively (§4.11) the single sequence of TSUs as all that ever exists, where all parts of each individual TSU in the sequence are causally connected, and where all consecutive TSUs in the sequence are in a causal succession. Naturalism has thereby been derived, as everything that ever exists is a part of the sequence, and is directly or

indirectly causally connected to everything else that ever exists in the sequence. The single sequence is named as the Universe. Naturalism can thereby be also formulated as the doctrine that *all parts of the Universe are directly or indirectly causally connected* and *all that ever exists is a part of the Universe*. The meaning of naturalism is illustrated in terms of two arbitrary particulars x and y. There are two alternatives: (1) x and y are realized at the same time; (2) x and y are realized at different times.

(1) As x and y are realized at the same time, they are parts of the same TSU. Therefore, they either overlap or are spatially separate. If they overlap, they are obviously causally connected. If they do not overlap, they are still causally connected as presentism and causality imply this. To illustrate, e.g. an atom on Earth is gravitationally connected to the Earth; the Earth is gravitationally connected to the Sun; the Solar System is connected to the Milky Way; the Milky way is connected to some cluster of galaxies; and so forth up to the TSU as a whole. Therefore, all parts of a single TSU are causally connected, directly or indirectly. Such gravitational connections are characterized in terms of a system of *nested energy frames* in the Dynamic Universe model,[40] and their acceptance resembles *Mach's Principle* (p. 26).

(2) As x and y are realized at different times, they are parts of different TSUs. Either x is realized earlier than y or vice versa. Suppose that x is realized earlier than y. As all parts of a single TSU are causally connected, all parts of TSU X whose part x is are causally connected, and all parts of TSU Y whose part y is are causally connected. The causality axiom implies that X and Y are causally connected, for X participates in the following chain of temporally and causally connected TSUs: X, X+1, X+2, ..., Y. In sum, x and y are causally connected in the sense that x is causally connected to all parts of X, X as a whole is causally connected to Y as a whole through the TSUs in between X and Y, and y is causally connected to all parts of Y.

To illustrate that naturalism is conclusive, consider the following question. Is your mental state x_M today when reading this sentence the cause of the state of a dust particle y in Andromeda after a million years from now? Claiming that x_M is *the cause* of y is very different from claiming that x_M and y are at least indirectly causally connected. First, as the mental state x_M is inseparable from particular x, we can talk about the causal connections of x (§4.12). Second, x is a part of the present TSU t and thus causally connected to every part of t. TSU t causes TSU $t+1$, which causes $t+2$, which causes $t+3$ and so forth. This way, x participates in causing the chain of TSUs where the dust particle y resides in Andromeda after t + one million years. But this does not mean that x would cause the state of y in the same way as e.g. you affect the state of a rocking chair by sitting on it.

4.9 Rejection: Transcendism and Modal Realism as a Version of Transcendism. The Roots of Naturalisation in Aristotle's Naturalisation of Platonism

Transcendism[41] is rejected as an uneconomical alternative to naturalism. In the context of naturalism the *actual world* —our world as the world where we reside— is exactly the

[40] See §5 and Suntola [384, §4.1.4, pp. 29, 34, 48-49, 70, 101].

[41] 'Transcendism' denotes here solely the metaphysical doctrine that violates naturalism and which commits to the existence of 'transcendent' or other-worldly entities. E.g. Kant's *transcendental idealism* is compatible with naturalism (See Stang [374]). A *transcendental proof* or argument is not involved with transcendism. One translation is that a transcendental proof of X is that X is necessary: "Transcendental proofs are like demonstrations in that transcendental proofs provide necessity. That is, the conclusion of

same thing as the Universe and accordingly all parts of the Universe are actual. Economy favours naturalism, for naturalism is sufficient and gets by with one single world whereas transcendism adds one or more worlds that are causally isolated from the actual world. This is a sufficient reason for rejecting transcendism. Armstrong was clear about this:

> The reason why we need not take the worlds realistically is that they have no causal or nomic links with the actual world. ... The actual world will be no different whether they are there or are not. Why, then, give the possible worlds ... any existence (Armstrong [21, p. 68])? But if the entities postulated lie beyond our world, and in addition have no causal ... connection with it, then the postulation has no explanatory value. ... Other possible worlds, whether Leibnizian or Lewisian, are not thought to have any effect on our actual world. Nor is there thought to be any non-causal law of nature linking such worlds with our world. Armstrong [18, pp. 7-8]

It is important to reject transcendism because it is highly confusing. The most direct sing of its confusing nature is that even its rejection results in terminological ambiguities, but these ambiguities must be temporarily accepted as transcendism has already entered the philosophical thought. The actual world is selected as the stable anchor which must be used in discussing transcendism, while the meaning of 'the Universe' is left floating in the below combinations. Naturalism as the combination A&B is depicted on the top of figure 8. A version of transcendism is either not-A&B, A&not-B or not-A&not-B.

A: all parts of the Universe are directly or indirectly causally connected.
B: all that ever exists is a part of the Universe.
not-A: some parts of the Universe are not causally connected even indirectly.
not-B: something that exists at some time is not a part of the Universe.

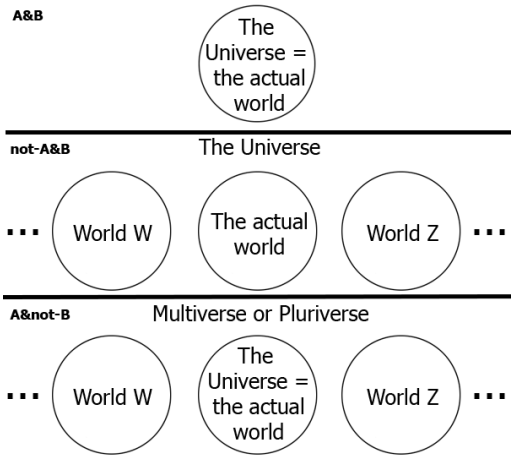

Figure 8: A&B on the top; not-A&B on the center; A&not-B on the bottom.

not-A&B is depicted on the center of figure 8. As always, we are situated in the actual world. As B is sustained and A is rejected, the Universe is the repository of worlds that are absolutely causally isolated from each other, and where the actual world is one of these worlds. All other worlds are *transcendent* with respect to the actual world, which

a transcendental proof must be true" (Bayne [45, p. 33]). Bunge [68, p. 74] uses the term *transcendent* to denote anything that is not necessarily observable.

means that they are causally isolated from the actual world.[42] Given any world, all other worlds are transcendent to it. When X and Y are different worlds, it is absolutely impossible for X to have any direct or indirect effect on Y in any way, and vice versa; if there were a chain of effects between X and Y, then they would be parts of the same world. Even if transcendent worlds would exist, these could not affect the actual world. This remark points the attention towards that sense of 'transcendent' which *does* affect us. Only *ideas* about transcendent worlds in the thinking of some people living in the actual world affect us. And this reveals the sense in which 'personal transcendism' can do something that 'personal naturalism' cannot. The *belief* itself in transcendism may guide the actions of a person; a person who does not have this belief is not affected by the belief.

A&not-B is depicted on the bottom of figure 8. Sustaining A allows us to call the actual world the Universe. As B is rejected, something that exists at some time is not a part of the Universe. It follows that the container of all things that ever exist must be given another name, such as *multiverse*, or *pluriverse* as Armstrong [29, p. 95] calls it.

not-A&not-B is depicted in figure 9. The overall collection of all worlds and collections (of collections, ad enough) of worlds is called *multi-pluriverse*. The rejection of A implies that the Universe contains at least two worlds which are causally isolated from one another. The rejection of B implies that there exists worlds also outside the Universe. Whether these exist individually or inside a container depends on imagination. Likewise, the actual world is drawn as an element of the Universe by free association.

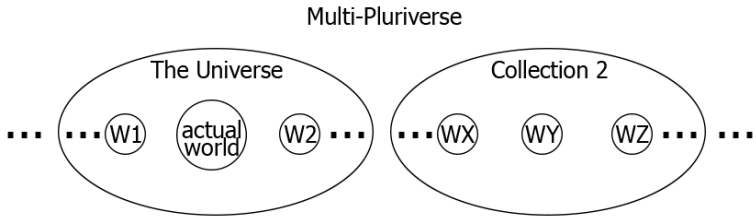

Figure 9: The combination not-A&not-B.

SOME DEFINITIONS. Four definitions are given which are compatible with both naturalism and transcendism, and one definition which is incompatible with transcendism, in order to underline that the rejection of transcendism requires both A and B. (1) This definition allows the existence of transcendent parts of the physical world: "The physical world consists entirely of physical facts. What is not a physical fact is not part of the physical world. And physicalism is the thesis that the physical world is the only world there is, or the only world that is real" (Stroud [379, p. 264]). (2) This definition allows that the actual world contains transcendent parts: "Actualism is the doctrine that there are no things that do not exist in the actual world" (Adams [3]). (3) This definition only requires that if there exists a transcendent world X, then everything in X affects something else that exists in X: "everything that exists makes a difference to the causal powers of something" (Armstrong [26, p. 41]). (4) This definition allows that nature contains transcendent worlds: "The hypothesis that nothing but nature, the single, all-embracing spatio-temporal system exists" (Armstrong [16, I, p. 138]). It can be safely

[42]The causality principle A is in practice altered into causality-within-a-world: all parts of world x are causally connected (directly or indirectly). Otherwise there would be no sense in talking about 'actual world' —nor about any world— for if causality-within-a-world would not hold in the actual world, then the actual world would contain causally isolated worlds.

assumed that Armstrong especially intended to reject everything transcendent, but without A, the *single all-embracing spatio-temporal system* can contain transcendent parts. (5) This definition incorporates A by 'related' and B by 'single': "All the particulars which we have any reason to postulate are related to each other in a single space-time" (Armstrong [16, II, p. 63]).

REJECTION OF MODAL REALISM AS A VERSION OF TRANSCENDISM. David Lewis [221] presented modal realism as the ontological base for counterfactual analysis or more generally for possible worlds semantics or just a theory of possibility. According to Williamson [411, p. 10] "Lewis's modal realism gave him a way of informally explaining what a possible world is in non-modal terms: roughly, a spatiotemporal system; the individuals in such a system are spatiotemporally connected to each other and to nothing outside the system." Consider Lewis' orientation behind modal realism:

> I believe that there are possible worlds other than the one we happen to inhabit. If an argument is wanted, it is this. It is uncontroversially true that things might be otherwise than they are. I believe, and so do you, that things could have been different in countless ways. But what does this mean? Ordinary language permits the paraphrase: there are many ways things could have been besides the ways they actually are. On the face of it, this sentence is an existential quantification. It says that there exist many entities of a certain description to wit 'ways things could have been'. ... I therefore believe in the existence of entities that might be called 'ways things could have been'. I prefer to call them 'possible worlds'. ... When I profess realism about possible worlds, I mean to be taken literally. ... Our actual world is only one among others. We call it alone actual not because it differs in kind from all the rest but because it is the world we inhabit. Lewis [221, p. 84-5]

Lewis is correct in noting that a theory of modalities requires ontological foundations, but it is another question that what are the minimal and sufficient foundations. It will be shown in §7 that EUO is a sufficient ontological foundation for such a theory —including counterfactual analysis and complementations about physical possibilities, fictions and logical possibilities— and thus transcendent foundations are not needed. Therefore it suffices to show here that modal realism is uneconomical with respect to EUO. Showing this requires only seeing that modal realism is a version of transcendism: Lewis [223, p. 78] explicitly states that the possible worlds are causally isolated from one another. Modal realism is thereby rejected as uneconomical. Rejecting modal realism is important because it is the prime version of contemporary transcendism and thus one of the prime sources of confusion in philosophy. According to Williamson [411, p. 8] Lewis is the "most influential figure in the development of analytic metaphysics over the final quarter of the twentieth century, and the contemporary philosopher most cited within recent analytic philosophy." Therefore it is important to emphasise that there are no *economical* reasons for following Lewis' ideology, i.e., that it is not just a matter of taste whether one is a modal realist or not.

Consider Lewis' [221, pp. 86-8] arguments for modal realism. Arguments (i-ii) do not favour modal realism in any way and are thus not commented. (i) Transcendent worlds cannot be rejected just by saying they do not exist. (ii) A non-actual possibility is confined to one world only and thus does not pose problems for individuation. (iii) Transcendent worlds cannot be rejected on the basis of parsimony (economy), for Lewis maintains that modal realism does not add more *kinds* of entities or more *qualities* but only adds quantitatively more entities, as for Lewis all possible worlds are of the same kind and only qualitative parsimony is "good in a philosophical or empirical hypothesis." This argument is nothing more than a sleight of hand, i.e., Lewis basically insists that his theory should not be evaluated by a fair criterion. First, if transcendent being is

not different in kind than actual being, then what is different in the first place? Second, even if it is accepted that the other worlds are not qualitatively but only quantitatively different, it is unbearable to disregard the importance of quantitative parsimony. For, if quantitative parsimony would not matter, then e.g. a spatially infinite TSU would be as economical as a finite one. It is essential that both aspects of parsimony must be taken in account, for the quantity of one kind of a metaphysical entity can compensate the number of different kinds of metaphysical entities. (iv) Lewis' strongest argument is that modal realism is the only successful attempt he knows that manages to systematize the modal opinions that there are not just tables and chairs but that these could have been arranged differently. As EUO manages to systematize just these opinions but without transcendism, the principle of economy favours it over modal realism.

ARISTOTLE'S NATURALISATION OF PLATONISM. Thus far, transcendism has only been rejected, but concepts defined in terms of a transcendist ontology have not been naturalised yet, i.e., they have not yet been defined in terms of EUO. Both the rejection of transcendism and its naturalisation were initiated by Aristotle as a reaction to Plato. The roots of transcendism can be traced back at least to Plato[43] according to whom forms such as *sphere* and *goodness* reside in a 'heaven.' This is where the term 'Platonic heaven' derives from. The Platonic heaven is a repository which contains the forms, and Plato's theory of forms or *Platonism* is the doctrine that the forms exist in their own realm that is separate from the objects in the actual world. As the Platonic heaven as the realm of forms is not causally connected to the objects, the Platonic heaven is analogous to a transcendent world. Aristotle rejected Plato's theory of forms and replaced it by a naturalist theory where (a) forms are forms of objects and forms do not exist separately from the objects, and where (b) conceptualised forms exist, i.e., ideas that are realized in minds of human beings about other ideas and objects exist.[44] The forthcoming naturalisations are merely versions of what Aristotle did. (a) is equivalent with the naturalist definition of properties and universals in §4.10. (b) is equivalent with the definition of abstract as thought in §4.14. As Lewis' modal realism is merely a contemporary version of transcendism, also its rejection and the giving of naturalist foundations for modalities in §7 are continuous with what Aristotle started.

RECONCILIATION OF PLATONISM AND NOMINALISM. According to the *PhilPapers* survey, of 1803 philosophy faculty members and/or PhDs, 40.8% accept or lean toward nominalism and 36.3% accept or lean toward Platonism. This lack of consensus gave the initiative to reconcile them. If these are contradictory theories then they cannot be fitted together. They are contradictory when Platonism is interpreted as a theory where abstract objects and universals exist as transcendent entities,[45] and where nominalism especially rejects everything transcendent; according to Rodriguez-Pereyra [336], one version of nominalism rejects the existence of abstract objects and the other rejects the existence of universals. However, the applicable ingredients of Platonism can be incorporated by defining 'abstract' and 'universal' in a way that is compatible with nominalism. This can be done by defining these in terms of EUO which is a naturalist ontology. That is, the ontological function of nominalism is interpreted here to be equivalent with naturalism, or equivalent with the fusion of naturalism and physicalism, which are both implied by presentism and causality. This is compatible with Rodriguez-Pereyra

[43]E.g. *Republic* 509d-511e, *Phaedo* 65d, 76d-e, *Phaedrus* 247c.

[44]See e.g. *Metaphysics* 991a, 1033b, *Physics* 259a, , and *On Ideas* which has survived only in Alexander Aphrodisian's commentary of *Metaphysics*. Also Armstrong [26, p. 22] [19, preface] supports the view that forms do not exists independently of objects.

[45]E.g. Balaguer [40] and Cheyne [83, pp. 2-3] define Platonism as the metaphysical doctrine that completely causally inert and non-spatiotemporal abstract objects or universals exist.

(*ibid*): "what motivates Nominalism (in one of its senses) is basically the rejection of non-spatiotemporal and causally inert objects." Compatibility with nominalism, when interpreted to be equivalent with the fusion of naturalism and physicalism, is guaranteed by defining abstract things as thoughts of human beings (§4.14), and by defining universals as properties, and properties as ways of how particular exist (4.10). In sum, when EUO is accepted to be a nominalist ontology, versions of 'nominalism' become definitions on the top of EUO (§4.10).

4.10 Definitions: Properties; Universals. Theorem: the Principle of Instantiation

Properties and universals are defined in terms of the axioms for presentism and causality; the principle of instantiation follows as a side product.

(1) By presentism and causality and the definition of particulars, particulars are all that ever exist, there are no causally isolated transcendent particulars (§4.8), and there are no bare particulars, i.e., when a particular exists it exists in some absolutely determinate way rather than in no way at all (§4.7).
(2) Property is an absolutely determinate way of how a particular exists.
(3) Properties may be called universals. A universal is thereby a property which is instantiated by a particular in the past, present or in the future (cf. Armstrong [19, p. 76]), and no transcendent universals exist. This is close to Armstrong [26, p. 38] who advocates the conception of "universals as ways, ways things are and ways things stand to each other." This definition can be complemented: the more instantiations a property has during a given time interval, the more universal it is within that interval.
(4) The principle of instantiation, according to which all universals are instantiated in particulars and there are no uninstantiated universals (Armstrong [19, pp. 75-81]), follows from (1-3): as particulars are all that ever exist, as properties are solely properties of particulars, as properties are universals, and as transcendism is rejected, there is no other place for properties to exist than in particulars.

Again, a property is an absolutely determinate (absolutely precise) way of how a particular is. The notion of an absolutely determinate property can be grasped by contrasting it to a *determinable range*[46] of properties. For instance, *mass* is a determinable range of properties, whereas a single mass property such as *1 kg* is absolutely determinate, qualified by the precise numeric value 1 of the unit *kilogram*; *atom* is a determinable range of properties, whereas a single atom property such *hydrogen* is absolutely determinate, qualified by the precise numeric value 1 of the unit *atomic number*; *length* is a determinable range of properties, whereas a single length property such as *1 metre* is absolutely determinate, qualified by the precise numeric value 1 of the unit *metre*.

A determinable range is an abstraction which is thought to contain two or more properties which are such that a particular cannot instantiate any two of them simultaneously in the same respect. A particular can instantiate the property *1 kg* which belongs to the determinable range *mass*, but it follows from the law of non-contradiction that a particular cannot instantiate simultaneously in the same respect any other property such as *2 kg* which belongs to the range *mass*. A particular can instantiate the property *hydrogen*, but a particular cannot instantiate simultaneously in the same respect any other property such as *oxygen* which belongs to the range *atom*. Similarly for all ranges. Because of this reason, Simons [362, p. 20] calls determinable ranges *exclusion families*.

[46]See Armstrong's definition [16, II, pp. 112, 117] and Johnson's [189, ch. 11] original definition.

DISJUNCTIONS AND CONJUNCTIONS OF PROPERTIES. A particular cannot literally instantiate a determinable range, but expressions such as *red*(x) and *atom*(y) are meaningful. *red*(x) means that particular x instantiates *some* property in the range *red*, and *atom*(y) means that particular y instantiates *some* property in the range *atom*. As a disjunction of properties, the range *atom* can be expressed e.g. as: *hydrogen* or *helium* or *lithium*, or ... or *atom-n*, where *atom*(y) means that y instantiates one of the disjuncts. Likewise, the range *1 kg or 2 kg* contains two mass properties, which makes it evident that *1 kg or 2 kg*(z) means that particular z instantiates one of the disjuncts: either the property *1 kg* or the property *2 kg*, but not both. While a disjunction of properties is not a property, some conjunctions of properties can be called a property (Armstrong [16, II, chs. 14-15]). Consider particular x which has a certain mass M, a certain colour C, and a certain geometrical form F. This can be expressed e.g. as $M\&C\&F(x)$, where the conjunction of properties $M\&D\&F$ may be called a property of x.

RESEMBLANCE AND IDENTITY OF PROPERTIES. As properties are ways of how particulars are, saying that two properties which are elements of some range resemble, is an indirect way of saying that two or more particulars resemble in some respect. For instance, the closer two properties are in the range *length*, the more they resemble one another with respect to length: *2 metres* resembles *10 metres* more closely than *1 metre* resembles *10 metres*. This is equivalent with saying that a *2 metres* particular resembles a *10 metres* particular more closely than a *1 metre* particular resembles a *10 metres* particular, with respect to length. In this scenario e.g. the following expressions are equivalent characterizations of particulars x and y:

(a) x and y resemble absolutely with respect to length.
(b) x and y are identical with respect to length.
(c) x and y instantiate the same length property L.
(d) x and y are elements of class $[L]$ whose all elements resemble absolutely with respect to length.

Let us take (a) and (c) under scope and contrast the given suggestion with *resemblance nominalism*, which is defined by Rodriguez-Pereyra [336] as: "it is not that scarlet things resemble one another because they are scarlet, but what makes them scarlet is that they resemble one another."

The given suggestion: (a) $\leftrightarrow$ (c)
Resemblance nominalism: (a) $\rightarrow$ (c)

In the given suggestion, (a) and (c) are equivalent statements about x and y, and the only primitive entities are x and y. In resemblance nominalism (a) and (c) are not equivalent, resemblance is taken as primitive and the task is to somehow reduce properties to the resemblance of particulars. The given suggestion can be defended by economy, which favours presentism and causality, which in turn imply that all particulars which ever exist, exist in certain ways rather than in no way at all. Calling the ways that particulars exist properties and universals adds only terminology to EUO. As particulars are primitive in EUO, the resemblance of particulars follows from the particulars themselves, i.e., resemblance of particulars is nothing over and above the particulars (cf. Armstrong [19, p. 56], Rodriguez-Pereyra [335, pp. 120-1]). If one works in the context of presentism and causality, there are no genuine alternatives to accepting that (a) $\leftrightarrow$ (c) holds, and the project of trying to reduce properties to resemblance classes can at best result in formulations of equivalent expressions. Therefore, in the context of EUO, resemblance nominalism of the kind (a) $\rightarrow$ (c) cannot hold, and if a 'resemblance nominalism' holds in EUO, we are dealing with a semantical or a terminological construction on the top of EUO where (a) $\leftrightarrow$ (c) holds. Then again, if a version of resemblance nominalism is built on an

ontology that is genuinely different from EUO, the case comes down to evaluating their complexities. The question is that what exactly is different in a nominalist ontology. At least naturalism is implicit in nominalism as well as in EUO (§4.9). If also physicalism is implicit in nominalism, then there are no bare particulars, i.e., when a particular exists it exists in some absolutely determinate way rather than in no way at all; if so, why cannot (a) $\leftrightarrow$ (c) hold?

4.11 Theorem: Eternal Universe

Presentism gives the present TSU p, and the causality axiom states that p is the consequence of the preceding TSU $p-1$ and the cause of the succeeding TSU $p+1$. This implies that the Universe is eternal: that the past is infinite and the future is potentially infinite.

THE PAST IS INFINITE. Presentism gives p which is the only TSU that exists. Given p, causality states that $p-1$ did exist; given that $p-1$ did exist, causality states that also $p-2$ did exist; given that $p-2$ did exist, causality states that also $p-3$ did exist; and so on infinitely.

THE FUTURE IS POTENTIALLY INFINITE. Presentism gives p which is the only TSU that exists. Given p, causality states that $p+1$ will exist; given that $p+1$ will exist, causality states that also $p+2$ will exist; given that $p+2$ will exist, causality states that also $p+3$ will exist; and so on potentially infinitely. Given any assigned time $p+n$ in the future, some finite sequence of TSUs will be realized at times $p+1, p+2, \ldots, p+n$. Yet, an infinite sequence of TSUs will not be realized in the future: the future will never be complete, for one present TSU will always come after another. As the future is never complete, there is no such thing as 'all' TSUs which will be realized in the future. This raises a tension because when you think of the future, your mind forces you to think about it as a completed stretch, but the notion that it is potentially infinite and never complete simultaneously indicates that thinking about it as a completed stretch is misleading. This reasoning is compatible with Rundle:

> But while there cannot be a time when, starting from the present, the universe will have existed for an infinity of years, this does not debar us from saying that it could go on for an indefinitely long period of time, that it could continue in existence for the foreseeable future, even that it could go on for ever; Rundle [341, p. 179]

ALTERNATIVE VERSION OF CAUSAL SUCCESSION. Alternative interpretations about whether all TSUs at all times in the past, present and future are similarly causally connected are evaluated by the principle of economy. The central interpretations are depicted in figure 10, and axioms (1-4) which imply these interpretations are listed below, where (1) is the given version of the causality axiom.

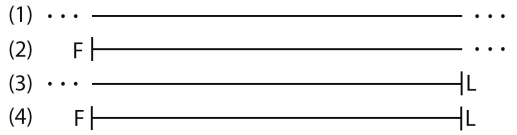

Figure 10: Alternative versions of the causal succession of TSUs.

(1) TSU p is the cause of $p+1$ and the consequence of $p-1$.
(2) (1) holds for all TSUs except for the first TSU F which is the cause of F+1 but not

a consequence of any TSU.
(3) (1) holds for all TSUs except for the last TSU L which is the consequence of L-1 but not a cause of any TSU.
(4) (1) holds for all TSUs except for F which is the cause of F+1 but not a consequence of any TSU, and for L which is the consequence of L-1 but not a cause of any TSU.

Given (1), all TSUs are of the same type as all are both causes and consequences. In (2) the first TSU F is not a consequence of anything. In (3) the last TSU L is not a cause of anything. In (4) F is not a consequence of anything and L is not a cause of anything. The principle of economy thus favours (1) over (2-4) based on qualitative economy. Note especially that economy does not favour rejecting the premisses of the eternal Universe theorem on the basis that more things are supposed to exist if the past is infinite than when the past is finite; for, only the present exists in EUO, i.e., supposing that the infinite past *did exist* does not increase the metaphysical weight of EUO, as long as the same axioms are supposed to have held for each past TSU —all of which once were present— which is the case with (1). In addition to plain economy, (2-3) are bothered by counter-intuitive implications. The primary lessons about the forthcoming analysis are that (1) does not suffer from the counter-intuitive implications, and that cosmology is tightly interrelated with philosophical questions.

First, either F was born out of nothing or the length of F was infinite, and either L will vanish into absolute nothing or its length is potentially infinite. As the lengths of all other TSUs are finite (§4.3), the exceptional-length solution further increases the metaphysical weight of F and L and thus of (2-4). If the exceptional-length solution is rejected, the problem becomes to make sense of birth out of nothing and of vanishing into nothing. Instead of seeing birth out of nothing as a problem, for Craig [412] it gives a function to God, i.e., to the explanation that God is the first cause that created the Universe. On one hand, if one wishes to call the TSUs which preceded F as 'God-times' and if these are of a different type than the rest, then we are dealing again with parameters; on the other hand, if God is totally separate from the Universe, then we are dealing with uneconomical transcendism and there is also the problem that how could God affect the Universe; on the third hand, if the TSUs before F are like all the rest, then we are dealing with (1) or (3). For Craig this cannot be the case for he especially argues that the past cannot be beginningless, i.e., that it cannot be infinite. Craig has two central arguments.

Craig's [412, p. 12] central a priori argument is that various absurdities would result if an actual infinity were to be instantiated in the real world. The primary remark here is that in EUO there are no actual infinities in the sense of a *completed totality whose all parts exist simultaneously* which is the meaning of 'actual infinity' in mathematics when applied to abstract entities such as the set of all natural numbers. Spatial infinity and infinite divisibility are especially rejected by the finiteness axiom; the past especially does not exist in EUO but it did exist, for this is what presentism means. It is true that the Universe has infinitely may parts for in EUO the past is infinite, and as the Universe is equivalent with the actual world, in this sense we are dealing with *the actual world with an infinite past*, but again, the past does not exist at the present. Craig makes an analogy of the past and an actually infinite library whose manipulation would have paradoxical consequences. Morriston [279, p. 148] correctly answers that the past cannot be manipulated. Morriston also rejects Craig's other a priori arguments against the infinite past. The central a posteriori argument of Craig and Smith [412] is the Big Bang theory of the standard model cosmology. Reichenbach reviews how Craig could be answered in terms of the relativist standard cosmology. The answer seems to be very

mysterious:

> [G]iven the Grand Theory of Relativity, the Big Bang is not an event at all. An event takes place within a space-time context. But the Big Bang has no space-time context; there is neither time prior to the Big Bang nor a space in which the Big Bang occurs. Hence, the Big Bang cannot be considered as a physical event occurring at a moment of time. ... Time might be multi-dimensional or imaginary, in which case one asymptotically approaches a beginning singularity but never reaches it. And without a beginning the universe requires no cause. The best one can say is that the universe is finite with respect to the past, not that it was an event with a beginning. Reichenbach [328]

This response replaces Craig and Smith's excessive metaphysics by relativistic metaphysics, where the background is the relativistic conception of tenseless eternalist space-time (§4.4,5.6.3). One way to understand Reichenbach's reply is to consider the past as a sequence such as 1, 0.5, 0.25, 0.125, ... which never reaches the singularity 0. One must ask that is a *Big Bang theory* which denies that the Big Bang itself is a physical event really plausible? Reichenbach seems to consider the past as the open interval]0, ..., 0.125, 0.25, 0.5, 1] where the Big Bang 0 itself does not exist as the cause but only its consequence exists. The question that how can a consequence exist without a cause remains, and it does no go away by trying to blur the case by a converging sequence or a mystical conception of time.

In contrast, the Dynamic Universe model (DU) starts by assuming that the previous singularity was merely a turning point from contraction to expansion: the contracting space was the cause of the singularity and therefore God is not needed as the cause. Craig and Smith's argument from the Big Bang theory is thereby exhausted in the context of DU, and DU is compatible with the eternal Universe theorem. There are basically two alternatives to combine DU with the eternal Universe theorem. First, one may suppose that the Universe was contracting for the whole infinite past, which how Suntola [384] visualises the case. When this alternative is considered backwards, the Universe should be growing infinitely backwards, unless one maintains that the growth rate decreases conveniently, and one may find difficulties from this approach. Second, one may fit DU with the *Bouncing Universe model* or the *Cyclic Theory of the Universe* where the past is an infinite sequence of contraction-singularity-expansion cycles (cf. Steinhardt [375]). Although such model is not analyzed in Suntola [384], Suntola personally considers it as the most obvious alternative.

4.12 Axiom: Ontological Realism

Ontological realism and its competitors are handled as versions of mental realism. Mental realism is defined and defended first, after which ontological realism is defined and defended as the most economical version of mental realism.

MENTAL REALISM. According to mental realism, mental states of human beings exist. This formulation is congenial with Kim's [199, p. 344] definition of mental realism as the doctrine that "mental properties are real properties of objects and events" and compatible with Restrepo's [331] definition of mental realism as "the doctrine that mental properties, objects, and events are a part of the causal structure of the world, and that they enter into causal relations as mental."[47] Mental realism is verified by direct experience: that you have first-person access to your conscious thoughts proves that your thoughts exist; that you think proves that your thoughts exist, as Descartes famously

[47]It is also congenial with the definitions of Demeter [106, p. 60] and Tozser [400, p. 337].

conjectured with his slogan *cogito ergo sum*. The only alternative to mental realism is to deny that your thoughts exists. Such a denial contradicts the evidence given by first-person access. Moreover, denying that your thoughts exist requires thinking, as the denial is an act of thinking. Mental realism is thus postulated as the only alternative that explains experiences.

ONTOLOGICAL REALISM. According to ontological realism, a proper part of the Universe is independent of human minds. This formulation is congenial with various formulations[48] including Niiniluoto's [289, p. 10] formulation: "At least part of reality is ontologically independent of human minds." When fitted in EUO, ontological realism becomes the doctrine that human beings with their mental states are proper parts of some temporal stages of the Universe and the other parts of the Universe are independent of the mental states of human beings.

VERSIONS OF MENTAL REALISM. When defending ontological realism, it is useful to apply the dichotomy of (a) *your mind* and (b) the rest of the Universe, where (b) denotes everything which does not overlap with (a), including minds of all the other people. This way it is easy to see ontological realism as the *mind-independence thesis*: (b) is independent of (a). Ontological realism may now be contrasted to other versions of mental realism, as depicted in figure 11. Starting from the top, plain mental realism leaves open

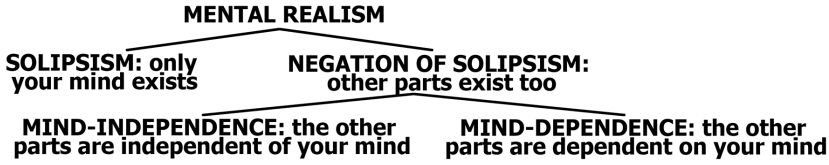

Figure 11: A classification of versions of mental realism.

whether your mind is all that exists or whether there exists something external to your mind, i.e., plain mental realism leaves open the selection between *solipsism* and its negation. The defence of ontological realism against solipsism is given the last. The negation of solipsism states only that something exists which is external to your mind, but leaves open the selection between ontological realism as the mind-independence thesis and the *mind-dependence thesis*. The mind-independence thesis may now defended against the mind-dependence thesis.

MIND-INDEPENDENCE VS. MIND-DEPENDENCE. Objects such as planets, stars and the other people seem to be independent of your mind. The mind-independence thesis is postulated as the explanation: they seem to be independent because they are independent. Accordingly, and as the apparent independence is not explained by supposing that they are dependent, the mind-dependence thesis is rejected.

The dependence of (a) on (b) and the subjectivity of (a) are compatible with the mind-independence thesis. Perception yields a sensation of a mind-independent object in your consciousness, where the sensation is in correspondence with the mind-independent object (§8.1). As your sensation reflects the mind-independent object, your sensation is in this sense dependent on the object, i.e., (a) is dependent on (b). The mind-independence thesis is not violated, as the dependence of (a) on (b) does not imply that (b) is dependent on (a). Changes in the perceived (b) change (a), but changes in the thoughts of the perceiver do not change anything in (b), and therefore (b) is independent of (a). Sensations about mind-independent objects are subjective in the sense that every conscious

[48]See e.g. Hirst [170, p. 77], Devitt [107, II.2.4] and Halldane [160, p. 15].

agent experiences the mind-independent objects in the particular way in which the agent happens to experience them, but the subjectivity of sensations does not entail that (b) is dependent on (a). E.g. Peirce and Mach insisted that there are no good reasons for confusing the subjectivity of sensations with the violation of the mind-independence thesis:

> Even the man in the street knows how external circumstances and sense organs affect our impressions of the world, so that it appears somewhat different to each one of us. Scientific experience confirms this, and teaches us further that sensation (perception) is determined by the final link in a chain reaching from the environment to the central organ of sense; in exceptional cases, it can occur spontaneously, without external stimulus, in the form of hallucination. ... placing too great an importance on these exceptional cases can easily lead to monstrous systems of idealism, or even solipsism. Mach [242, p. 39]
>
> The first step of Kant's thought ... is to recognize that all our knowledge is, and forever must be, relative to human experience and to the nature of the human mind. ... At this point, the idealist appears before the tribunal of your reason with the suggestion that since these metaphysical conceptions are ... only valid for experience and since all our knowledge is relative to human mind, they are not valid for things as they objectively are; and since the conception of *existence* is pre-eminently a conception of that description, it is a mere fairy tale to say that outward objects *exist*, the only objects of possible experience being our own ideas. ... Kant *never* said that. ... we have *direct experience of things in themselves*. Nothing can be more completely false than that we can experience only our own ideas. That is indeed without exaggeration the very epitome of *all* falsity. Our knowledge of things in themselves is entirely *relative*, it is true; but all experience and all knowledge is knowledge of that which is, independently of being represented. Peirce [304, 6.95]

The inseparability of human mind from human body (§4.13) is compatible with the mind-independence thesis. The inseparability entails that mental states are causally connected to all other parts of the TSUs where human beings are realized. However, all required causal connections are compatible with the mind-independence thesis. For instance, gravitational links do not qualify as links of mind-dependence, because (b) is in the relevant sense independent of the changes in (a). On the other hand, as the changes in (a) are also changes in the whole particular whose mental property (a) is, changes in (a) in this sense gravitationally influence all other parts of the TSUs. Calling such influences as *links of mind-dependence* is over-propagation, for such influences only remind that nothing is causally isolated: that there are no causally isolated things should certainly not be over-propagated into the heights of thinking that everything is mind-dependent. In the historical *Copenhagen interpretation* of quantum theory, it is supposed that there are superluminal influences between spatially separated particulars where a change in one particular especially changes the other. If such influences would exist, then also (b) could in principle depend on (a). However, in the Dynamic Universe model such influences do not have to be supposed, and as cited in §5.2, there are interpretations quantum theory which get by without such influences.

THE EQUIVALENCE OF EMPIRICALLY SUFFICIENT SOLIPSISM AND ONTOLOGICAL REALISM. If you are a solipsist, then your mind is absolutely everything that exists and nothing that exists is external to your mind: "solipsism states that the world is *my world*, or that everything there is equals to the contents of my thoughts" (Pihlström [310, pp. 15-16]); "It adopts a position that only acknowledges the existence of one's very own mind and opposes that there is anything beyond the realm of my mind that could be known" (Sötemann [368, p. 73]. Solipsism thus seems to propagate mental realism into heights where the dichotomy of your mind and the rest of the Universe has vanished. Similarly as with any internally coherent metaphysical postulate, the refutation of solipsism without having economy as the judge is impossible in the sense that

whatever arguments you provide, the solipsist can always say that it is in his mind, and he can qualify his mind by whatever further metaphysical commitments. For comparison, Pihlström [308, p. 275] notes that it is "trivially true that solipsism... cannot be conclusively refuted." Therefore, the prerequisite for refuting solipsism as uneconomical or insufficient is to first spell out the exact version of solipsism to be refuted, which is some system of metaphysical postulates that is coupled with the initial postulate 'my mind is all that exists.' In other words, the rejection of solipsism is a matter of searching for alternative versions of solipsism, explicating their metaphysical commitments, seeing if these are empirically sufficient, and if so then evaluating their metaphysical complexities against ontological realism.

Johnstone [190] classifies various versions or solipsism found in the literature. Due to space limitations, it is impossible to review these versions here. It suffices to note that Johnstone manages to refute various versions as empirically insufficient, but he is also forced to conclude that one version cannot be refuted, although it does not have any special empirical support either. Moreover, those versions that Johnstone manages to refute as insufficient can always be complemented by additional parameters which would make them sufficient, no matter how weird they look like. The decisive question is thus that is the minimal and sufficient version of solipsism more economical than ontological realism. The aim of the following proof is to show that a version of solipsism that is both empirically sufficient and minimal, must incorporate ontological commitments which make it practically equivalent with ontological realism, i.e., that the best solipsism can ever do as a metaphysical theory is to be equivalent with ontological realism. The idea that solipsism is equivalent with ontological realism can be found from Wittgenstein [413, p. 82]: "Here we can see that solipsism coincides with pure realism, if it is strictly thought out."[49] Given that they are equivalent, it becomes a matter of style or terminology whether ontological realism and a minimal and sufficient version of solipsism is used. However, some terminology must be used consistently, and the terminology of ontological realism is chosen because it matches the common use of language better.

An empirically sufficient and minimal version of solipsism is contrasted to ontological realism in figure 12, where the mind of the solipsist is depicted on the top and the mind of an ontological realist as a proper part of the Universe on the bottom. For a realist, perception yields verified beliefs about the rest of the Universe in the mind of the realist, and the rest of the Universe is independent of the mind of the realist. For a solipsist, there is no such thing as the rest of the Universe, as the mind of the solipsist is all that exists. The mind of the solipsist is classified in two parts: the sense-realm and the insensible realm. The sensations of the solipsist such as visual sensations, smell sensations and touch sensations are parts of the sense-realm. The solipsist senses e.g. the other people, trees, mountains and his own body; all these are parts of the sense-realm. The sense-realm is classified in two parts: the experienced part and the sensible-but-unexperienced part. The solipsist's dichotomy of sense-realm and insensible realm is analogous to the ontological realist's dichotomy of verifiable and unverifiable&unfalsifiable beliefs. The solipsist's dichotomy of experienced and sensible-but-unexperienced parts of the sense-realm is analogous to the ontological realist's dichotomy of verified and verifiable-but-unverified beliefs about the rest of the Universe. The solipsist's mind is thus analogous with the ontological realist's mind, with the crucial exception that the solipsist's mind

[49] As cited in Pihlström [310, p. 83]. According to Pihlström (*ibid*, p. 106) "transcendental kind of solipsism ... claims with Wittgenstein ... that solipsism is in the end not incompatible with, but rather indistinguishable from realism." See Pihlström (*ibid*, chs. 3-4) for remarks about transcendental solipsism. See definitions of 'transcendental' in p. 67.

does not contain the ontological realist's belief in the existence of the rest of the Universe.

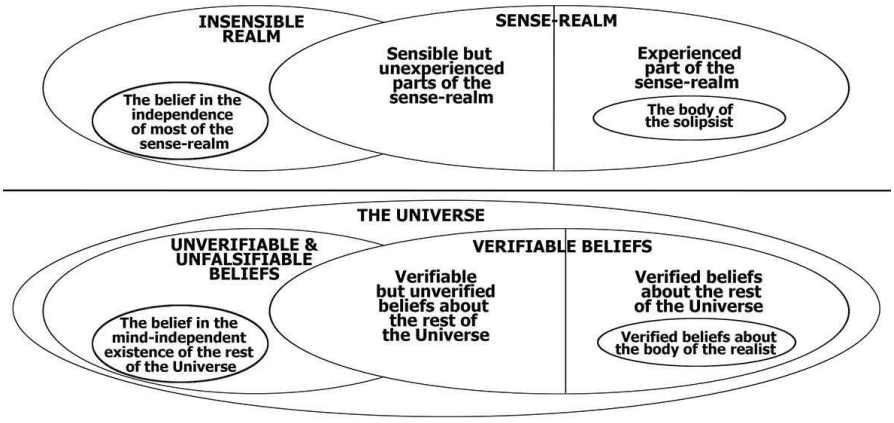

Figure 12: Solipsist's mind on the top. Ontological realism on the bottom.

The solipsist's sensations testify that the behaviour of most of the experienced parts of the sense-realm such as planets and stars and the other people who disagree about what the body of the solipsist says, is independent of the desires and hopes of the solipsist. Conversely, the solipsist's sensations testify that the body of the solipsist has a very special status compared to the other parts of the sense-realm, for the body typically behaves as the solipsist wishes. The body (especially the brain) is the nerve center of the solipsist, who senses when the body is manipulated and who experiences the sense-realm through the body. In order to explain these experiences, the solipsist must accept the link between his body (brain) and his thoughts, and the existence of two essentially different proper parts of the experienced part of the sense-realm: the very special body of the solipsist which is dependent on the hopes and wishes of the solipsist; the rest of the experienced part of the sense-realm which exists independently of the hopes and wishes of the solipsist.

These commitments are dangerously close to ontological realism where mind-independence is postulated as the explanation of why most things seem to be independent of your mind, and the mind of the realist is postulated to be inseparable from the body of the realist. In effect, the only difference between ontological realism and solipsism seems to be a naming convention: in ontological realism the Universe is all that ever exists and it is divided in your mind and the rest of the Universe; in solipsism your mind is all that ever exists and it is divided in that part which is dependent on your hopes and wishes and that part which is independent. This result is applied in §§6.2,6.3.

THE ARGUMENT FROM THE PAST. Niiniluoto presents another very straightforward argument for ontological realism:

> [W]e have very strong evidence from many fields of contemporary science that there was a point of time t_0 in the history of our planet when no human being had yet appeared through evolution. ... This gives us a powerful test of mind-independence: whatever existed before t_0 must be ontologically independent of human mentality and human cultural constructs such as concepts. This refutes all philosophical doctrines—such as subjective idealism, phenomenalism, solipsism, positivism and pragmatism (in some of their varieties), internal realism, and social constructivism, which literally claim that nothing exists independently of the human mind or that all objects are our constructions. Niiniluoto [291, p. 168]

Niiniluoto's argument functions as such in the context of presentism. Something additional could be invented to reject it, but everything additional is ruled out as uneconomical. For instance, an eternalist solipsist can maintain that he exists tenselessly and thus the past can be his mental creation, but eternalism is rejected in §4.4.

4.13 Theorem: Physicalism. Rejection: Mind-Body Dualism

Physicalism as the doctrine that *all that ever exists is physical* clarifies ontology and feeds economical unification (cf. Poland [312, p. 35]). When applied specifically in philosophy of mind, physicalism attaches mental to physical and functions as the base for rejecting all varieties of *mind-body dualism* where thoughts and minds can exist independently of bodies of human beings, which are physical particulars in EUO. The goal of attaching mental to physical is implicit also in Stoljar's [377] formulation of physicalism as "the thesis that everything is physical, or ... that everything supervenes on the physical" where the supervenience of mental on physical guarantees that everything mental is inseparable from something physical. The axioms of EUO imply physicalism as a theorem. The essential content of physicalism is embedded in this partial formulation of the causality axiom: every part of the present TSU realizes energy in an absolutely determinate location in an absolutely determinate way (§4.7). However, strictly speaking presentism and the full causality axiom are needed to imply physicalism as a theorem. Let this theorem be called TPC:

> All that ever exists is a part of the Universe and directly or indirectly causally connected to all other parts of the Universe, and realizes energy at some absolutely determinate time in some absolutely determinate location in some absolutely determinate way.

When the doctrine that *all that ever exists is a part of the Universe and all parts of the Universe are directly or indirectly causally connected* is abbreviated as *naturalism* (§4.8), TPC can be written as:

> Naturalism + all that ever exists realizes energy at some absolutely determinate time in some absolutely determinate location in some absolutely determinate way.

When *physical particular* is defined as *a particular which is endowed with energy, realized in an absolutely determinate location at an absolutely determinate time*, TPC can be written as:

> Naturalism + all that ever exists is physical.

Finally, as physicalism is the doctrine that *all that ever exists is physical*, TPC can be written as: *naturalism + physicalism*. This version of physicalism and thus also EUO are compatible e.g. with all 13 versions of physicalism listed by Stoljar [377], and with the following definitions: "The world could not have been different in any respect without having been different in some strictly physical respect" (Haugeland [164, p. 1]); "*Within a physicalist system*, once the physical facts and truths are fixed, then so are all the facts and truths" (Poland [312, p. 285]).

REJECTION OF MIND-BODY DUALISM. When ontological realism (a version mental realism) is coupled with physicalism as the theorem that physical particulars are all particulars that ever exist, the result is that some physical particulars are in some sense mental. However, the supervenience of mental on physical does not yet guarantee that human minds supervene on human bodies, for minds could in principle be considered as physical objects whose existence is independent of human bodies. Therefore, in addition to plain physicalism, it is explicitly supposed by economy that human minds supervene on physical human bodies. The inseparability thesis explains why the human mind seems to guide the actions of the human body, it disambiguates the theories of truth and possibility where propositions are considered as thoughts of human beings and which are thereby attached to human bodies, and it is more economical than to suppose that there exists mental things which are separate from the body. All forms of mind-body dualism are thus rejected.

PHYSICAL PARTICULAR WITH CONCRETE AND MENTAL PROPERTIES: THE DUAL-ASPECT THEORY? Thus far, it has been pointed out that the fusion of presentism, causality and ontological realism attach mental to physical, and the inseparability thesis especially attaches human minds to physical human bodies.[50] Accordingly, that *a mental thing exists* means that a physical particular exists which is in some sense mental. This can be expressed by saying that a physical particular has a mental aspect, that a mentality-involved particular exists, or that the particular has mental properties.[51] If *panpsychism* (see below) is true, then all particulars have mental properties. If panpsychism is false, then only some particulars have mental properties. In either case, all particulars have concrete properties. Supposed that some physical particulars have mental properties and some do not, physical particulars can be classified in two: physical particulars which have both concrete and mental properties; physical particulars which have concrete properties only; Stubenberg characterises the dual-aspect theory:

> All versions of the theory appear to be committed to the view that there are certain substances... that are intrinsically neither material nor mental. Nevertheless these substances can present themselves under the aspect of the mental and the aspect of the physical. And these aspects are distinct yet inseparable and basic in the sense of being irreducible to each other or to anything else. Stubenberg [380]

In EUO physical objects are all substances there is, and at least some of these are neither fully mental nor fully concrete, in the sense that physical particulars may have both aspects. If this is what Stubenberg means by saying that some substances are "intrinsically neither material nor mental" then EUO is compatible with the dual-aspect theory in this sense. Consider the characterization that "these aspects are distinct yet inseparable and basic in the sense of being irreducible to each other or to anything else." Concrete and mental are 'distinct' in the sense that they are opposites of one another, but they are also inseparable as they are after all aspects of the one and the same physical thing; the physical is irreducible to anything else as physical particulars are the primitive building blocks in EUO; therefore, if a physical particular is incomplete without both aspects, one aspect only cannot complete the other, i.e., they are irreducible to one another.[52] Thus, if the question is the *mind-body* problem as "that of finding a place for

[50]This investigation concentrates on human beings, but also minds of other creatures such as animals are supposed to be inseparable from their bodies.

[51]For comparison, Martikainen [251] uses the convention that mental things *subsist*; according to Marek [246], Alexius Meinong [264, pp. 252-3, 366-7] uses *subsistence* to denote the existence of mental things.

[52]However, there are no reasons to deny that one day the mental state of a relatively simple organism such as a banana fly could be deduced based on the knowledge of its concrete properties, for this only

the mind in a world that is fundamentally physical" (Kim [200, p. 2]), then the answer of EUO is that the human mind is an aspect of the physical human body.

There is no contradiction here: the case is merely a matter of fitting together conveniently the meanings of the terms 'exists,' 'physical,' 'concrete,' and 'mental.' Consider three alternative naming conventions, where (A) is the given convention, where the difference of (A) and (B) is merely terminological, and where (C) clashes with Strawson's argument (below).

(A) 'Exists' is equivalent with 'physical' and 'exists=physical' denotes the primary form of existence; 'exists=physical' is different from 'concrete' and 'mental'; 'concrete' and 'mental' are opposites. Again, anything that ever exists in whatever way at all is existing=physical; all existing=physical particulars have the concrete aspect whereas only some existing=physical particulars have the mental aspect (given that panpsychism is not true), i.e., existing=physical, mental and concrete by definition fit together, because mental and concrete are merely aspects of existing=physical particulars.
(B) Plain 'existence' denotes the primary form of existence; 'exists' is different from 'physical,' 'concrete' and 'mental'; 'physical' is equivalent with 'concrete'; 'concrete=physical' and 'mental' are opposites. Some existing particulars have two aspects (the physical=concrete and the mental aspects) while others have only one aspect (the physical=concrete aspect). The difference to (A) is merely terminological.
(C) 'Physical,' 'concrete' and 'exists' are equivalent and 'concrete=physical=exists' denotes the primary form of existence; 'concrete=physical=exists' and 'mental' are opposites. In this convention mental things are not said to exist but e.g. to subsist (although subsistence could be applied also with (A) and (B)). This convention gets driven into the paradoxical situation where mental things supervene on or are emergent from physical=concrete=existing things, but where Strawson's argument shows that concrete=physical=existing particulars should somehow contain mental things, while concrete=physical=existing and mental are simultaneously opposites. This convention does not work as mental cannot be emergent on its opposite, for this would imply that mental is *in* its opposite, as Strawson's argument shows, whereas in (A) and (B) mental is not in its opposite but only inseparable from it.

From here on, convention (A) is applied again. A characterization of the concrete-mental dichotomy is a characterization of the concrete and mental aspects or properties of particulars. The following characterizations were inspired originally by Sowa [370, p. 76]. The mental properties of a particular are conceivable, but not perceivable with material senses nor measurable even in principle with particle detectors nor expressible in any units of the international system of units (SI) such as metre, kilogram, coulomb and so on. The concrete properties of a particular are especially perceivable, in principle measurable and expressible in SI units. For instance, we can conceive but not perceive a mental image such as a *square* by vision nor by any measurement device, but we can measure the approximate location of the particular X whose mental property X is. Among the concrete properties of X are an absolutely determinate mass, energy, a location in space and causal effects; the mental square has a mass, energy, a location in space and causal effects only through the concrete properties of X, with which it is inseparable. The concrete-mental dichotomy is applied in §4.14 in the definition of *abstract*.

STRAWSON'S INSEPARABILITY ARGUMENT. To emphasize the inseparability of mental from physical, consider Galen Strawson's [378] argument against *brute emergence*, where

requires that our science has succeeded in correctly capturing the complexity of the banana fly. At this stage intentionality or entelecheia (p. 110) must have been incorporated.

'brute emergence' could be replaced by 'brute supervenience,' by 'brute grounding' and alike, i.e., no version of physicalism can escape Strawson's argument. In the following, X denotes a mentality-involved particular, and X_m denotes the mental aspect of X. Strawson emphasizes that X_m is inseparable from X. In the below quote $X_m = Y$:

> If it really is true that Y is emergent from X then it must be the case that Y is in some sense wholly dependent on X and X alone, so that all features of Y trace intelligibly back to X .... *Emergence can't be brute.* It is built into the heart of the notion of emergence that emergence cannot be brute in the sense of there being absolutely no reason in the nature of things why the emerging thing is as it is.... For any feature Y of anything that is correctly considered to be emergent from X, there must be something about X and X alone in virtue of which Y emerges, and which is sufficient for Y. Strawson [378, p. 18]

When $Y = X_m$, there are no difficulties, for 'brute' emergence is not involved: the expression 'X_m is emergent from X' is a way of saying that X_m is inseparable from X, a property of X, or the mental aspect of X. To emphasize that it is contradictory that X_m is *not* inseparable from X, suppose temporarily interpretation (C) above, where there are only the mental aspect X_m and the concrete=physical=existing aspect X_c, and that X_m is simultaneously emergent from X_c and not a property of X_c:

> If it really is true that X_m is emergent from X_c then it must be the case that X_m is in some sense wholly dependent on X_c and X_c alone, so that all features of X_m trace intelligibly back to X_c. *Emergence can't be brute.* It is built into the heart of the notion of emergence that emergence cannot be brute in the sense of there being absolutely no reason in the nature of things why the emerging thing is as it is. For any feature X_m of anything that is correctly considered to be emergent from X_c, there must be something about X_c and X_c alone in virtue of which X_m emerges, and which is sufficient for X_m.

X_m cannot be simultaneously emergent from X_c and not a property of X_c, for if X_m would be emergent from X_c, then X_m would be a property of X_c, and thus X_c would after all be the whole particular X.

Strawson intended to support panpsychism with the above argument against brute emergence, the "view affirming the presence throughout nature of mentality" (Clarke [88, p. 1]) or "the doctrine that every physical particular enjoys some measure of mentality" (Stubenberg [380]). No stand is taken for nor against panpsychism.[53] It suffices to note that EUO is compatible with panpsychism and with its negation: if panpsychism holds, then every particular has a mental aspect; if panpsychism does not hold, then some particulars do not have a mental aspect. This reasoning is compatible with Stoljar, and also the dual-aspect theory seems to be:

> [N]o matter how implausible and outlandish it sounds, panpsychism per se is not inconsistent with physicalism [cf. Lewis [222]]. After all, the fact that there are some conscious beings is not contrary to physicalism — why then should the possibility that everything is a conscious being be contrary to physicalism? ... the paradigms or exemplars in terms of which one characterises the notion of the physical might turn out to be radically different from what we normally assume ... they might turn out to be in some essential or ultimate respect mental. ... To illustrate, imagine a world in which the fundamental properties are both mental and physical. That is certainly a far-fetched scenario but it doesn't seem to be impossible. Would physicalism be true in such a world? It is hard to see why not; Stoljar [377]

[53] Whether panpsychism is true depends on what is the definition of mental. Suppose that mental is defined as intentional; further, suppose that everything which aims towards the *minimum potential energy* is intentional. In this case everything would be mental in the context of the Dynamic Universe model, but still e.g. rocks and atoms would be very far from human mentality.

4.14 Definition: Abstract

The concept 'abstract' is defined in terms of EUO in a way that it (a) saves all functionality that is required from abstract things; (b) disambiguates the concrete-abstract dichotomy by drawing a clear and philosophically significant line between concrete and abstract things and thereby manages to classify the paradigm cases of concrete and abstract things in the standard way (cf. Rosen [337]); (c) is metaphysically minimal and compatible with nominalism, i.e., does not have transcendent foundations (§4.9). The ontological base of the definition of abstract consists of the axioms for presentism, causality and ontological realism (mental realism), which imply naturalism and physicalism as theorems, and the inseparability of human mind from human body.

> Abstract thing: a thought realized in a human mind.

All thoughts do not have to be abstract but all abstract things are thoughts, and all thoughts are mental. Whenever an abstract thing (or an abstract idea) exists, it is a mental property of an existing physical particular. As the concrete-mental dichotomy was already given in §4.13 and as abstract has been defined as thought, a concrete-abstract dichotomy is merely a version of the concrete-mental dichotomy where it has been decided just which thoughts are called abstract. At the widest, all thoughts can be classified as abstract: any sensation such as a colour sensation, any visualized idea such as a circle, a square or a street view, any emotion or a feeling such as joy, anger, love; any consciously or subconsciously experienced thought or belief. Alternatively, one may classify only consciously experienced thoughts as abstract, another one may classify only thoughts about other thoughts as abstract, one may classify all thoughts which are not consciously pointed at concrete properties of objects as abstract, and one may wish to disclude e.g. emotions and all sensations which result from direct perception out of the scope of abstract. The task of giving a specific criterion of just which thoughts are classified as abstract exceeds the main focus of this section: all concepts contemplated in any field of inquiry can be called abstract if one wishes to use this naming convention.

'Abstract' has thereby been naturalised. The naturalist definition directly contradicts the traditional definitions of 'abstract' as something transcendent. But this should not be worrying as the task is to naturalise the concept in a way that it does all required jobs. Margolis and Laurence [247] is used as the most central source in showing that it does. They approach the case in a slightly different way, starting from the question of what is a concept and noting that there are two central answers: "One proposes that concepts are mental representations, while the other proposes that they are abstract objects" (*ibid*, p. 561). They do not reject abstract as something transcendent as such, but they in any case maintain that such abstract things do not do the job they are supposed to, whereas concepts as mental representations —as thoughts— do (*ibid*, p. 580). The given account thus complements their project and vice versa. In both cases the conclusion is that thoughts suffice, whereas the notion that concepts are transcendent only brings confusion, just because of transcendism itself. Rosen [337] presents paradigm cases of concrete and abstract things:

> [I]t is universally acknowledged that numbers and the other objects of pure mathematics are abstract ... whereas rocks and trees and human beings are concrete. Some clear cases of abstracta are classes, propositions, concepts, the letter 'A', and Dante's Inferno. Some clear cases of concreta are stars, protons, electromagnetic fields, the chalk tokens of the letter 'A' written on a certain blackboard, and James Joyce's copy of Dante's Inferno. Rosen [337]

In the given definition objects of pure mathematics, classes, propositions, concepts and the conceived letter 'A' are thoughts and these can be called abstract. Trees and human beings as well as all particulars are physical and have concrete aspects; a part of a human being has also the mental aspect, and thoughts are mental properties which may be called abstract. The given definition of abstract as thought thus succeeds in disambiguating the concept by defining it clearly: the definition functions as a philosophically significant line between concrete and abstract things, and therefore also manages to classify the paradigm cases of concrete and abstract things.

Consider mathematical objects such as the number 17. It is an idea which is realized in our minds from time to time. Rosen (*ibid*) asks: "Is there one 17 in your mind and another in mine? In that case, the appearance of a common mathematical subject matter is an illusion." Margolis and Laurence [247, p. 567] maintain that this argument is based on type-token confusion: "the question is whether different tokens in different minds can be of the same type, and we see no reason why they can't be." There is one 17 in my mind and another 17 in your mind; you and I as well as our ideas are spatially separate, but the appearance of a common mathematical subject matter is not an illusion, for the consciously experienced ideas are identical or near enough identical to be of the same type, so that applying mathematics is possible and we can communicate about mathematical ideas. Margolis and Laurence (*ibid*, p. 567) point out that Frege's [148, p. 60] complaint about this is that we cannot be sure that we are talking about the same representation, and that therefore some non-mental abstract objects are needed. They resolve the case as follows:

> [S]uccessful communication doesn't require that people can always establish that they are talking about the very same thing. What matters is simply that they are talking about the same thing, not that they know that they are... That is, what's important is that speakers and hearers are reliably coordinated in how they interpret one another's sentences. ... Why think that communication requires anything more? Margolis and Laurence [247, p. 567-8]

Peacocke [303, p. 169] argues that concepts cannot be mental representations for this would rule out the possibility of there being concepts which human beings did not or could not conceive. Margolis and Laurence [247, p. 568] reply as follows: "it simply amounts to the claim that there are mental representation types that will never be instantiated in anyone's mind." In EUO, the reply to Peacocke's argument is: there strictly speaking are no types that will never be realized in someone's mind, although the idea about such types is realized in our minds: this is the idea of types that will never be realized, such as a visualized 'black box' of types. Partial determinism allows that some thoughts that are or have been realizable are never realized (§7.6).

Margolis and Laurence (*ibid*, ch. 4) maintain that mental representations do not get driven into a regress, for positing an internal system of representation does not require positing further levels of representation. They (*ibid*, ch. 5) maintain that mental representations cannot lack the needed structure for otherwise human productivity could not be explained. They (*ibid*, ch. 6) maintain that it suffices that the view of concepts as mental representations works for human beings, i.e., that we do not have to worry about angels, Martians nor God here, and they (*ibid*, ch. 7) maintain that neo-behaviorism is too costly to undermine the identification of beliefs and concepts with mental representations.

Hale's [161] central argument for mind-independent abstract objects is that some assertions contain singular terms which denote abstract objects; as the assertions are true and they need to be true independently of us, also abstract objects need to exist independently of us. A commitment to mind-independent abstract objects is a premise

in Hale's argument. Consider the assertion 'a triangle has three angles.' In the transcendist reading 'triangle' denotes a transcendent object and the assertion 'has three angles' corresponds to the object. In the naturalist reading, we have a commonly agreed and conceivable definition of triangle as a closed form with three sides, and the assertion 'has three angles' corresponds to particular conceptualisations or mental images of triangles, as well as to concrete triangles. The truth or our assertions thus does not require postulating transcendent forms.

The same thing can be said by contrasting *transcendist Platonism* to *naturalist Platonism*. On the left side of figure 13, there is a concrete triangle in the Universe. When a person perceives the concrete triangle, an experience of the triangle becomes realized in the person's mind as an idea (the leftmost triangle). In addition to the plain triangle which is realized in the mind of the naturalist Platonist, it is practical to talk about triangles with different sizes, or about all geometrical forms. As we do talk about *all geometrical forms*, the conception of the collection of the forms is implicit. Further, we may talk about *all mathematical objects* or about *all abstract objects*. In EUO the

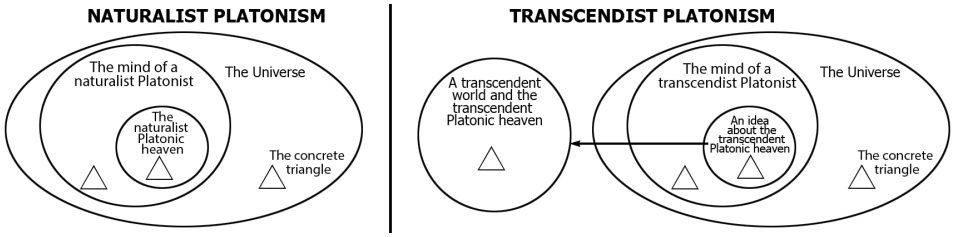

Figure 13: Naturalist Platonism contrasted to transcendist Platonism.

collection of all abstract objects is the naturalist Platonic heaven, which is itself an idea which is realized in the mind of a person. The right side of figure 13 represents Platonism in a transcendist mapping, where the Platonic heaven is considered as a transcendent world which is supposed to exist literally. Given this interpretation, there are not just the three triangles as on the left, but there is also the fourth triangle in the transcendent heaven plus the transcendent heaven itself, which is especially external to the transcendist's idea about the heaven. Transcendist Platonism is uneconomical with respect to naturalist Platonism, and as it is not needed it is rejected as uneconomical.

Transcendent foundations for mathematics or for any discipline can be characterized as 'necessarily unnecessary.' For, everything transcendent is by definition causally isolated from us, and thus cannot affect in any way how mathematics is applied or practiced. Or, only the idea of a transcendent heaven affects some people living in the Universe. Margolis and Laurence [247, p. 580] make a similar remark: "the relation can't be causal, since senses, as abstract particulars, are supposed to fall outside the realm of physical causes and effects. But if it's not causal, the nature of the relation remains utterly mysterious." Even if transcendent abstract objects existed, these would still have to be conceived always when these are contemplated, i.e., the commonly agreed definitions would be applied in any case, but in addition to these there would be the unnecessary idea about the transcendent heaven. All this is repetition of Aristotle's arguments against Plato's theory of forms: "The Forms we can dispense with, for they are mere sound without sense; and even if there are such things, they are not relevant to our discussion, since demonstrations are concerned with predicates such as we have defined." (Aristotle, *Posterior Analytics*, 83a33). The difference is systematicity: the rejection of transcendism

is justified by economy, and economy is justified by its progressiveness. Consider how the given definition of abstract in terms of EUO helps to clarify an ambiguity:

> An ontology which announces that it recognizes no entities but physical ones, and promises an uncompromising naturalism, takes on, one would have thought, some obligation to find naturalistic interpretation for mathematics. At least Platonism seems to be ruled out. But when he needs sets or numbers, Post just helps himself to them —even allowing Platonism, if that's your preference. The physical suddenly comes the mathematical-physical. Campbell [73, p. 359]

In EUO physical particulars are all that ever exist; mental things are properties of some physical particulars; some mental things may called abstract, such as sets, numbers and all mathematical objects. So, the physical does not become mathematical-physical suddenly, as mathematical objects are abstract, and abstract things as thoughts are properties of some physical particulars. In EUO there are no abstract objects if there are no conscious agents who conceive the abstract objects: this is sufficient for mathematics and for natural science in general as long as conscious agents exist; when conscious agents do not exist, abstract objects are not needed in the first place.

This can be contested by smuggling transcendism in as a premise e.g. by maintaining that 1+1=2 is timelessly true, even before any human-like conscious creatures existed, and that this requires a transcendent Platonic heaven. It suffices to show that the definition of abstract as thought suffices in the relevant sense as the basis of the timeless truth of 1+1=2, where the 'timeless truth of 1+1=2' is not understood to contain transcendism as a hidden premise. So, consider a time before any human-like conscious creatures. Back then there were no mathematicians and thus nothing like mental constructions which are today contemplated by them. Therefore the only domain of application of the timeless truth of 1+1=2 concerns objects such as planets and particles; summing up one planet and another made up two planets even then. This means that nowadays human beings can conclude that 1+1=2 corresponds to various objects that existed before conscious agents existed, but this does not require transcendism.

But what about back then? Was it not true that two planets made up two planets even then, even if humans never existed? 'True proposition' will be defined in §6 as thought that corresponds to an object. Given the definition of a true proposition, saying that it is true that two planets made up two planets even then means only that there existed two planets back then. We cannot escape the fact that this is in any case a matter of us contemplating what happened in the past. It is true that two planets made up two planets even back then and even if it had turned out that humans never existed, but now humans happen to exist. Alternatively, one could postulate a transcendent repository for true thoughts back then, which would be uneconomical.

TRADITIONAL DEFINITIONS. 'Abstract' is typically defined as something absolutely causally inert, i.e., as something transcendent. According to Rosen [337] "if any characterization of the abstract deserves to be regarded as the standard one, it is this: An object is abstract if and only if it is non-spatial and causally inefficacious." Rosen lists various definitions.

1. An object is abstract iff (if and only if) it is both non-mental and non-sensible.
2. An object is abstract iff it is both non-physical and non-mental.
3. An object is abstract iff it is non-spatial and causally inefficacious.
4. An object is abstract iff it fails to occupy anything like a determinate region of space.
5. An object is abstract iff it either fails to occupy space, or does so only in virtue of the fact some other items occupy that region. For instance, the set {Peter, Paul} occupies a

location in virtue of the fact that its physical elements, Peter and Paul, together occupy that location, but the set does not occupy the location in its own right.
6. Abstract things are equivalent with universals.
7. Abstract things are classified in terms of paradigm cases.
8. Abstract is defined by way of abstraction. According to Lewis [223, pp. 84-5] "abstract entities are abstractions from concrete entities. They result from somehow subtracting specificity, so that an incomplete description of the original concrete entity would be a complete description of the abstraction." According to Rosen [337]: "abstraction is a distinctive mental process in which new ideas or conceptions are formed by considering several objects or ideas and omitting the features that distinguish them. One is given a range of white things of varying shapes and sizes; one ignores or 'abstracts from' the respects in which they differ, and thereby attains the abstract idea of whiteness."

The basic difficulties in defining abstract as non-spatial, causally inefficacious, non-mental, non-physical or alike are: (i) these state what abstract things are not instead of saying what they are, which renders the definitions incomplete and question-begging; (ii) even if abstract as transcendent would succeed in drawing a line between concrete and abstract objects, concepts as transcendent entities fail to do what is required from concepts, as was pointed out above; (iii) Transcendism is metaphysically complex with respect to Naturalism. Because of (i-iii), and as the definition of abstract as thought is plausible, there is no need to review the perplexities of the negative definitions in detail. It suffices to investigate what the definitions have to give, when forced into the naturalist-physicalist mold as characterizations of mental representations.

It is hard to find anything applicable from 1-4 whereas in 5 the set {Peter, Paul} can be considered as a mental representation of two physical objects. On one hand, 6 cannot be totally fitted together with the given definition of abstract as thought in the sense that universals are especially defined as properties in §4.10, and although thoughts are mental properties of physical objects, all properties are not mental properties. On the other hand, abstract things as conceptualised forms can be translated as 'conceptualisations of universals.' 7 could be considered as any classification of just which kinds of thoughts qualify as abstract, such as those given in p. 85. In the context of the given definition, 8 can be considered as a definition of which kinds of thoughts qualify as abstract. When extended far enough, whatever consciously experienced thoughts can be considered as abstractions by the way of abstraction.

4.15 Axiom: The Law of Non-Contradiction

Aristotle formulated the law of non-contradiction (LNC) in *Metaphysics*, 1005b18-20:

> Evidently then such a principle is the most certain of all; which principle this is, let us proceed to say. It is, that the same attribute cannot at the same time belong and not belong to the same subject and in the same respect;

When fitted in EUO, LNC can be formulated as: one property cannot be instantiated and not instantiated by the same particular at the same time in the same respect. As temporal stages of the Universe (TSUs) are particulars, it follows from LNC that the TSUs are non-contradictory. E.g. the attribute *round* cannot at the same time and in the same respect belong and not belong to the subject *ball*, where the ball is a physical object. The attribute *round* can be translated as a determinable range of properties

(§4.10): a particular can instantiate exactly one of these properties at one time in one respect.

LNC applies also for mental properties of particulars: one mental property cannot belong and not belong to the same particular at the same time in the same respect. E.g. the property *round mental object* cannot at the same time and in the same respect belong and not belong to the same particular. Saying that the property *round* cannot at the same time and in the same respect belong and not belong to the *mental* property *ball*, is an indirect way of saying that the property *round mental object* cannot at the same time and in the same respect belong and not belong to the same particular.

According to Gottlieb [156] the above version of LNC is the ontological version which "concerns things that exist in the world" and this is also its intended scope here.[54] Gottlieb maintains that altogether three versions of LNC can be found from Aristotle: ontological, doxastic and semantic versions, where the doxastic version is not immediately important with respect to the topics of this thesis. Aristotle formulates the semantic version as follows: "opposite assertions cannot be true at the same time" (*Metaphysics* 1011b13-20). The semantic version seems to be very close to the *coherence theorem of correspondence truths* (§6.1) —a theorem of ontological realism and the ontological version of LNC— where correspondence truths are the assertions, i.e., propositions realized in minds of human beings. This is in line with Tahko's [389, p. 27] remark that "Aristotle's line of thought suggests that the link that is often taken to exist between language or grammar, and logic, is in fact between reality and our thoughts." Gottlieb [156] notes that the semantic version results from the ontological version: "the idea that opposite assertions cannot be true at the same time suggests that this third version is better interpreted as a variant of the first formulation." That is, the semantic version follows from the ontological version when it is coupled with the notion that "any assertion involves predicating one thing of another" (*ibid*); and this is very close to saying that the coherence theorem follows from the fusion of ontological realism and the ontological version of LNC. Form here on, LNC denotes the ontological version. Consider three arguments for LNC.

(1) A violation of LNC is inconceivable. If a particular would violate LNC, we could not conceive how that violation is realized, for everything that is in principle conceivable conforms to LNC: "The law of non-contradiction provides the 'formal' criterion of conceivability: anything that violates it is inconceivable" (Stang [373, p. 191]). In other words, perception can never confirm the existence of a contradiction, because it is impossible to simultaneously perceive (or measure) and not to perceive something in the same respect. For instance, it is impossible to measure that the temperature is 10 Celsius and not 10 Celsius in the same place at the same time in the same respect.

(2) If something is interpreted to violate LNC, the same thing can be interpreted so that LNC is not violated, i.e., we are dealing with mutually exclusive metaphysical commitments. The commitment that there are some particulars that violate LNC and some that do not (those which are perceived), is more complex than the commitment that all particulars conform to LNC, and therefore economy favours committing to LNC.

[54] For comparison, Kutach [212, ch. 1.6] postulates something very close to LNC: "Fundamental reality is as determinate as reality ever gets. ... Fundamental reality is consistent." Sami Pihlström commented: "Contradictions can be found from expressions of language or in logical systems, but hardly in the world itself; it is not wholly clear that it is even sensible to attribute contradictoriness or non-contradictoriness to nature." Certainly, if one commits to LNC, then one commits to non-contradictoriness of nature. LNC may seem to be self-evident, but it is important to explicitly postulate this self-evident axiom, so that there would be no ambiguities about the case.

(3) The rejection of LNC is either meaningless or the rejection implicitly commits to LNC. Suppose that an extreme relativist argues that LNC is a vague or a subjective statement that does not have a definite meaning; if the relativist's argument has a definite meaning, then he commits to LNC, for his argument does not simultaneously have and not have a meaning in the same sense; if the relativist's argument does not have a definite meaning, then there is nothing to worry about. Gottlieb [156] says the same, where PNC denotes LNC: "Anyone asking for a deductive argument for PNC, as Aristotle points out, is missing the point, or, rather, is asking for something that is impossible without using PNC. You cannot engage in argument unless you rely on PNC." As the rejection of LNC requires committing to LNC, it follows that the willingness to reject LNC is a signal of either a failure in understanding the meaning of LNC, or of self-deception. Self-deception occurs when a person implicitly relies on what he explicitly denies. When a relativist travels in an aeroplane at 30 000 feet, he implicitly relies on the technology that is used in building the aeroplane, but he explicitly denies the validity of LNC which is a prerequisite for the technology (cf. Norris [294, pp. 249, 314]). Norris (*ibid*, p. 249) refers to an example from Richard Dawkins [100, p. 32]: "show me a cultural relativist at 30 000 feet and I'll show you a hypocrite." Likewise, when a relativist is seriously ill and accepts the medicine which was developed by holding LNC as a premise, he implicitly relies on what he explicitly denies.

MANY-VALUED LOGIC, PARACONSISTENT LOGICS, DIALETHEISM. LNC is compatible with the existence of propositions which violate the *law of the excluded middle* and the *principle of bivalence*, i.e., LNC does not exclude the application of many-valued logics (§7.3). LNC is also compatible with paraconsistent logics, whose basic idea is in *non-trivial inconsistency*: although the surface structure of a sentence is incoherent, you can deduce something intelligible from it, but you cannot deduce *everything* from it, i.e., paraconsistent logic accepts incoherent statements but denies that everything can be deduced from them. To illustrate, even though the surface structure of the proposition S="Mary is happy and sad" is incoherent, S makes perfect sense together with the propositions "Mary won the lottery" and "Mary's house burned down." Mary is happy in the sense that she won the lottery and sad in the sense that her house burned down, i.e., LNC is not violated here as Mary is not happy and sad at the same time and in the same respect.

Whether LNC and *dialetheism* are compatible or incompatible depends on how LNC is interpreted and how the range of dialetheism is interpreted. According to Priest and Berto [316] a "*dialetheia* is a sentence, A, such that both it and its negation, $\neg A$, are true." E.g. "Mary is happy" seems to be a dialetheia in the sense that it is true and its negation is true, in the context of the above paragraph: again, not in the same sense and therefore LNC is saved. Priest and Berto maintain that dialetheism violates a certain version of LNC, which is denoted here as the *linguistic LNC* (LLNC): "for any A, it is impossible for both A and $\neg A$ to be true." Again, Priest and Berto talk solely about sentences (propositions) and they do not indicate anything about the correspondence of sentences to mind-independent reality. Therefore, they do not claim that the ontological version of LNC is violated, but they remain strictly in the linguistic realm.

Priest and Berto [316] note that dialetheism draws its orientation from the paradoxes of self-reference. Also the self-reference industry is purely linguistic, or if it is metaphysical then it is uneconomical: genuine self-reference is explicitly rejected in §4.18 on the basis that it violates finite divisibility, which is an axiom of EUO. Therefore, there are no paradoxes of self-reference to be resolved in EUO: if a seemingly self-referring proposition has a meaning —other than the intention of expressing a paradox— then the meaning can

be explained also without self-reference. The order is the same as always in economical unification: ontology first, semantics second. It would be against economical unification to take a paradoxically formulated surface structure of a sentence so seriously as to propagate it into a violation of LNC. Although Priest and Berto maintain that other "cases involve contradictions affecting concrete objects and the empirical world" they still remain in the linguistic realm and discuss violations of LLNC, not LNC. To illustrate, they consider transition states of leaving a room, maintaining that there must be "a precise instant in time, call it t, at which I leave the room. Am I inside the room or outside at time t? ... if I am neither inside not outside the room, then I am not inside and not-not inside" and that this is "a dialetheic situation." This does not violate LNC, for nothing in the temporal stage of the Universe which is realized at t violates LNC, although examples that violate LLNC can be invented.

4.16 Rejection: Backward Directed Causation

Expressions may be formulated in a way that their surface structure seems to require backward causation. For instance, one can state that the fact that a person is a president now, caused his desire to take part in the elections 2 year ago. This may be translated as: the person's desires and hopes 2 years ago to become the president caused him to become the president. In general, statements of the form 'the past was determined by the present' may be translated as 'in the past our goal was to get to where we are now' or as 'our past contemplations essentially effected our present state.' If the present would really affect the past, this would require genuine backward causation, i.e., genuine time travel. It is notable that the emergence of time travel stories walked hand in hand with the rise of the relativistic conception of time in the late 19th century:

> [T]he exponential explosion of timetravel stories in the popular media, beginning late in the nineteenth century, is an indication that a very new conception of time is brewing in the Zeitgeist. The utter absence of any timetravel stories whatsoever prior to the nineteenth century is a profoundly puzzling fact. Bigelow [49, p. 35]

The resolution of the puzzle is that time travel stories have no place in a common-sensical ontology. This reminds that one of the central themes of this thesis is the replacement of the relativistic conception of time with presentism and absolute simultaneity, which are compatible with the Dynamic Universe model. Along with this replacement, time travel stories are limited into the context of pure fiction, and excluded from the context of science.

Genuine backward causation contradicts EUO. In EUO the past has been realized, it has caused the present, and it does not exist any longer. In genuine backward causation the past has been realized and it has caused the present, but still a part of some past TSU is changed. This is contradictory in EUO as this requires that some part of a past TSU was realized and was not realized in the same respect. Once the initial contradiction is accepted, other contradictions follow: "one travels into the past and kills one's grandfather before one's father has been conceived, thus making it the case that one is not conceived, which thus makes it the case that one does not travel into the past, in which case one's father is conceived, and so on" (Tooley [120, p. x]).

The rejection of backward directed causation requires the fusion of the axioms for presentism, causality and the law of non-contradiction (LNC). Backward directed causation can be incorporated by dropping one or all of these axioms and switching them into something uneconomical. As the rejection of LNC is hard to conceive and its violation

is impossible to conceive (§4.15), let LNC be sustained. As LNC is sustained, the incorporation of backward directed causation requires postulating transcendism or some naturalist version of branching sequences of TSUs: as LNC is sustained, the past is in some sense forever unchanged; however, as the past is still being changed in backward causation in some sense, there must be two senses of the past, such as two branching sequences of TSUs or two different worlds of which the other is transcendent to us. Both of these options violate EUO, namely, transcendism violates naturalism —a theorem of presentism and causality— and branching TSUs violate the causality axiom (§7.4). Both of these are uneconomical with respect to EUO, and as the explanation of perceptions in the context of the Dynamic Universe model does not require backward directed causation, these are rejected, along with backward directed causation.

In contrast to its rejection, van Inwagen [405] especially enables time travel by introducing the *hypertime framework*, where the hypertimes are analogous to transcendent worlds or to a single naturalist branching space-time, such as Belnap's version in §7.4. In EUO, there has been only one history, and therefore only one period P from the year 1900 to the present: P=[1900 present]. In the hypertime framework, if you travel from the present to 1900 with a time machine, the period P becomes a mere hyper-period, while P' becomes the new 'real' period that starts from 1900 and contains you and the time machine. This is perfectly legitimate if transcendism or naturalist branching space-time is supposed: there must be as many hyper-pasts as there are trips back in time.

Forrest [147, p. 29] maintains that the hypertime framework is an interpretation of what the physicists have done when they have sent a particle or two back in time. The uneconomicality of transcendism and branching space-time guides into searching for another explanation. Whenever someone claims that genuine time travel has occurred, you have two options: (1) you can accept that genuine time travel has indeed occurred and accept the hypertime framework or another uneconomical construction among your ontological commitments as this is the implication of genuine time travel; (2) you can deny that genuine time travel has occurred, drop uneconomical explanations that are needed in having time travel, and try to come up with an interpretation that does not require time travel.

Time travel can be *interpreted* to have support: from empirical science "G.Feinberg suggested that there might be particles — called tachyons — which travelled faster than the speed of light, and which thus, according to the Special Theory of Relativity, would have to travel backward in time" (Tooley [120, pp. ix-x]). Where did the interpretation that there are superluminal particles originally come from? If it came from an interpretation of the *Bell inequality tests*, then it suffices to note that there are interpretations of these tests which do not require superluminal influences (§5.2). As another example, the Dynamic Universe model incorporates instantaneous gravitational influences without postulating particles that convey the influences, and without requiring backward causation.

4.17 Axiom: Finiteness

EUO would be too ambiguous without explicating how great the temporal stages of the Universe (TSUs) are spatially and how far they are divisible. The finiteness axiom states that all TSUs and thus all particulars are spatially finite and consist of finitely many indivisible and positive interrelated parts.[55] The finiteness axiom is the fusion of the

[55]The finiteness axiom is compatible with option (1) of Tahko's [392] classification of the four logical combinations: (1) spatial finiteness and finite divisibility; (2) spatial infinity and finite divisibility; (3)

axioms for *spatially finite TSUs* and *finite divisibility*.[56]

SPATIALLY FINITE TSUS. Perceptions testify that space continues very far. This raises the question of just how far. Consider two mutually exclusive empirically sufficient unfalsifiable hypotheses: every TSU is spatially finite; some or all TSUs are spatially infinite. Economy favours the hypothesis of spatially finite TSUs, which is thereby selected as an axiom of EUO. Answers to questions about the volume and the contents of the spatially finite TSUs are sought from cosmology in §5. It is notable that both the Dynamic Universe model and the standard model of cosmology get by with spatially finite TSUs, and thus natural science gives no reason for supposing otherwise.

FINITE DIVISIBILITY. Particulars which are perceivable by the material senses such as rocks, trees, mountains and planets consist of proper parts and are in this sense divisible in parts. This raises the question about the limits of divisibility. Consider two mutually exclusive empirically sufficient unfalsifiable hypotheses: particulars are finitely divisible and consist of finitely many parts; particulars are infinitely divisible and consist of infinitely many parts. Economy favours the hypothesis of finite divisibility, which is thereby selected as an axiom of EUO. Finite divisibility leaves open how much will ever be verified, but explicitly rejects infinite divisibility.

Finite divisibility is only the starting point; if it could be established somehow that a particular natural number is a sufficient and *unfalsifiable* limit of division, this would be even better. Finite divisibility should not be confused with the doctrine that the currently verified limit of division N is the ontological limit. Ernst Mach [239] famously rejected the hypothesis of the existence of atoms, thereby committing to 'N' of his day, but his hypothesis was falsified when the existence of atoms was verified. The commitment to today's N does not qualify as an axiom of EUO because an axiom of EUO is by definition unfalsifiable. An axiom ought to function as an unshakeable pillar of a world-view, and as history shows that the commitment to N would have been falsified time and again, this commitment can be rejected without further consideration. This does not mean that some assigned finite limit could not be accepted as an axiom, but such limits are not suggested here.

Finite divisibility implies that every spatially finite structural particular consists of a finite number of indivisible interrelated parts. The axioms for spatially finite TSUs and finite divisibility together imply that every TSU consists of finitely many indivisible parts. The finitely many parts are supposed to be positive by economy. That every TSU consists of finitely many parts leaves the following mutually exclusive metaphysical hypotheses open: (i) all indivisible parts are positive; (ii) some indivisible parts are positive and some are non-positive; (iii) all indivisible parts are non-positive. Qualitative economy favours (i) over (ii) for (i) gets by with positive parts only while (ii) commits to both positive and non-positive parts. (iii) begs the question of how can something positive be built out of *finitely* many non-positive parts. One could try to make sense out of (iii) by assuming that relations between the non-positive parts are positive, but this would

spatial finiteness and infinite divisibility; (3) spatial infinity and infinite divisibility.

[56]Simo Knuuttila asked how does the finiteness axiom relate to the open selection between positive and zero duration of the present in §4.3. The finiteness axiom is compatible with both options. Also the selection between *qualitative finiteness* (QF) and *qualitative infinity* (QI) was left open. These metaphysical options can be defined by applying diachronic possibility (§7). QF: finitely many different particulars have a possibility of being realized at the future time t. QI: infinitely many different particulars have a possibility of being realized at the future time t. The account of how these two open selections or dichotomies —QI vs. QF and zero vs. positive present— relate to the other axioms of EUO is one of the interesting analyses that was not included because of the lack of space.

only be a switch from positive parts and positive relations into positive relations and non-positive parts, which would be qualitatively uneconomical.

COMPATIBILITY WITH CONTEMPORARY MATHEMATICS. (See the glossary for the meanings of 'infinite,' 'transfinite' and 'potential infinity.') The ontological hypothesis of finite divisibility is compatible with sustaining transfinite idealizations in mathematics, such as all set theoretic idealizations of sets which contain infinitely many elements, but such idealizations are not required in modeling individual particulars in EUO. Although the modeling of an individual particular does not require an idealization of anything infinite nor transfinite in EUO, the eternal Universe theorem states that the past is an infinite sequence of TSUs and thus modeling the past naturally requires an idealization about the infinite past (§4.11). A mathematical model that is capable of modeling such sequences contains infinitely many elements and such models are called transfinite. That is, in EUO transfinite mathematical models can be used whenever needed and they are needed at times, but EUO does not force one to use such models everywhere. In contrast, if ontological infinite divisibility were supposed, the modeling of all particulars —except points if this is the selected idealization— would especially require a transfinite model.

COMPATIBILITY WITH CONTEMPORARY PHYSICS. Finite divisibility is merely an alternative to infinite divisibility. Finite divisibility in turn implies that there exists indivisible particulars at the bottom, but this should not be interpreted as a suggestion about anything further, for everything further is left to the physicists: elementary particulars can be called elementary *fields, energy objects, resonators, waves* or whatever is convenient, i.e., the term 'elementary particular' does not have to refer to a billiard ball like Democritean atom. Finite divisibility is fully compatible with contemporary physics, unless hypotheses about infinite divisibility count as physics. It is sufficient for both models of physics that are evaluated in §5, and e.g. particle physics does not need infinite divisibility. It is independent of whether there exists the same number of elementary parts at all times, whether and how they change and so forth. Consider what Ross, Ladyman and Spurrett say about divisibility:

> Physicists do not believe there are such things as good a priori grounds for holding beliefs about the constitution of the physical world, and we suggest that only a foolhardy philosopher should be willing to quarrel with them on the basis of his or her hunches. Ross, Ladyman and Spurrett [213, p. 18]

A number of physicists have speculated about divisibility. Some have favoured finite divisibility and some infinite divisibility, i.e., physicists have provably speculated about the a priori grounds, and the source of these speculations can be safely be assumed to be in mathematical idealizations. E.g. Dehmelt [105] and Georgi [154, p. 456] have speculated about non-wellfounded structures. Bohm [53, pp. 132-40] speculates about infinite divisibility but also notes that his view is compatible with finite divisibility. I asked two physicists with different backgrounds to answer the question that does physics require infinite divisibility. Tuomo Suntola (30.9.2015): "the Dynamic Universe Model does not require that mass objects are infinitely divisible." Tapio Ala-Nissilä (2.10.2015): "I cannot at this instant come up with an example. As a matter of fact the contemporary quantum theory entails that in the smallest scales matter (and everything else, i.e., fields) should be quantised." Suppose that two physicists disagree: one favours finite and the other infinite divisibility. Which one should we believe? Similarly as all metaphysical speculations, the metaphysical speculations of physicists —about divisibility or about anything else— should be judged by the principle of economy. It is very hard to even imagine examples which would violate the following principle: if an explanation of a

perceptions appeals to infinite divisibility, then the same perceptions can be explained equally by appealing only to finite divisibility. It can be safely concluded that finite divisibility is compatible with contemporary physics.

COMPATIBILITY WITH ONTIC STRUCTURAL REALISM. EUO starts from the causal succession of temporal stages of the Universe, which are structural particulars whose parts are causally connected. EUO is thus compatible with all views that emphasise the importance of relations between parts and the importance of the causal structure of the Universe, as long as objects are not totally eliminated. When characterizing ontic structural realism (OSR) Ladyman and Ross [213, §3] strongly emphasise the causal structure of the Universe. On one hand, they (*ibid*, p. 130) proportionally diminish the role of objects: "There are no things. Structure is all there is.... We will argue that objects are pragmatic devices used by agents to orient themselves in regions of spacetime, and to construct approximate representations of the world." On the other hand they (*ibid*, p. 152) maintain that OSR is construed as either (i) or (ii): (i) there are only relations, and no relata; (ii) there are relations in which the relation is primary, while the things are secondary. As EUO is compatible with (ii) and the causal structure of the Universe is the starting point, compatibility with OSR is secured. It seems to be hard to combine (i) with a model of physics that commits to mass objects, i.e., basically all models, but if the relations somehow do the job of mass objects then the case is different.

Problems of Infinite Divisibility. Infinite divisibility is the metaphysical postulate that all particulars which are perceivable by material senses are infinitely divisible. Infinite divisibility was rejected above because finite divisibility is simpler. Now it is shown that infinite divisibility brings along further problems or ambiguities. Consider two interpretations of infinite divisibility: the *point-continuum* interpretation and the *non-wellfoundedness* interpretation.

POINT-CONTINUUM. Point-continuum is the conception that a continuous mathematical object such as a line segment consists of infinitely[57] many zero-size points: the segment is dense (a point exist between any two points) and continuous (the segment contains no holes). Considerations about point-continuum realized in nature have been around since the antiquity, most famously by Zeno of Elea (cf. Dowden [115]). When point-continuum is mapped to a positive structural particular, the particular is accordingly thought to consist of infinitely many zero-size parts, and the only simple particulars are individual zero-size parts. Consider a particular which has the width 1. The particular is thought to be infinitely divisible in proper parts. The zero-size points are considered as *limit values* of infinite divisions. For instance, point 0 is the limit value of the sequence of divisions $0.5, 0.25, 0.125, \ldots$. Set theory is usually considered as the formal foundation of point-continuum. point-continuum can be enriched with *infinitesimals*, but the infinitesimal-enriched point-continuum is not investigated here.

NON-WELLFOUNDEDNESS. Non-wellfoundedness is the conception that there are no zero-width points as limits of infinite divisions, but instead the infinite divisions are realized as infinite chains of ever smaller parts, where "spaces may contain spaces as proper parts ad infimum without being composed of simple things at all" (Armstrong [23, pp. 117-8], cf. [16, II, p. 67], Lewis [225, p. 203]). Non-wellfounded set theory (Aczel [2]) suffices as the formal foundation of non-wellfounded structures. Non-wellfounded set theory discludes the *axiom of foundation* which, together with the other axioms of e.g. Zermelo-Fraenkel set theory, implies that non-wellfounded sets do not exist. Two types

[57]The *continuum hypothesis* is the hypothesis that the cardinality of a continuous segment or any other continuous thing is the second-order infinity, whereas the cardinality of the infinite sets of natural and rational numbers is thought of as the first-order infinity.

of non-wellfounded sets can be identified: sets that do not contain themselves and sets that do contain themselves. When self-containing sets are given an ontological status, e.g. the following kind of a particular is allowed to exist: atom $\in$ molecule $\in \ldots \in$ Universe $\in$ atom .... The historical roots of non-wellfoundedness can be traced back to the Kabbalah religion.[58]

ELIMINATIVE STRUCTURAL REALISM. The view that there does not exist objects such as elementary parts but only relations has been called *eliminative structural realism* (ESR). ESR can be seen as over-propagation of relations. Unsurprisingly, ESR has been criticised by the argument that 'relations without relata' does not make sense e.g. by Psillos [318] and Dorato [112, 113]. The fusion of ESR and finite divisibility would amount to positive and indivisible relations without relata: it is quite hard to make sense out of this combination, unless this only means that also parts are now called relations. The fusion of ESR and infinite divisibility finds a logical foundation e.g. from *continuous mereology*[59] and a model of non-wellfounded set theory where all members of all sets are infinitely divisible without a bottom: as everything is divisible in interrelated members, ad infimum, the relations are eventually all that exist. Morganti [278, p. 83] is trying to dig out the useful features of ESR: "I think that in a proper interpretation of ESR we should take it to be 'agnostic' in relation to what exists, if anything, beyond knowable structures." If ESR is interpreted as agnosticism about what exists, then the relations-only postulate naturally loses its ontological meaning and the selection of the metaphysical axiom is left open.

ESR has defenders. Schaffer [351, p. 499] asks: "So why believe there *is* a fundamental level? Why not an infinite descending hierarchy of levels? ... The proposition that there is a fundamental level is widely accepted but seldom defended." Schaffer notes that the existence of elementary parts cannot be proved, maintains that therefore there is no reason to believe that they exist, and concludes that this is a sufficient reason to commit to ESR. However, it cannot be proved either that the positive and indivisible elementary parts *do not exist*. We are dealing with two mutually exclusive metaphysical commitments which both explain perceptions, given that 'relations without relata' after all makes sense: ESR and finite divisibility. Finite divisibility is simpler, and therefore economy favours finite divisibility. Schaffer (*ibid*, p. 503) notes that history shows that the confirmation of deeper and deeper divisions has been like a regularity. No matter how deep divisions will be confirmed —even 1000 divisions per year— the discovery rate will always be finite, and infinitely many divisions will never be confirmed because the future is only potentially infinite (in EUO). Therefore, finite divisibility will always be sufficient. It is noted in the next example that potentially infinite divisibility is not a mid-option between finite and infinite divisibility.

POSITIVE OUT OF ZEROS? In arithmetic 0+0=0, and thus also the sum of infinitely many zeros should be zero. However, the point-continuum interpretation of infinite divisibility forces one into interpreting that positive mathematical objects can be built out of zero-size points. In mathematics, the interpretation that point-continuous intervals such as [1 2] consist of continuum-many zero-size points which are *arranged in such a way* that

[58] An excerpt from Ashlag at al. [33, p. 489]: "It is written in The Zohar, Vayikra, Parashat Tazria, p 40, "Come and see, all that exists in the world, exists for man, and everything exists for him, as it is written, 'Then the Lord God formed man,' with a full name, as we have established, that he is the whole of everything and contains everything, and all that is Above and below, etc., is included in that image.""

[59] Mereology (appendix A) gets continuous by adding the axiom which states that every aggregate has a proper part: $\forall x \exists y (y \prec x)$. Continuous mereology is incompatible with discrete mereology, i.e., if the axiom for continuous mereology is added then the axiom for discrete mereology must be dropped.

[1 2] contains no holes, has been conventional for more than 100 years. But it is still an additional interpretation that infinitely many zeros can make up something positive. This interpretation can be used in mathematics as an idealization, but this does not mean that it should be supposed in the ontological sense. To elaborate the difficulty of this interpretation, consider Aristotle's reasoning. (Note that Aristotle did not handle the divisibility of abstract geometrical objects and the divisibility of particulars separately.)

> —nothing that is continuous can be composed of indivisibles: e.g. a line cannot be composed of points, the line being continuous and the point indivisible. ... since indivisibles have no parts, they must be in contact with one another as whole with whole. And if they are in contact with one another as whole with whole, they will not be continuous: for that which is continuous has distinct parts: and these parts into which it is divisible are different in this way, i.e., spatially separate. Aristotle, *Physics*, bk.6, ch.1, 231a19-b15

Aristotle's reasoning is still fresh and shows that point-continuum requires the additional interpretation. Finite divisibility does not require the extra interpretation, which makes it more economical. Although Aristotle rejected infinite divisibility, he thought that all *assigned* magnitudes are further divisible, i.e., divisible *potentially infinitely*. Potentially infinite divisibility of abstract objects is compatible with finite divisibility in the sense that conscious agents can only ever divide finitely and assign finitely many smaller and smaller numbers. However, consider a particular which exists exactly at one time such as a concrete rock with the diameter of 10 cm: it is either finitely or infinitely divisible for it has either finitely or infinitely many parts at one time, i.e., potentially infinite divisibility is not a mid-option.

Summary. The aim of the above review was to show that there are no obstacles for rejecting infinite divisibility in the ontological sense and for selecting finite divisibility as an axiom of EUO: there is a long way from Mach's rejection of atoms to the rejection of infinite divisibility. The greatest obstacle in the context of philosophy for not openly accepting finite divisibility may be the traditional attitude of taking logic first without asking what is empirically sufficient, and then imposing logic to nature; in the case of divisibility the logic-first attitude happens to be heavily seasoned with the charm around infinity. In other words, supposing that infinite divisibility is after all needed in the ontological sense would mean first inventing that nature is infinitely divisible, and then maintaining that infinite divisibility is needed. The clearest problems of committing to infinite divisibility in ontology is that this results in pondering about which version of infinite divisibility to choose and which to reject, when no version of infinite divisibility is needed in the first place in explaining phenomena. For instance, Armstrong [16, II, pp. 68-9] rejects only self-containing non-wellfounded structures as follows: none of the proper parts of the structural property P are identical to P. This does not rule out those non-wellfounded structures which do not contain anything identical to themselves, and does not rule our point-continuum nor infinitesimals. Finite divisibility rules out all versions of infinite divisibility and thus cleans the table from all contemplations about infinite divisibility. Finite divisibility is applied in §4.18 in rejecting genuine self-reference.

4.18 Rejection: Genuine Self-Reference

Genuine or ontological self-reference requires postulating the existence of infinitely divisible thoughts; such mental objects violate *Miller's Law* [273], and they also violate finite divisibility of the finiteness axiom, given the inseparability thesis of complexity (below). Because of these reasons and because genuinely self-referring thoughts are not needed in

explaining phenomena, these are explicitly rejected. The topic is handled exhaustively in order to plug all holes leading into genuine self-reference. The explicit rejection of self-referring thoughts is needed also in exactifying limits of the object-based correspondence theory of truth and in defending it in §§6.1,6.4,6.8.1,6.8.3: self-correspondence is rejected along with self-reference, for self-correspondence entails self-reference.

Example I shows that the existence of a genuinely self-referring thought violates Miller's Law and finite divisibility, given the inseparability thesis of complexity, and requires postulating non-wellfoundedness. Example II shows that two thoughts cannot refer to one another, for this entails self-reference. Examples III-V show that correspondence and identity are mutually exclusive relations: when proposition a corresponds to its truthmaker —which is in object-based correspondence an object or a mental property of an object— the truthmaker cannot be identical to a; when proposition a is identical to proposition b, a cannot correspond to b. Examples I-V thus show that the reference relation and the correspondence relation along with it is asymmetric, i.e., that a thought cannot refer to itself, nor to anything identical to itself. (Recall the difference of identity and sameness in §4.6). Example VI elaborates the limitations which result from rejecting genuine self-reference. Examples VII-IX show how cases which only *seem* to be involved with self-reference can be given plausible positive interpretations.

The result that all mental things such as thoughts or ideas are properties of particulars and inseparable from particulars is used (§4.13). E_a, F_a, G_a denote ideas which are properties of particulars E, F, G, respectively. $E_a = ref(G)$ means that E_a is the reference to G, i.e., that the reference to G is the only part of E_a.

EXAMPLE I: A SELF-REFERRING IDEA. Suppose that E_a refers to itself, which is written as $E_a = ref(E_a)$. $E_a = ref(E_a)$ implies $E_a = ref(ref(ref(\ldots)))$, i.e., that E_a is a non-wellfounded transfinite hierarchy of thoughts without a bottom. The first reason for rejecting ontological self-reference is thus that it is uneconomical. The second reason is that Miller's Law directly contradicts the existence of E_a. According to Miller's Law, a person can conceive/visualize simultaneously 7 plus-minus two individual mental objects. A person can visualize the *definitions* $E_a = (((((((\ldots)))))))$ and $E_a = ref(E_a)$ *of* a transfinite collection, but the transfinite collection that the definitions define cannot be literally realized in a person's mind as an idea. The question is not about whether the upper limit is absolutely 9, for any finite limit guarantees that E_a cannot be realized. If one commits to Miller's Law (or to another finite limit) one also admits that genuine self-reference and thus also self-correspondence is impossible. For comparison, already Ockham concluded that the limit of levels in thinking about what one is thinking is finite:

> [S]peaking naturally, there will be some vision that cannot be seen. This is because our intellect is a limited power and thus capable of a set number of visions and no more. I do not know, however, at which vision [the regress] is stopped —though perhaps it is stopped at the second-order vision, since the second-order vision may not be seen naturally. Ockham [298, I, q. 14], as quoted in Brower-Toland [63, p. 214]

Whether the genuine existence of $E_a = ref(E_a)$ also violates finite divisibility of particulars is a matter of interpretation, but the interpretation that it does not violate finite divisibility is more complex than the interpretation that it does. Again, suppose that E_a consists of infinitely many mental parts which are all consciously experienced simultaneously, even though this violates Miller's Law, i.e., Miller's Law is temporarily dropped for the sake of the example. Recall the basic setting in §4.13 where some particulars such as E have two aspects: the concrete and the mental aspect which are inseparable.

E_a is a mental property of E and inseparable from the concrete aspect E_c of E. There are two alternative interpretations.

(1) *The separability thesis of complexity*: E_a can consist of infinitely many parts while E_c consists of finitely many parts.
(2) *The inseparability thesis of complexity*: If E_a consists of infinitely many parts, then also E_c consists of infinitely many parts.

Given (2), genuine self-reference would violate finite divisibility. Given (1), genuine self-reference would not violate finite divisibility, but (1) would detach the complexity of E_a from the complexity of E_c. This would practically violate the inseparability of human mind from human body (§4.13), which would in practice be some version of mind-body dualism, for in this case the link between E_a and E_c would be very loose. Thus, unless something too close to mind-body dualism is accepted, it is hard to see how (1) could be plausible. Moreover, Miller's Law together and empirical data together support (2). To illustrate, consider a commonly known fact: "As regards the issue of complexity, this is quite evident: the brain is one of the most complex systems we know" (Atmanspacher [34]). Now, even though the brain is extremely complex, still Miller's law gives 9 as the limit. If you wish to select (1), you must disregard all this.

In sum, given that Miller's Law holds or finite divisibility with (2) holds, a thought (a proposition) cannot refer to nor correspond to itself. Self-referring thoughts in any case violate Miller's Law and are uneconomical, but given that (1) holds, self-referring thoughts do not violate finite divisibility but instead require something close to mind-body dualism. This reminds that in metaphysics everything is interrelated and that a satisfiable analysis requires explicating the interrelations.

EXAMPLE II: TWO IDEAS CANNOT REFER TO ONE ANOTHER. Suppose that E_a refers to F_a and that F_a refers to E_a, which is written as $E_a = ref(F_a)$ and $F_a = ref(E_a)$. Together they imply $E_a = ref(ref(E_a))$, which implies $E_a = ref(ref(ref(\ldots)))$, i.e., the existence of a genuinely non-wellfounded thought, which is uneconomical as shown in example I. Exactly the same paradox concerns all circular chains of ideas such as the following: $E_a = ref(F_a)$, $F_a = ref(G_a)$, $G_a = ref(E_a)$. Together, these imply $E_a = ref(ref(G_a))$, which implies $E_a = ref(ref(ref(E_a)))$, which implies $E_a = ref(ref(ref(\ldots)))$. In sum, two spatially separate ideas cannot refer nor correspond to one another in EUO as wholes.

EXAMPLE III: A PROPOSITION CANNOT SIMULTANEOUSLY CORRESPOND TO AND BE IDENTICAL TO A PARTICULAR. Suppose that the proposition E_a='Mount Everest is over 8000 metres tall' corresponds to its truthmaker: the physical object, the mountain Mount Everest. Clearly, the proposition E_a which is realized in the mind of a human being cannot be identical to a concrete mountain. Compare to Candlish [75, p. 205]: "the fact which makes true the proposition that I have an Australian 5$ note note in my pocket seems to involve a piece of plastic; but the proposition itself does not."

EXAMPLE IV: IF PROPOSITION a CORRESPONDS TO IDEA b, THEN a CANNOT BE IDENTICAL TO b. Suppose that a corresponds to b. For instance, a is the true proposition that b is a circle. In other words, a is the proposition that a certain person is experiencing a mental image which is a circle, and a is true because that person *is* experiencing a circle, i.e., the person who conceives b conceives a circle. In this case a and b are not identical, for the proposition a='b is a circle' is not identical to the idea b='circle.' This example is about as close as possible of a truthbearer being identical to a truthmaker in the context of object-based correspondence. For, if you think that another person is thinking about a circle, you are thinking about a circle too, although not in the same sense as the other

person. The difference is revealed clearly by the following example: suppose that you think that another person is feeling pleasure and your proposition is true; your belief that another person is feeling pleasure is not identical to the feeling of pleasure that the other person experiences.

EXAMPLE V: IF PROPOSITIONS a AND b ARE IDENTICAL, THEY DO NOT CORRESPOND TO ONE ANOTHER. Suppose that a and b are identical. For instance, suppose that persons A and B are standing in front of one another, that A thinks that B is thinking about a circle, and B thinks that A is thinking about a circle. Both A and B are experiencing an identical proposition: *the person in front of me is thinking about a circle.* A is experiencing the proposition a and B is experiencing the proposition b, where a and b are identical but not the same, as they are spatially separate (§4.6). Now, a and b are identical, but a does not correspond to b —nor vice versa— for the proposition a='B is thinking about a circle' does not correspond to the mental state of B. The proposition a='B is thinking about a circle' is not true because B is not thinking about a circle. What B is thinking about is this: 'A is thinking about a circle.'

EXAMPLE VI: PRACTICAL LIMITATIONS. Recall that the Universe has been defined as the sum of all that has existed in the past, all that exist now, and all that will exist in the future. That is, we have the idealization U of all that ever exists. The difficulty is that the idealization U also exists, and thus if U refers to the sum total of all that ever exists, U refers to itself. In EUO, U is interpreted to not to refer to U itself. Russell [343, p. 225] had exactly the same solution. Although the solution that U cannot refer to itself may feel problematic in the sense that all that ever exists should be covered by the idea of all that ever exists, this problemacy is explicitly taken as a practical limitation in EUO. In contrast, a proponent of infinite divisibility may accept that self-reference actually takes place, and conclude that U is a non-wellfounded structure.

As an equivalent example, in EUO the present temporal stage of the Universe (TSU) p determines which TSUs are realizable at time $p+1$ (§7.1). Consider the proposition E_a: "TSU p determines which TSUs are realizable at time $p+1$." If E_a is true, then TSU p is the truthmaker of E_a. If E_a is stated at p, i.e., if E is a proper part of TSU p, then E_a refers to E. Again, in the context of EUO it is accepted as a practical limitation that E_a cannot refer to itself. Therefore, if E_a is especially stated at p, then the expression 'TSU p' in E_a must be interpreted to not include E_a.

EXAMPLE VII. An agent perceives the sign on the left side of figure 14. The agent interprets that the meaning of the sign is that the sign refers to itself, as depicted on the right side of the figure, where the arrow is the interpretation. POSITIVE INTERPRETATION. The sign THIS is not the same nor identical to the sign plus the interpretation of the sign, i.e. THIS≠THIS+interpretation. Therefore, nothing infinite is required here. NONPOSITIVE INTERPRETATION. THIS is interpreted to be the same or identical to THIS + interpretation. It follows that THIS = THIS + interpretation + interpretation + interpretation + interpretation ..., i.e., THIS contains all the infinitely many interpretations.

Figure 14: A sign on the left and the sign with an interpretation on the right.

EXAMPLE VIII. Consider an announcement that you hear in a buss station: "Buss number 42 leaves at 15.00 from platform 6. This announcement will not be repeated."

POSITIVE INTERPRETATION. The term 'this' refers to "Buss number 42 leaves at 15.00 from platform 6," i.e., 'this' does not refer to itself. NONPOSITIVE INTERPRETATION. 'This' refers to itself, and therefore non-wellfounded sets find application. For instance, Barwise and Ross [44] apply non-wellfounded sets in modeling such cases. Again, using non-wellfounded sets as mathematical idealizations is one thing, but this does not require assuming that nature, including thoughts, is genuinely non-wellfounded.

EXAMPLE IX. Suppose that there are three zoom-levels: (A) a picture of the Earth taken from space; (B) a picture of a country; (C) a picture of a room where is the picture A among other things. POSITIVE INTERPRETATION. There is a link from A to B, from B to C, and from C to A: this is what is done in practice in any case with computers. The idea that you can zoom potentially infinitely is enough and nonproblematic: always when you zoom, a function calculates what exists in the next level; there is no need to think that the zooming goes *infinitely all the way through*. NONPOSITIVE INTERPRETATION. The non-wellfounded sets A={B}, B={C}, and C={A} are used in modeling the case. (The other members of the sets are not written out.)

Similarly with Mandelbrot's [244] fractals. Although these were defined originally as non-wellfounded sets and these can be applied in many ways e.g. in modeling economical behavior and living organisms, this does not require supposing that nature is genuinely non-wellfounded: living organisms do not need to literally contain themselves nor be infinitely divisible in order for fractals to apply in modeling them. The repetition can continue as far as it must, but it does not have to continue infinitely all the way through in order for fractals to apply in the relevant sense.

SUMMARY. Genuine ontological self-reference is not needed, and non-wellfounded mathematical idealizations can be applied without supposing that nature is infinitely divisible. Therefore, there is no place for genuine self-reference in an economically unified theory. Supposing that genuine self-reference takes place means in practice that unnecessarily heavy mathematical idealizations are imposed on nature, i.e., this case is very close to imposing infinite divisibility in general on nature.

4.19 Summary

It was shown how the axiomatic method can be applied together with the principle of economy in metaphysics in an easily understandable and informal way. The axioms of EUO were derived, defended and interconnected, and their central connections with the Dynamic Universe model (DU) were explicated. The axioms of EUO —presentism, causality, ontological realism, the law of non-contradiction, finiteness— are mutually compatible, compatible with DU and they function together seamlessly in the overall axiomatic system. Some indispensable concepts were defined in terms of the axioms, some theorems were proved from the axioms, and some rejections were committed.

The axioms were defended primarily by economy, but also by relying on the existing literature, yet without going into details of all presented arguments and their resolutions. Opening up all arguments that have been presented for and against the axioms is impossible because of limitations in space. But there are no surprises in the vicinity: the functioning of the axioms does not hang on good luck.

Presentism is defended exhaustively in this and the other sections: in addition to being the simplest axiom for temporal existence, all arguments against presentism I could find from the literature are exhausted. When defending presentism, it becomes impossible to miss the importance of coupling DU with EUO, for the only genuine threat to presentism

is the Theory of Relativity. Much was built on the fusion of presentism and causality. The causality axiom attaches everything to space, rejects propertyless particulars, and accepts that every cause has a consequence and that all objects are directly or indirectly causally connected. The causality axiom underlines the connections of EUO and DU, as EUO relies on those descriptions of causal connections between objects that are postulated in DU, and as there is a small step from the causality axiom into the conservation law of energy and Mach's Principle. Ontological realism was contrasted to solipsism and it was concluded that an empirically sufficient version of solipsism is at best equivalent with ontological realism, and thus the commitment to ontological realism stands on a firm footing. It is very difficult to find any good arguments against the ontological version of the law of non-contradiction. The finiteness axiom is a sufficient explanation of perceptions, it is simpler than its alternatives and it is very difficult to find relevant obstacles for accepting it.

Once again, it is not argued that EUO is final or perfect or complete or all-pervasive. The purpose of EUO is to function as an economically unified foundation for the concepts defined in terms of it, so that these function in the focal contexts. EUO can be rejected at once it is shown that it does not do what it ought to. There are different ways of pointing out errors of EUO. One is to show that EUO is contradictory. One is to show that EUO does not suffice in explaining something that is required by the concepts defined in terms of it. One is to present a viable alternative fusion of axioms, show that it is compatible with some theory or some combination of mutually compatible theories of fundamental physics, and to show that the principle of economy favours this fusion over EUO+DU. One can also come up with another objective, clearly formulated and in all ways as viable evaluation criterion. But one should not reject EUO without showing what is wrong with it. Criticising one axiom in isolation of the totality or in isolation from the job that EUO is intended to do would be equivalent with criticising one axiom of a collection theory such as mereology or set theory without seeing its role in the total system. If one axiom is criticised and it is suggested that it should be replaced by an alternative, then the effects of this replacement with respect to the total ontology and its intended function must be taken in account.

5 Ontology II: The Dynamic Universe Model

The Dynamic Universe model[60] (DU) and physics based on the Theory of Relativity are investigated and evaluated. This is done in order to show that EUO and DU fit together seamlessly, to show why EUO is incompatible with relativistic physics, and to provide together with §4 an easily accessible introduction to some of the central relations of physics and topics that are typically investigated in philosophical literature, where the most central intersections are time and causality. The following abbreviations are used.

DU: The Dynamic Universe model. The central postulate is the zero-energy formulation of the conservation law of energy within spherically closed space. In DU the Universe is a sequence of consecutive TSUs which are in a forward directed temporal and causal succession, where all parts of a single TSU are causally connected and exist absolutely simultaneously. Every particular aims towards its minimum potential energy and potentiality aims to get actualized/realized into motion. (Suntola [385, p. 125], [384, ch. 1]).
SR: The Special Theory of Relativity. The central postulates are the relativity principle (§5.6), constant velocity of light and Lorentz transformations.
GR: The General Theory of Relativity. GR inherits all postulates of SR. The central addition is the equivalence principle (p. 109).
FLRW: The Friedmann-Lemaître-Robertson-Walker model, the contemporary standard model of cosmology (§5.4). Inherits all postulates of GR and adds postulates on the top of these.
Relativistic physics: all physics based on SR and GR, including FLRW.

DU and EUO are compatible and form together the given version of the unified theory. The left side of figure 15 illustrates that DU and EUO share the causality axiom and absolute simultaneity, but no other postulates. The smaller ellipse on the right denotes what DU and EUO together state or imply to exist. The larger ellipse on the right denotes all that is compatible with DU. While DU leaves open the selection of some axioms, in EUO these selections are especially done. Although DU does not explicitly commit to all axioms of EUO, it is compatible with all of them. DU does not stand in the need of their alternatives, although DU is compatible with some of them.[61] As DU and EUO function

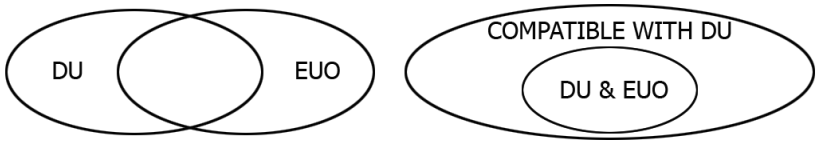

Figure 15: The overall relations of DU and EUO.

together and as numerous popularisations of relativistic physics are available but none of DU, this section concentrates on popularising DU, whereas the account of how DU differs from relativistic physics is secondary. Although DU explains phenomena from the cosmological scale down to the sub-atomic scale, the emphasis here is on cosmology. As the function of a model of cosmology is to predict how the Universe behaves in the largest cosmological scale and to give an account of the overall contents of the Universe,

[60] DU was formulated by Tuomo Suntola [384]. See also Suntola [386] and Suntola, Lehto, Kallio-Tamminen and Sipilä [387]. More publications about DU are available at `http://www.physicsfoundations.org/founders/tuomo-suntola/foundations-of-physics/`

[61] Suntola personally commits to all axioms of EUO and their implications, except he leaves the case between the mind-independence thesis and mind-dependence thesis open (§4.12).

cosmology is a natural starting point to investigating all-pervasive principles in physics, that are essential in forming a comprehensive and unified world-view. This introduction is mainly informal and aims only to give a an understandable introduction to the overall metaphysical structure of DU, without going into details. A more detailed investigation would require more formalism and such accounts are already available.

5.1 The Basic Structure of DU: 4D Geometry and Zero-Energy Balance

What is the center of the Universe which is at rest, i.e., where is the center of each temporal stage of the Universe (TSU)? Perceptions show that when looking at any direction from the Earth or anywhere from the Solar System, space is homogeneous: there is approximately as much perceivable matter everywhere. We see as 'far' in every direction, and all perceived galaxies appear to move away from the observer. Based on the observed redshifts, the farther away a galaxy or a supernova is from the observer, the faster it appears to be moving away from the observer. Thus, if space is three-dimensional, the observer can consider himself as the center of the TSUs. Given the amount of galaxies, it is terribly improbable that just the one where we reside is the center point. Thus, the huge improbability must be explained away. DU gives an answer to the question about the center point by means of four-dimensional spherical geometry. In DU, a TSU is modeled as a *three-dimensional surface of a four-dimensional sphere*, where the radius of the 4D sphere is the fourth dimension, and where the 3D space is *spherically closed* (Suntola [384, pp. 36-9, 73-4]).[62] Accordingly, the Universe is modeled as a sequence of such TSUs, i.e, the Universe behaves or evolves as if the 3D space were the surface of a 4D sphere that expands.

As it is impossible to draw a 4D figure, the closing of a 3D object with the fourth dimension can be characterized by an analogy with the closing of a 2D object with the third dimension. A closed object has no edges. There is a 2D plate (a piece of paper or *parallelogram*) on the left side of figure 16. The plate is not closed, as it has four sides as the edges. On the center, the plate is wrapped into a tube, which eliminates two of the four edges. As the plate is wrapped into a tube, the third dimension is added as the radius of the tube. The tube still has two edges in the ends. As depicted on the right, all four edges can be eliminated by wrapping the plate into a sphere, which is the simplest structure that can eliminate all edges. Also the sphere has a radius, which is the third dimension. The 2D plate has thus been closed by wrapping it into the form of a 2D surface of a 3D sphere. An analogous wrapping is made to the 3D Universe: its edges

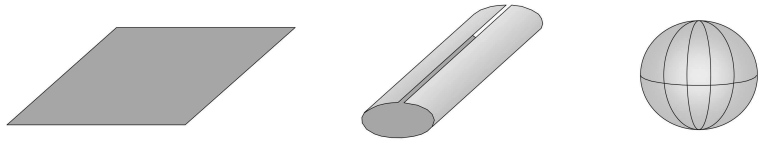

Figure 16: Closing 2 dimensions with a third dimension. Suntola [384, p. 73].

are eliminated by wrapping it into s form of a surface of a 4D sphere. The surface of the

[62]More accurately, *hypothetical homogeneous space* (p. 111) has the shape of a perfect 3D surface of a 4D sphere, creating the overall zero-energy condition of motion and gravitation. The process of formation of local mass centers in 3D space conserves the zero-energy balance by tilting the 3D space relative to the 4-radius, i.e., bending the surface of the 4D sphere in the vicinity of mass centers.

sphere counts as the three dimensions, and the radius of the sphere counts as the fourth dimension. That a TSU is a 3D the surface of a 4D sphere means that the surface of the sphere is all that exists: nothing exists inside nor outside the sphere. As the surface is closed, if one could move far enough in any one direction, starting from point x, one would eventually return to point x.

In DU the center of a TSU is the center of the 4D sphere. The center of a TSU is not in the 3D space, for the 3D space is the surface of the 4D sphere: the center is only a part of the 4D model *of* the 3D space, i.e., the center of a TSU is merely an idealization. The fourth dimension is the radius of the 4D sphere and the radius has metric nature as it is given in meters. In contrast, in relativistic physics the fourth dimension is time-like. 4D spherical geometry is not a new idea, as spherically closed space was outlined in the 19th century by Ludwig Shäfli and Bernhard Riemann (Suntola [384, p. 33], cf. Feynman [142, p. 164]).

THE FUSION OF 4D GEOMETRY AND THE CONSERVATION LAW. The conservation law of energy (CLE) states that *the total amount of energy of every possible temporal stage of the Universe is identical*. The basic structure of DU can be characterized as the fusion of the 4D geometry and CLE. DU incorporates CLE in the form of the *zero-energy principle*, where zero[63] is the sum of the total *potential energy* and the total *energy of motion*.[64] In DU, potentiality aims to get actualized/realized into movement and moving objects aim at their minimum of potential energy: the apple aims to actualise its potential by dropping into the location of its minimum potential.

The energy of motion comes in two forms: the energy of motion related to the expansion or contraction *of* space;[65] the energy of motion of localized objects that move *in* space. The energy of motion results primarily from the expansion of space, and motion within space may be disregarded in the largest cosmological scale. Likewise, *gravitational energy* is the primary form of potential energy, and other forms of potential energy may be disregarded in the largest cosmological scale. Figure 17 depicts relations of the 4D geometry and the zero-energy balance between the gravitational energy and the energy of motion, within one contraction-expansion cycle. When the Universe expands the radius of the 4D sphere increases; when the Universe contracts the radius of the 4D sphere decreases. An analogy with an *ideal pendulum* is depicted on the bottom of the figure. On the extreme left at the initial stage of the contraction-expansion cycle, the pendulum is ideally still, the radius of the 4D sphere is at the widest, the energy of motion is minimal and the gravitational energy is maximal. The maximal gravitational energy is mathematically 0. When the Universe contracts the radius of the 4D sphere decreases. Mathematically, when the Universe contracts the energy of motion increases in the positive direction, and the gravitational energy decreases, i.e., increases in the negative direction, where their sum is always zero. The contraction continues until the singularity, where the gravitational energy has reached its minimum and the energy of motion has reached its maximum, where their sum is zero as always. The closer the Universe is to the singularity in the contraction stage, the faster is the contraction and the greater the energy of motion, and the smaller the gravitational energy. After the

[63]That the total energy of every possible TSU is 0 does not imply that an empty TSU is possible.

[64]The zero-energy principle finds roots in G. W. Leibniz's dichotomy of *vis viva* or the living force, and *vis mortua* or the dead force. See e.g. Leibniz's *Specimen Dynamicum* (1695) [217, vol. VI, p. 238f]. Energy of motion or kinetic energy analogous to vis viva, and potential energy is analogous to vis mortua. Vis viva is obtained against release of vis mortua and vice versa. In turn, Suntola [385, p. 46] maintains that "Leibniz was searching for a physical expression for Aristotle's *entelecheia*, the actualisation of potentiality" which is discussed in §5.2.

[65]This is equivalent with *rest energy* in relativistic physics.

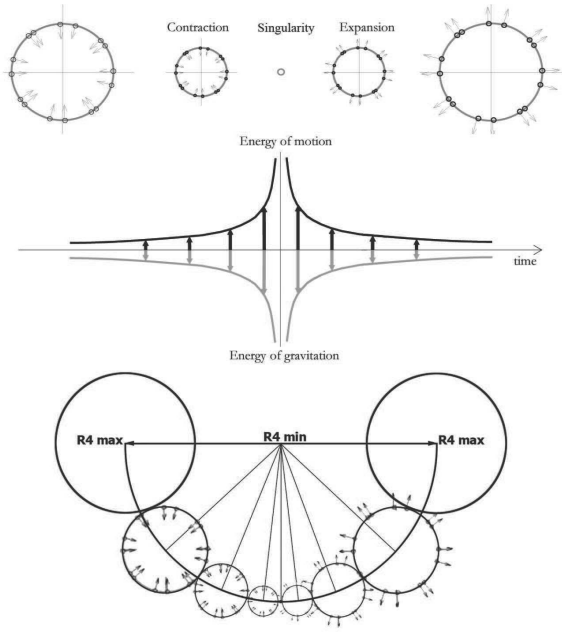

Figure 17: The balance of the gravitational energy and the energy of motion. The figure is a modified version of Suntola [384, p. 82].

singularity, contraction turns into expansion. Currently the Universe expands: the radius of the 4D sphere increases, the energy of motion decreases and the gravitational energy increases.

Suntola [385, p. 148] uses an analogy with a book-keeper's principle: the gravitational energy (potential energy) which is released into motion in the contraction stage is paid back in the expansion stage. The closer the Universe is to the state of maximal expansion, the slower is the velocity of expansion and the smaller the energy of motion, and the greater the gravitational energy. Ideally, when the expansion has stopped the Universe is 'still' and the energy of motion is minimal and the gravitational energy is maximal. After this the contraction may start again, i.e., the cycle may start again. DU is compatible with the eternal Universe theorem (§4.11) although Suntola does not speculate about any other cycles than the current one.

THE ENERGY BALANCE EQUATION, MASS AND THE VELOCITY OF LIGHT. DU's energy balance equation interrelates CLE, the velocity of expansion/contraction (c) in the fourth dimension, the radius of the 4D sphere (R_4), the mass of the Universe (M) and the mass equivalence (M'', p. 111). The equation states that the energy of motion (the left side of the equation) is equal to the potential energy (the right side of the equation):

$$c_0^2 M = \frac{GMM''}{R_4}$$

c_0 is the velocity of expansion of space, i.e., the velocity of the increase of R_4.[66] As a consequence of the zero-energy balance, c_0 is the maximum velocity of any object moving *in* space. Thus, c_0 is also the maximum velocity of light *in* space. In *hypothetical*

[66]The velocity expansion in the expansion stage; the velocity of contraction in the contraction stage.

homogeneous space (p. 111) the velocity of light in space is equal to c_0. However, in reality space is not homogeneous, and in the vicinity of mass centers in space, local space is tilted in the fourth dimension, making local velocity of light smaller than c_0.[67] The velocity of light in space changes along with the change of R_4, and with the local gravitational state. This is a decisive difference to relativistic physics where the velocity of light is constant.

In DU all particulars —including electromagnetic energy particulars— have mass and all forms of electromagnetic energy are derivatives of the energy of motion. Therefore 'particular' and 'mass particular' are equivalent. In DU mass is postulated as the substance of the expression or realization of energy, i.e., mass particulars are the substances that realize energy: mass is eternal but the ways or forms of how mass particulars realize energy change. A mass particular realizes both forms of energy: potential energy such as gravitational energy and energy of motion. This applies to temporal stages of the Universe (TSUs) as wholes as illustrated by the energy balance equation, as well as to proper parts of the TSUs. In the level of TSUs the energy balance equation states that the energy of motion of the mass of a TSU is equal to the gravitational energy of the mass of the TSU. See *unified expression of energy* in Suntola [384, pp. 40-1, 336].

THE RELATION OF A PARTICULAR'S GRAVITATIONAL ENERGY AND ITS ENERGY OF MOTION. In DU the energy state of a particular is its combined state of motion and gravitation. A particular which is a proper part of a TSU —such as a planet, a star, a galaxy or a single particle— resides in a certain location in a gravitational potential field created by all other mass in space. The particular recognizes (§5.2) its gravitational potential as its gravitational energy. A particular expresses two forms of energy of motion: motion *with* space in the fourth dimension (or rest energy); motion *in* space as kinetic energy. In sum, the energy state of a particular is its combined state of motion and gravitation, and its state of motion is its combined state of motion with the expanding space and its state of motion in space. *Mach's principle* is thus is implicit in DU (p. 26).

As an implication of the conservation of energy mechanism, an object's momentum in the fourth dimension decreases when its momentum in a space direction increases, and vice versa; the closer the velocity of an object in space is to the velocity of light, the smaller its momentum in the fourth dimension, and vice versa. Consider three cases. (i) An object such as a photon moving at the velocity of light in space has momentum only in the direction of its motion in space. (ii) An object at rest in space has momentum only in the fourth dimension. (iii) An object moving in space at a velocity lower than of light has momentum both in the fourth dimension and in a space direction.

There are two cases of the change of velocity of an object: acceleration/deceleration at a constant gravitational potential; acceleration in free fall in a gravitational field and deceleration in escape in a gravitational field. At a constant gravitational potential an object such as a particle in an accelerator on the surface of the Earth gains kinetic energy from the energy released by the accelerator. The obtained state of motion of the object is associated with an increase of its inertial mass. The kinetic energy of an object in free fall in a gravitational field is obtained against reduction of its rest energy; this does not increase the inertial mass of the falling object. See Suntola [384, §4] for a more accurate description of these proportions.

COMPARISON WITH GR. In GR there are particulars which have mass, and particulars which do not have mass such as photons, gluons and gravitons. A particular's mass is expressed in terms of its rest mass (or *invariant mass*) and inertial mass (or *relativistic*

[67] See Suntola [384, p. 106, eq. 4.1.1:13; p. 109, eq. 4.1.1:28, p. 141].

mass). The rest mass of a particular is independent of its velocity in space, whereas its relativistic mass depends on its velocity in space. The *Equivalence Principle* —which states that an object's gravitational mass is equal to its inertial mass or that "the state of affairs in a homogeneous gravitational field is identical to the state of affairs in a uniformly accelerated coordinate system" (van Dongen [404, p. 6])— implies that an object's inertial mass increases along with the increase of velocity in both cases: when an object is accelerated at a constant gravitational potential; when an object's velocity increases in free fall.

5.2 From Mechanistic Force to Nonmechanistic Energy

Relativistic physics (RP) is *mechanistic* as all influences are explained solely in terms of moving objects. DU is *nonmechanistic* as only some influences are explained in terms of moving objects and others in terms of potential energy (Suntola et al. [387]). Mechanicism would be more economical than nonmechanicism if all influences could be explained without difficulties in terms of moving objects and if mechanicism would not be involved with metaphysical postulates equal to the postulates of nonmechanicism. However, mechanicism happens to be involved with equally heavy metaphysical postulates as nonmechanicism, plus the hypothesis of mechanistic influences that propagate at the velocity of light faces unsurmountable problems, whereas the hypothesis of instantaneous nonmechanistic influences resolves these.

In RP objects emit force-conveying particles that move in space: forces are thought to be conveyed via particles called *gauge bosons*. Also gravitation is mechanistic in the RP, where gravitation is thought to propagate mechanically at the speed of light via gauge boson particles called *gravitons*. The existence of gravitons has not been empirically verified, which makes them hypothetical entities. This means that mechanistic gravitation is as metaphysical as nonmechanistic gravitation.

Gravitons reveal a disunified feature of RP. Particles which move in direction D are generally conceived to *push* objects in direction D, and not *pull* them in the opposite direction. On one hand, in the scale of individual galaxies and smaller systems such as star systems, gravitons are supposed to move with a force towards direction D, but still pull the objects which they hit towards direction opposite to D. On the other hand, in the largest scale the pushing-idea works at least partially, in the sense that dark energy is supposed to push the galaxies away from one another in FLRW. In addition to the pushing-pulling controversy, the idea that gravitation propagates at the speed of light faces a problem which was recognized by Pierre-Simon Laplace. The stability of the Solar System requires that the velocity of gravitation must be remarkably faster than the speed of light:

> I was first led to suppose that the propagation of gravitation is not instantaneous, but happens with the speed of light. This seems at odds with results obtained by Laplace, who announced [in Mécanique Céleste 1, 1799-1825] that this propagation is, if not instantaneous, at least much faster than that of light." Poincaré, as quoted in Suntola [385, p. 73]

Instantaneous gravitation would sustain the stability. However, if instantaneous gravitons were accepted, the idea of graviton *particles* could be rejected altogether, for instantaneous movement is not movement at all: to move instantaneously from location A to location B is the same as to *be* in A and B simultaneously. DU replaces the *conveying of forces via moving particles* by *recognition of the local gradient of potential energy.*

Objects recognize their potential energies always, everywhere and instantaneously: the recognition is the link between an object and its potential energy. Take gravitation as an example. DU shifts from *mechanistic conveying of gravitation via graviton particles* into *recognition of the local gradient of gravitational potential*. For instance, the recognition of the gradient of the gravitational potential of a football may be analogized with the recognition of the steepness of the hill where the football is situated.

To illustrate the difference of DU and RP, consider an apple hanging from a tree. In RP, gravitons that are emitted by the Earth hit the apple and attract it towards the ground. Also the apple emits gravitons which hit the Earth. The apple remains in the tree as long as the gravitational force conveyed by the gravitons is weaker than the force of the chemical bonds of the molecules that keep the stem of the apple attached to a branch. In DU, the apple recognizes its gravitational energy and it also recognizes the energy of the chemical bonds with which the apple is attached to the tree. The gravitational energy together with the chemical bonds create a local minimum of potential energy at the bonding distance, i.e., at the location where the apple hangs from the tree. When the apple hangs from the tree in location x, the apple is in a local minimum in x, and therefore the apple does not fall to the ground. As the apple ripens, the chemical bonds weaken. In effect, the location of the local minimum of the apple changes: the apple falls to the ground to the new local minimum.

In DU, potentiality aims to get actualized/realized into movement and the moving objects aim at their minimum of potential energy: the apple aims to actualise its potential by dropping into the location of its minimum potential. This scenario is close to Aristotle's *entelecheia*, the idea that movement is actualization of potentiality:[68] "Now since every kind of thing is divided into the potential and the real, I call the actualization of the potential as such, motion" (Aristotle, *Metaphysics*, bk. 11, 1065b15-20). Suntola [385, p. 132] maintains that the "study of space as a dynamic energy system reestablishes Aristotle's ... actualization of potentiality, to the status of a primary law of nature." Actualization of potential energy into energy of motion naturally fits perfectly together with the zero-energy balance of these two forms of energy.

That gravitation is instantaneous in DU does not mean that whatever superluminal influences should be applied by free association. The order must be always kept in mind: if the simplest explanation of a phenomenon does not require superluminal influences, these should not be imposed. For instance, Di Lorenzo, [229, 230], Jaynes [187], Thompson [396], Geurdes [155], Christian [86] and Bryan and Medved [65] have argued that superluminal influences are not required as the explanation of the results of the *Bell inequality* tests, as long as one sticks with the mind-independence thesis (ontological realism). DU does not support the interpretation that explaining the results of the Bell inequality tests require something superluminal.

5.3 DU's Expansion Hypothesis and Other Calculations

It is shown how the 4D spherical geometry and DU's energy balance equation can be applied together in cosmological calculations. This section proceeds as follows. (i) The energy balance equation and the basic constants are listed. (ii) The circumference or the size of the present TSU is calculated. (iii) The concepts of *hypothetical homogeneous*

[68] Consider the relation of potentiality and possibility. Being at a local minimum at the present time is always a possibility, for the actual present is a possibility. Given partial determinism, when the apple drops from the tree, the location of its new local minimum is not totally determined, but there are several possible locations. See e.g. Sach [346, ch. 2] for a discussion of Aristotle's entelecheia.

space and *mass equivalence* are explained and the mass of a TSU is calculated. (iv) The volume and density of the present TSU are calculated. (v) It is explained how the changing velocity of light is derived from the basic structure of DU. (vi) It is calculated how much time has passed since the singularity. (vii) The hypothesis of decelerating expansion is calculated.

ENERGY BALANCE EQUATION $c^2M = \frac{GMM''}{R_4}$, where R_4 is the radius of the 4D sphere. The equation states that the energy of motion (the left side of the equation) is equal to the potential energy (the right side of the equation).
MASS OF THE UNIVERSE $M = \frac{M''}{0.776}$.
MASS EQUIVALENCE $M'' = 0,776\ldots \times M$.
CURRENT VELOCITY OF LIGHT $c = 300000\frac{km}{s}$ or $3 \times 10^8 \frac{m}{s}$.[69]
ONE LIGHT YEAR $9.4605284 \times 10^{15}m$. The distance travelled in one year at the current c.
GRAVITATIONAL CONSTANT $G = 6.67 \times 10^{-11}\frac{m^3}{kgs^2}$.
MEGAPARSEC $Mpc = 3.086 \times 10^{22}m$.
HUBBLE CONSTANT $H = 70\frac{km/s}{Mpc}$. The dimension of H is $\frac{velocity}{distance}$. H denotes the current expansion rate of the Universe.[70]
HUBBLE RADIUS $R_H = 1.4 \times 10^{10}$ light years or $1.32 \times 10^{26}m$. R_H is equal to the current R_4.

CIRCUMFERENCE OR SIZE OF THE PRESENT TSU. First, $R_4 = \frac{c}{H}$, i.e., R_4 can be calculated from the constants H and c. Second, the size of the present TSU may be considered as the circumference of the 4D sphere, which is $2\pi R_4 = 88$ billion light years. The circumference increases proportionally to the increase of R_4. As a TSU is a closed system in DU, you can imagine that you are holding one end of an ideal thread with the length of 88 billion light years in one hand, and the other end in another hand; the length of the thread increases along with the expansion of the Universe. 88 billion light years is analogous to the concept of *co-moving distance* in FLRW.

MASS; MASS EQUIVALENCE; HYPOTHETICAL HOMOGENEOUS SPACE. Hypothetical homogeneous space and mass equivalence are used for several purposes in DU. These are not ontological commitments but syntactical idealizations. In hypothetical homogeneous space, all mass is thought to be uniformly distributed in space: objects are not thought to move *in* space, but they are only moving along the expansion of space, i.e., all objects are thought to be at rest in space. The mass equivalence is set in the center of the 4D sphere. Consider a particular such as an elementary part (or test mass) m in space. The gravitational energy of the hypothetical homogeneous space that affects m, is equal to the gravitational energy of the mass equivalence M'' which is set in the center of the 4D sphere. Consider the energy balance equation $c^2M = \frac{GMM''}{R_4}$. Eliminating M from both sides of the equation results in $c^2 = \frac{GM''}{R_4}$. By elaboration, $M'' = \frac{c^2R_4}{G}$. With the above values $M'' = 1.78 \times 10^{53}$ kg.[71] $M = \frac{M''}{0.776} = 2.3 \times 10^{53}$ kg. As mass is conserved in DU,

[69] Although the local velocity of light c_x in a specific location x in space is different from the velocity of expansion c_0, as was explained in p. 108, the difference is very small. For instance, when x is in the vicinity of the Earth, $c_0 = 1.000001c_x$ approximately (Suntola [384, p. 123]). Because the difference is so small, and as the Hubble constant (below) is inaccurate, and as these are used together in the below calculations, we can simplify the notation and use plain c in all examples.

[70] Empirical estimations of H have varied in the past. Chen and Ratra [152] calculate the median statistical value $H = 68 \pm 5.5\frac{km/s}{Mpc}$, based on some 553 estimations. As the error margin of the value $H = 70\frac{km/s}{Mpc}$ is so great, everything that is calculated by using H must be seen as an inaccurate approximation as well.

[71] The mass equivalence is calculated in (Suntola [384, §§3.2.1-3.2.2, pp. 85, 91])

every TSU has the same mass.

VOLUME AND DENSITY. The volume V of the present TSU —the volume of the 3D surface of the 4D ball— is given by the formula $V = 2\pi^2 R_4^3$, which makes about $4.5 \times 10^{79} m^3$. The average density $D = \frac{M}{V}$ is calculated by dividing the mass of a TSU M by its volume V, which makes about $5 \times 10^{-27} \frac{kg}{m^3}$. As in DU the density of a TSU can be calculated from the basic structure, the density parameter (with or without the dark energy) is not needed in the expansion hypothesis of DU, although the hypothesis of dark matter is required in the scale of an individual galaxy.

THE CHANGING VELOCITY OF LIGHT. As the mass of the present TSU has been calculated, the changing velocity of light can be calculated by changing R_4. Consider again the energy balance equation $c^2 M = \frac{GMM''}{R_4}$. By eliminating M from the equation and taking a square root of both sides, we get $c = \sqrt{\frac{GM''}{R_4}}$ as the velocity of expansion, which is also the velocity of light with the given R_4. When the Universe expands, R_4 increases and the velocity of light decreases; when the Universe contracts, R_4 decreases and the velocity of light increases. The greater the radius, the smaller the velocity of expansion and light; the smaller the radius, the greater the velocity of expansion and light. The velocity of light is equal to the velocity of the increase of R_4: the energy balance is primary, whereas the velocity of light is derived as a function of R_4. In the on-going expansion phase, as R_4 increases, the velocity of expansion decreases and all movement within space gets slower, including the velocity of light. The velocity of expansion is the maximum velocity that anything may have in space, and this is the velocity of light. The changing velocity of light is not measurable, for atomic clocks must be used in measuring it, and the ticking rate of atomic clocks is directly proportional to the velocity of light. Therefore, all measurements give always a constant speed of light. Although the velocity of light will always be measured and experienced to be the same, the length of one second now is shorter relative to one second in the future, for the velocity of light decreases as the Universe expands.

TIME THAT HAS PASSED SINCE THE SINGULARITY. If the velocity of light were constant and the present velocity of light, about 14 billion years would have passed since the singularity. The decreasing rate of the expansion and the proportionally decreasing velocity of light entail that the velocity of light was higher in the past, and it can be calculated that $\frac{2}{3} \times 14 = 9.3$ billion current years have passed since the singularity (Suntola [384, pp. 90-4]). In DU the 14 billion light years radius R_4 makes up only 9.3 billion current years because the velocity of expansion has been decreasing ever since the singularity.

DECELERATING EXPANSION. Similarly as FLRW, DU applies in its expansion hypothesis the Hubble constant, the gravitational constant and the current velocity of light. Once these are given, mass and density of the present TSU can be derived from the basic structure of DU as shown above. The velocity of expansion c_t at time t —where c_t is also the velocity of light at time t— is calculated with the formula $c_t = \frac{2}{3}\frac{R_{4,t}}{t}$, where t is the time that has passed since the singularity, and $R_{4,t}$ is the radius of the 4D sphere at time t (Suntola [384, eq. 3.3.3:8]). Given the current $R_4 = 14$ billion light years, and the current time $\frac{2}{3} \times 14 = 9.3$ billion years since the singularity, the formula gives $c_t = \frac{2}{3}\frac{R_{4,t}}{t} = c_0$, where c_0 is the current velocity of light, about $300000 \frac{km}{s}$.

When calculating the expansion rate at other times t, R_4 at time t is needed, which is given by the formula $R_{4,t} = \sqrt[3]{\frac{9}{4} t^2 GM''}$ (Suntola [384, eq. 3.3.3:7]). For instance, what is the velocity of expansion one billion years from the present, where velocity is

given proportionally to the current velocity of light? The value t = the present time + 1 billion years must be fitted as explained above. Again, currently $\frac{2}{3} \times 14 = 9.3$ billion years have passed since the singularity, and so the question is what is the velocity of the expansion at $t = 9.3 + 1 = 10.3$ billion years from the singularity? When t is placed in $R_{4,t} = \sqrt[3]{\frac{9}{4}t^2GM''}$, the result is about 15×10^9 current light years. When $R_4 = 15 \times 10^9$ light years, and $t = 10.3$ billion years are placed in the equation $c_t = \frac{2}{3}\frac{R_{4,t}}{t}$, the result is about 98% of the current velocity of light, i.e., the velocity of light decreases about 2% during the next billion years.

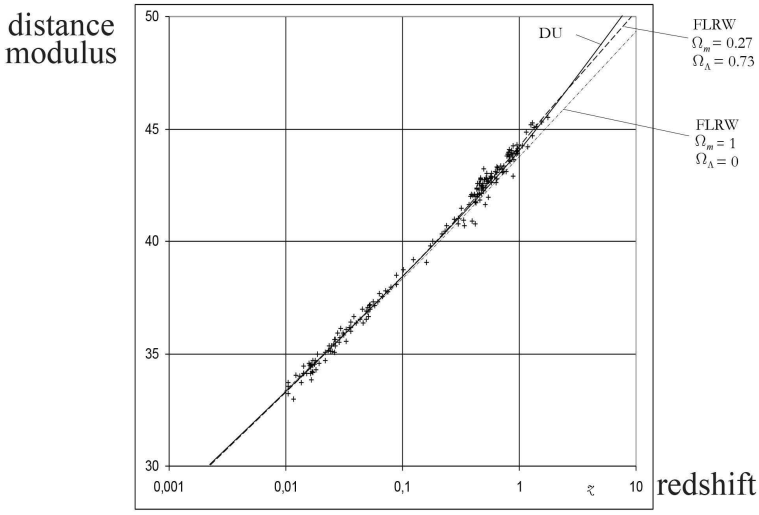

Figure 18: The crosses denote the observed distance modulus of Ia supernovae as the function of their redshifts. The dashed lines denote the FLRW prediction. The solid line denotes the DU prediction. The only actually measured values are the redshift and the *apparent magnitude* (or the distance modulus). The redshift describes the distance of the objects: the greater the redshift the greater is the distance.

Figure 18 shows the relation of the *distance modulus* (y-axis) and *redshift* (x-axis) of Riess et al. [133] dataset about observations of Ia supernovae. The FLRW predictions are obtained by giving the density parameter the value $\Omega_m = 1$ in the lowest FLRW curve, and $\Omega_m = 0.27$ and $\Omega_\Lambda = 0.73$ (dark energy) in the highest FLRW curve. The DU curve is obtained without the density parameter. At some point in the future even more accurate measurements will be available. Then we will see whether the current approximation of dark energy suffices, or whether the density parameter must be readjusted once again.

5.3.1 The Rate of the Passage of Time Argument

The *rate of the passage* argument will be discussed in defence of presentism here, because it can be effectively exhausted in the context of DU. A reader interested only in cosmology can skip this section. The argument has been formulated e.g. by Smart [366], but here it is handled according to Markosian's formulation:

> [T]here is no rate that can be coherently assigned to the passage of time. ("One hour per hour," for example, is said not to be a coherent answer to the question "How fast does time pass?") Thus, the argument concludes, it cannot be true to say that time really passes. Markosian [250]

If time would not pass, change would not take place, given intrinsic time. If change would not take place, the perceived change would be an illusion. It is first shown that the general question of how fast does time pass can be given a coherent and plausible answer in the context of DU. The answer appeals to the changing expansion rate, as explained above.

(1) The passage of time is in EUO and in DU a way of talking about the passage of change, and periods of time are defined in terms of sequences of temporal stages of the Universe, i.e., as change-sequences. For instance, the period of one second is the length of the sequence during which a cesium-133 atom performs 9,192,631,770 complete oscillations, when measured on the sea level on Earth.
(2) The definition of one second is exactly the same at all times, such as at the present and in the year F = the present time + 1 billion years.
(3) However, as the Universe expands, the expansion rate gets slower; the velocity of light and the characteristic frequencies of atomic clocks get slower. As calculated above, all these are about 2% slower at F than at the present. Therefore, the duration of one second at F is 2% longer than the duration of one second now, again when measured on the sea level on Earth. In other words, consider the period of one present second (s_P) and the period of one second at F (s_F): the duration of s_F is about $1.02 \times s_P$; the duration of s_P is about $0.98 \times s_F$.
(4) Therefore, we can talk about the rate of the passage of time in year X in terms of the proportion to year Y.

Markosian[72] formulates two of Smart's [366] arguments and maintains that these do not have force. Note that Markosian is unaware of the answer that can be given in the context of DU, but still maintains that Smart's arguments do not have force.

THE FIRST RATE OF PASSAGE ARGUMENT.
(1) If time flows or passes, then there is some second time-dimension with respect to which the passage of normal time is to be measured.
(2) If there is some second time-dimension with respect to which the passage of normal time is to be measured, then the second time-dimension must flow or pass.
(3) If the second time-dimension flows or passes, then there must be some third time-dimension with respect to which the passage of the second time-dimension is to be measured, and, hence, some fourth time-dimension with respect to which the passage of the third time-dimension is to be measured, and so on ad infinitum.
(4) It's not the case that there is some third time-dimension with respect to which the passage of the second time-dimension is to be measured, and, hence, some fourth time-dimension with respect to which the passage of the third time-dimension is to be measured, and so on ad infinitum.
(5) It's not the case that time flows or passes.

The argument is answered in the context of EUO where all sorts of transcendist time-dimensions are rejected (§4.16), i.e., the time-dimensions must be found from the Universe. The time-dimensions which can be used in giving the answer can be considered in the context of DU as different times or different periods of time, such as (A) a period of one second in the year 2014 and (B) a period of one second in another year such as in the year 2014 + 1 billion years. The rate of A can be given proportionally to B and vice versa. There does not have to be infinitely many periods: that the rate of A is given proportionally to B does not require a third period for giving the rate to B, for the rate

[72]These citations are from an on-line paper `http://myweb.facstaff.wwu.edu/nmarkos/Papers/Rate.pdf` which is a version of Markosian [248]. Basically the same reasoning can be found from Carroll and Markosian [78, ch. 7.4].

of B is proportional to A. However, proportions can be calculated to as many periods as one wishes. For comparison, Markosian (*ibid*) rejects premise (1) on the basis that he cannot see why it should be accepted.

THE SECOND RATE OF PASSAGE ARGUMENT.
(1) If it makes sense to say that time passes, then it makes sense to ask 'How fast does time pass?'
(2) If it makes sense to ask 'How fast does time pass?', then it's possible for there to be a coherent answer to this question.
(3) It's not possible for there to be a coherent answer to this question.
(4) It doesn't make sense to say that time passes.

An answer was given to the question of how fast does time pass: the passage rate of one period of time can be given proportionally to another period. For comparison, Markosian (*ibid*) makes guesses about what 'rate' means in the first place, and aims to show that whichever coherent answer is selected "there is some premise of Smart's argument that is, according to the way I have answered the relevant questions, clearly false."

5.4 From Newton into SR into GR into FLRW and its Expansion Hypothesis

DU and FLRW agree that the Universe is currently expanding and that gravitation constrains the expansion by pulling the expanding parts together. The models agree that the Universe was smaller yesterday than it is today, smaller the day before yesterday than it was yesterday, and so on. The backward decrease in size is propagated in both models in the hypothesis that the Universe was condensed into a *singularity* in the past, which bursted out, although in DU the singularity is not supposed to be a zero-size point.[73] This is where the agreement stops. DU predicts that the rate of expansion has been decreasing since the singularity, whereas FLRW predicts that the expansion is currently accelerating. In the following, the 20th century development into FLRW and its hypothesis of accelerating expansion and the interrelated addition of *dark energy* as a parameter are explained. It is notable that the 20th century developments fit perfectly in the Kuhnian picture where the evolution of theories walks hand in hand with the increase of data; the more new data, the more additional parameters the old theory requires, which creates pressure to replace it by a more economically unified theory.

Newtonian physics suffices as the point of departure. In Newtonian physics, we have absolute time and linear three-dimensional space. Mass objects which move in space follow Newtons laws of motion and gravitation, which define the forces acting on mass objects. Newtonian physics does not explain why clocks in different states of motion and gravitation show different cumulated readings. SR explains this phenomenon by applying relativistic time (§5.6). In other words, SR produces the concepts of relativistic time (or time dilation) and length contraction, and applies these in explaining phenomena. Relativistic time and length contraction are best seen as parameters. Consider a step-by-step illustration of why relativistic time should be seen as a parameter: (1) we are evaluating systems of total physics that explain all scales; (2) contradictions are not accepted in such systems; (3) absolute simultaneity is implicit in cosmic time, which

[73] According to Suntola [385, p. 291], Lemaître was the first to suggest that the Universe started to expand from a single point. For comparison, Hoyle, Burbidge and Narlikar [175] suppose in their *quasi-steady state* model that there was no single singularity, but several little mini-bangs or mini-creation events.

is needed when applying FLRW in cosmology; (4) relativistic time contradicts absolute simultaneity; (5) as contractions are not accepted, we must accept two independent notions of time in relativistic physics: relativistic time and cosmic time (§5.6.2).

GR inherits all postulates of SR, and applies the Newtonian equivalence principle in a new way by equating gravitational mass with SR inertial mass. As the result, Newtonian linear space is replaced with curved space-time which modified celestial mechanics and explained the effect of gravitation on atomic clocks. Now, the modified time and distance become the parameters defining the curved spacetime in GR. These modified Newtonian gravitation and allowed re-interpretation of gravitation as the result of the parametrised non-linear space-time. GR became the point of departure for explaining phenomena on the cosmological scale. Although SR and GR explained more than Newtonian physics and were in this sense more unified explanations, the unification did not come without further parameters and was thus not *optimally economical* unification.

SR [123] was published in 1905 and GR [124] in 1916. In 1917, Einstein [125] supposed that the Universe is static, i.e., that it does not expand nor contract, and postulated the *cosmological constant* which is compatible with this commitment. Einstein (*ibid*) also suggested 4D spherical geometry as a logically consistent visualization of the General Relativity: "At any rate, this view is logically consistent, and from the standpoint of the General Theory of Relativity, lies nearest at hand." In Einstein's considerations, the 4D sphere was static, i.e., the Universe was not considered to expand nor contract, and therefore the static 4D model sufficed, together with the cosmological constant whose job was to make the Universe static.

In 1922 Alexander Friedmann's [151] dynamic solutions of the field equations of GR indicated that there are three alternatives: the Universe is static; the Universe expands; the Universe contracts. By the end of the 1920's there was enough data or empirical observations —Hubble's observations— about red-shifts and magnitudes of distant galaxies that these together with Friedmann's (*ibid*) and Lemaître's [219] (1927) reasoning proposed that the Universe is currently expanding. As Einstein had to accept that the Universe expands, he abandoned his static 4D model and the cosmological constant.[74] As a result of abandoning 4D spherical geometry, the geometry of space was left open, and the question about the center point of the Universe was left open along with it.[75]

As there was a consensus in the 1930's that the Universe is expanding and observations that supported the consensus, the cosmology model had to be developed so that it provides predictions which match these observations (Suntola [385, pp. 89-99]). The resulting model became to be called FLRW (the Friedmann-Lemaître-Robertson-Walker model), which became the standard model of cosmology. In its basic form, it contains two central parameters, the Hubble constant and the density parameter, which can be

[74]Why did Einstein not transform the static 4D model into a nonstatic and dynamic 4D model, which is exactly what is done in DU? This would have required very much work and re-thinking the fundamentals. Time was already the fourth dimension in the Theory of Relativity, whereas in DU the fourth dimension is the radius of the 4D sphere. The velocity of light was already postulated to be constant and the current velocity of light, which does not fit easily with the dynamic 4D model.

[75]On one hand, FLRW does not give a straightforward answer to the question of what is the center point. On the other hand, the answer can be sought by combining the *relativity principle* and the *cosmological principle*. According to the cosmological principle, the distribution of matter in the Universe is homogeneous and isotropic, when viewed in a large enough scale. According to the relativity principle, the equations describing the laws of physics have the same form in all admissible frames of reference. When the principles are combined, any perceiver is in some sense allowed to define his state as the state of rest, where everything else moves with respect to the perceiver. In this sense, the perceiver is always the unmoving center point of the Universe. As any part of any TSU can be considered as a perceiver, FLRW gives the freedom of mapping the center point anywhere in a TSU.

estimated by adjusting them in such a way that the predictions of the model match the observations.

In the end of the 1990's, accurate measurements of the magnitudes and red-shifts of sufficiently distant supernovae were available. In order to make FLRW match these measurements, something *repulsive* had to be incorporated. This repulsive element has become to be called *dark energy*. FLRW together with the dark energy gave the hypothesis that the expansion of the Universe is currently accelerating. In other words, observe figure 18 in p. 113. Without dark energy the lowest FLRW curve clearly misses the target, and therefore dark energy had to be added. The hypothesis that the expansion of the Universe is currently accelerating followed as a result.

FLRW's density parameter $\Omega = \Omega_m + \Omega_\Lambda$ consists of two central parts. Ω_m denotes the sum of the masses of the visible or normal matter and the so-called *dark matter*, which ought not be confused with dark energy. The visible matter includes all planets, stars, nebulae and so on. FLRW and DU both agree that there must exist some amount of directly inperceivable matter somewhere in the galaxies. Dark matter is needed in the scale of galaxies in both models in order for celestial mechanics to work: to explain the orbital velocities of the stars on the edges of the galaxies. This form of unperceived but gravitationally attractive matter is usually denoted as dark matter.

Ω_Λ denotes the dark energy. Unlike the perceived matter and dark matter, the dark energy is supposed to be gravitationally repulsive. According to NASA:[76] "The new estimate of dark matter content in the universe is 26.8 percent, up from 24 percent, while dark energy falls to 68.3 percent, down from 71.4 percent. Normal matter now is 4.9 percent, up from 4.6 percent." The dark energy is indispensable for FLRW to match perceptions. The dark energy is by far the greatest burden of the accelerating expansion hypothesis. Dark energy remains to be unperceived, which makes it a hypothetical entity. It is especially an exceptional entity, for it is supposed to work against gravitation, i.e. pushing masses apart instead of pulling them. The dark energy makes it difficult to sort out what is the role of CLE in FLRW, for it is an open question that does the quantity of dark energy increase or decrease.

The hypothesis of *inflationary* expansion is applied to some period near the singularity, where it is supposed that the expansion was immensely faster than today. After the inflationary stage the acceleration rate is supposed to follow the FLRW prediction which is supplemented by dark energy. In sum, FLRW must incorporate different expansion regularities at different times —inflation and acceleration— plus the hypothetical dark energy which entails the hypothesis of accelerating expansion.

CONTRADICTION WITH THE CONSERVATION LAW. The wavelength of radiation which moves in space —such as the cosmic background radiation— grows proportionally with the expansion of space. In relativistic physics and in standard physics in general, the Planck equation $E = hf$ —the energy of a photon in Joules is the Planck constant h multiplied by the photon's frequency f— is interpreted to describe intrinsic properties of radiation. Accordingly, as the wavelength λ of the radiation increases along with the expansion of the Universe, its frequency $f = \frac{c}{\lambda}$ —the velocity of light c divided by the wavelength λ— decreases and therefore its energy decreases along with the decrease of the frequency: $E = \frac{hc}{\lambda}$. Total energy thus decreases and CLE is violated, unless an additional parameter is invented to compensate the violation, which in effect would decrease the relative simplicity of FLRW. See Suntola [384, §6.4.1]. The role of CLE is

[76] March 21st, 2013 `http://www.nasa.gov/mission_pages/planck/news/planck20130321.html#.VP8axFbfihO`

thus at least ambiguous in FLRW, whereas DU incorporates CLE in its basic structure. For consistency with Maxwell's equations, Suntola [384, §5.1.1, pp. 162-168] has shown that the Planck equation describes the energy conversion in the emission/absorption of an electromagnetic wave; the energy the wave obtains in the emission is conserved in relation to the total energy in space; only the *energy density* of the wave decreases due to the increase of the wavelength, along with the expansion of space, but the total energy carried by the wave does not decrease. Therefore there is no contradiction with CLE.

5.5 Gravitationally Bonded Systems

In DU, all systems bonded by gravitation such as galaxy clusters, individual galaxies and planetary systems expand along with the expansion of the Universe, and the wavelength of the cosmic background radiation increases as the Universe expands, whereas compact objects such as planets and stars do not expand along with the expansion of the Universe (Suntola [384, §6.2.2-3]).

The standard interpretation since the 1930's has been that galaxies and planetary systems do not expand but the Universe as a whole expands (de Sitter [102]). The expansion is explained by *Hubble flow* between galaxies or galaxy groups (de Sitter [101]). Currently, in FLRW the hypothetical dark energy reduces the effect of gravitation and results in the hypothesis of accelerating expansion of the Universe, as pointed out in §5.4. FLRW's interpretation that local gravitationally bonded systems do not expand along with the expansion of space leads into conflicts with perceptions, and thereby requires additional parameters. To illustrate, consider an abbreviation of Heikki Sipilä's [364] presentation. The commonly accepted premisses are the following:

(1) The Solar luminosity or the radiation efficiency of the Sun increases about 7% in a billion years (Gough [157], Bahcall et al. [36]).
(2) There were seas in Mars about 4 billion years ago but nowadays all water is in the form of ice, concentrated in the poles of Mars; the current mean temperature of Mars is -63 Celsius.[77] Emiliani [131, p. 543] notes that there was water in Mars more than 3 billion years ago. That there is currently ice on Mars and its mean temperature is considered as common knowledge.
(3) There were seas and life on Earth some 3,85 billion years ago and the temperature was about 30-40 Celsius. See e.g. Kusky [211, p. 238] and Le Bihan and Fukuyama [50, p. 344] for the existence of life and water 3.85 billion years ago. Lunine [233, p. 162] notes that the Earth should have been frozen for the first three billion years due to the faint Sun but that geological findings suggest that the temperature of the seas was much higher 3.4 billion years ago than today.
(4) The distance between the Moon and the Earth increases 3,8 cm per year. This is considered as common knowledge.

THE FAINT SUN PARADOX: CIRCUMSTANCES ON EARTH. Suppose again that the Solar System does not expand. This supposition leads into the conclusion that the mean temperature on Earth was about -20 Celsius 3.85 billion years ago, for the solar luminosity was about 25% smaller back then. This raises the *faint Sun paradox*: How can there have been seas on Earth 3.85 billion years ago and why do the geological findings indicate that the temperature was about 30-40 Celsius and there was life back then, when it should

[77] Expressions of the form 'X billion years ago' function as such in the context of FLRW. However, in terms of DU, they are always translated into 'when the radius of the Universe was X billion light years smaller' (§5.3).

have been -20 Celsius? The heat produced by the nuclear reactions in the core of the Earth does not explain why there was water. Again, an additional parameter can be given: there was an atmosphere which had just that kind of a constitution where the temperature was so high that life could have been born: Lunine [233, p. 162] proposes an *atmospheric green house effect*. In contrast, DU predicts that the Earth was closer to the Sun in the past, and that the expansion rate is such that the mean temperature on Earth back then —30-40 Celsius— allowed the existence of seas (not ice) even with the smaller solar luminosity.

FAINT SUN PARADOX: CIRCUMSTANCES ON MARS. Suppose that the Solar System does not expand. This begs the question that how can there have been seas in Mars 4 billion years ago, when the temperature was a lot colder than it is now, because of the increase in solar luminosity? An additional explanation can be given: there was an atmosphere in Mars which had just that kind of a constitution that the temperature was so high that the seas could have existed a very long time ago. McNally [118, p. 602] proposes that *one has to assume* that there has been a greenhouse effect on Earth 2-3 billions years ago and on Mars 3.8 billion years ago. In contrast, DU predicts that Mars was closer to the Sun in the past, and that the expansion rate is such that the seas were possible even with the smaller solar luminosity at least around the equator of Mars. As the Solar System expanded, Mars gradually moved so far that the temperature decreased, and the seas turned into ice.

THE GROWING DISTANCE BETWEEN THE EARTH AND THE MOON. Given the hypothesis that all gravitationally bonded systems expand along with the expansion of the Universe, the Hubble constant and the current distance between the Moon and the Earth gives the hypothesis that the annual growth of the distance is 2,8 cm.[78] As 3,8 cm is the measured increase, in DU this leaves 1 cm to be explained in terms of the effects of the Moon and the Sun on the tides on Earth. In the context of FLRW the whole 3,8 cm must be explained in terms of the tides (Suntola [385, p. 180]).

In sum, the first two explanations of FLRW require very special atmospheric conditions, whereas the basic structure of DU alone suffices in both cases. DU provides a unificatory explanation, whereas FLRW requires inventing the extra conditions. In the third explanation FLRW makes the tides the only explainer, whereas DU requires the tides to explain only 1 cm. For consistency with coral fossil data, see Suntola [384, §7.4.2].

5.6 The Relativity Principle

According to Suntola [385, p. 39] "Galilei defined the principle of relativity, which was later inherited in both Newton's mechanics and Einstein's special relativity." Through SR it was conveyed into GR and through GR into FLRW. The relativity principle can be formulated as: *the equations describing the laws of physics have the same form in all admissible frames of reference*. Einstein's [127, p. 37] formulation has essentially the same meaning: "the same laws of electrodynamics and optics will be valid for all frames of reference for which the equations of mechanics hold good." Consider the central logical relations of presentism, the relativity principle, absolute simultaneity,

[78] The crude values in §5.3 give the following result, when the current mean distance between the Moon and the Earth is $384403000m$. There are $365 \times 24 \times 60 \times 60$ seconds in a year. The Hubble constant 70 $\frac{km/s}{Mpc}$ means that a stretch of space that has the length of one Mpc expands 70000 m in one second, and one Mpc is $3.08567758 \times 10^{22}$ meters. $\frac{384403000}{3.08567758 \times 10^{22}} \times 70000 \times 365 \times 24 \times 60 \times 60 = 0.0275m$.

cosmic time, eternalism, and an ontology which incorporates two independent and equally fundamental conceptions of time, relativistic time and cosmic time (2T):

Presentism XOR Eternalism
Relativity principle → eternalism

Presentism and eternalism are mutually contradictory axioms for temporal existence (§4.4). As the relativity principle implies eternalism (§5.6.3), it contradicts presentism.

Presentism entails absolute simultaneity
Cosmic time entails absolute simultaneity
Relativity principle → (relativistic time & no absolute simultaneity) or 2T

The relativity principle also implies relativistic time, where objects do not stand in the relation of absolute simultaneity (§5.6.1), i.e., the relativity principle contradicts absolute simultaneity, and thus also cosmic time and presentism. However, the relativity principle contradicts absolute simultaneity only if relativistic time is the only notion of time. As cosmology cannot get by without cosmic time and contradictions are not wanted, the only path to coherence in the context of relativistic physics is to commit to two independent conceptions of time, relativistic time and cosmic time, which is uneconomical (§5.6.2).

5.6.1 Atomic Clocks: Contradiction with Absolute Simultaneity

DU and GR interpret differently the results of tests with atomic clocks.

THE TEST SETTING. This test takes in account only differences in altitudes of the clocks and is in this sense analogous to Chou et al. [85]. Suppose that identical or sufficiently similar atomic clocks A and B stand side by side on the surface of the Earth on the sea level, and they tick at an identical rate and show the same reading. Clock A remains on the sea level while clock B is transported to a higher location, where B remains for some period of time, after which B is transported back to the side of A on the sea level. Again, the clocks tick at an identical rate, but B shows a greater cumulated reading than A.

DU'S EXPLANATION. The clocks show different cumulated readings because they have had different ticking rates; they have had different ticking rates because they have been in different states of gravitation. Clock B which has been in a greater gravitational potential than A has had a greater ticking frequency than A, and therefore B shows a greater cumulated reading than A. In DU, the ticking rate of an atomic clock is determined by the energy state of the clock, where the energy state of a particular is its combined state of motion and gravitation (Suntola [384, pp. 12, 54-7, 283-4, 301, 313]). The higher the altitude, the greater the gravitational potential (and the local velocity of light) and the faster is the ticking frequency of a clock; the greater the velocity (or the kinetic energy), the slower the ticking frequency of a clock. In this example, the difference of the velocities of the clocks was so small that it can be disregarded. This leaves gravitation to do all explaining. DU's interpretation is compatible with absolute simultaneity.

THE RELATIVISTIC EXPLANATION. The case is explained in terms of the central postulates of GR: constancy of the velocity of light, the relativity principle, the equivalence principle (p. 109), and coordinate transformations.[79] The relativity principle states that the equations that describe the laws of physics —that determine the ticking frequencies

[79]The coordinate transformations are formulas for calculating differences in the clock readings. As in this test we are dealing with differences in the state of gravitation, we apply Schwarzschildian metrics, which is a solution of the field equations of GR which is based on the equivalence principle. In contrast, if we were dealing only with differences in velocity in a fixed state of gravitation, Lorentz transformations alone would suffice.

of the clocks— have the same form in all admissible frames of reference, i.e., they have been the same for both clocks. However, the clocks show different cumulated readings. The different readings of A and B are correctly predicted by the coordinate transformations, and interpreted as *differences in the flow of time experienced* by A and B, i.e., there is no time which is the same and absolutely simultaneous for A and B, but instead the frames of reference where the objects reside have their own times: the clocks have 'experienced time differently.' Consider another phrasing.

(a) The relativity principle states that the equations and the interrelated metaphysical commitments of GR hold in all frames of reference.
(b) These include the commitment that the frequencies of identical atoms are identical in all frames of reference, such as the frequencies of all caesium-133 atoms, which are the resonators in atomic clocks.
(c) The test reveals that the atomic clocks show different cumulated times.
(d) In order for (a-c) to be mutually coherent, time must be postulated as an independent fourth dimension, which sustains the relativity principle and the equations of GR, but contradicts absolute simultaneity. In contrast, if absolute simultaneity were sustained, the relativity principle would have to be rejected, because this would imply that the atoms have resonated in different frequencies. But one cannot reject the relativity principle without rejecting GR.

Chou et al. [85] and various others interpret that the tests with atomic clocks 'prove' that GR is correct. It is now clear that the tests equally 'prove' that DU is correct. Both DU and GR give correct predictions about the focal phenomena, but they cannot both be true in the same sense as they have mutually contradictory premisses.

5.6.2 Cosmic Time and Relativistic Time: Contradictory or Independent?

Absolute simultaneity is implicit in the concept of a temporal stage of the Universe (TSU), for all parts of a TSU are realized absolutely simultaneously. As the relativity principle contradicts absolute simultaneity (§5.6.1), it also contradicts the existence of TSUs and thus also presentism where only the present TSU exists. The contradiction is unavoidable *if one commits to only one notion of time*, but the contradiction can be avoided by incorporating two different notions of time, which is in turn uneconomical.

Cosmology cannot get by without talking about TSUs and thus cannot get by without absolute simultaneity. For instance, saying that the age of the Universe is x years, that the diameter of the Universe is y meters, that the average density of the Universe is z kilograms per cubic meter, that the mass of the Universe is v kilograms, that the Universe expands at the rate denoted by the Hubble constant, and that a TSU has a total energy, makes no sense without absolute simultaneity. How can the Universe have any age, size, density, mass and expansion rate *now*, if we cannot talk about all parts of a single TSU simultaneously, and if all its parts have different times? Cosmologists have incorporated the notion of *cosmic time* just for this purpose. According to Wüthrich [420, p. 119] "two events are *FLRW-absolutely simultaneous* just in case they ... occur at the same cosmological time t." Absolute simultaneity is implicit in cosmic time, for cosmic time is the same for all parts of a TSU. E.g. Lehti [216] and Janzen [186] point out several instances where cosmologists including Einstein apply cosmic time when talking about e.g. the expansion of the Universe and its form. One of Einstein's [126] chapters is titled *Considerations on the Universe as a Whole*. Here he openly talks about the geometrical form of the Universe as a whole and about its radius: these are illegitimate without cosmic time. Lehti [216] cites Einstein [129, pp. 98-9] and notes that he in no

way indicates that he has given a suggestion about the structure of the Universe which is incompatible with his own relativity principle. Such remarks are not found from Einstein [126] either. The case can be summarised as follows.

(1) The relativity principle was postulated in SR.
(2) SR was extended into GR, and GR was extended into FLRW.
(3) The relativity principle contradicts absolute simultaneity.
(4) Cosmology requires cosmic time which entails absolute simultaneity.
(5) Therefore, either the contradiction must be accepted or cosmic time and relativistic time must be independent of one another.

Consider different reactions to this ambiguous state of affairs. Some have remained faithful to absolute simultaneity on the basis of understandability and common sense:

> "at the same time" belongs not to a special science but to logic; ... Our practical grasp of this logic is not to be called into question on account of recondite physics; for without such a practical grasp we could not understand even elementary propositions in physics, so a physicist who casts doubt upon it is sawing off the branch he sits upon. Peter Geach [153, p. 312].

Some have tried to reconcile SR with absolute simultaneity, such as Tooley [399, §11] and Craig [93]. This seems odd in the sense that SR especially incorporates the relativity principle which violates absolute simultaneity. Therefore, if the reconciliation would genuinely succeed, this would turn the Special Theory of *Relativity* into the Special Theory of *Non-Relativity*. Tooley and Craig have not tried to expand their solutions to GR or to FLRW. Some take the path of committing to two independent conceptions of time or leaving the case ambiguous. Consider a discussion with an anonymous physicist:

> I don't see why using 'cosmic time' (as an approximation valid just on extremely large scales) should be at all in contradiction with denying absolute simultaneity. Doesn't it just follow from the approximate symmetry seen on the very large scales?

The author refers to the cosmological principle, according to which the distribution of matter in the Universe is homogeneous and isotropic, when viewed in a large enough scale. Given the homogeneous and isotropic distribution, one can think that in large-enough scales the frames of reference are so similar in average that their relativistic times are equivalent with cosmic time which is thus the same for all frames in that scale, i.e., that relativistic and cosmic times meet at the largest cosmological scale. Absolute simultaneity would thus hold in the cosmological scale, but not on smaller scales. This requires accepting that some very big parts of TSUs exist absolutely simultaneously at the same cosmic time, but the proper parts of a very-big-part X do not exist at the same cosmic time as X, as the notion of cosmic time does not apply to small-scale parts. This does not resolve the contradiction between cosmic and relativistic times, for the idea that a whole can exist at time t without its parts existing at time t is itself contradictory. To this notion, the author replies by suggesting two different conceptions of time:

> Can't one think about the connection between large and small scales in the following way. Consider water flowing down a river and look at a bit of it with an extremely powerful microscope: what you'd see is water molecules moving rapidly in almost random directions and not a continuum fluid. Now look without the microscope and you see water flowing much more slowly as a continuous medium with a directed velocity field, but not the local motion of the molecules which dominates at small scales. However, the molecules are part of the fluid and share in its velocity field although that's not what you're aware of looking through the microscope. Transferring the analogy to the universe, the cosmic time is a property of the large-scale behaviour and is defined in terms of that, but the small scales

do inherit this property because of being part of the large scales. That seems to me to make sense!

This approach seems to resolve the contradiction, because now TSU X as a whole and all its parts exist at the same cosmic time, but small-scale parts of X also have their own relativistic times, i.e., we have two independent conceptions of time: cosmic time that applies in all scales but is primarily used only in cosmology; relativistic time which is applied in talking about smaller scales only. As always, explanatory failures can be fixed by incorporating more metaphysics, in this case two conceptions of time. The question is then that should one build on cosmic time or on relativistic time? For, one cannot build on both simultaneously. What does a physicist mean when he talks about the present time, relativistic time or cosmic time or both? In contrast and again, in DU cosmic time is the only time and it applies in all scales. A mature way of seeing the need for two conceptions of time in relativistic physics is as a prelude for unifying them, which is what has been done in DU.

5.6.3 Eternalism and the Entropy Mapping

Eternalism is rejected as an uneconomical alternative to presentism in §§4.4,7.4. In addition to violating absolute simultaneity, the relativity principle entails eternalism.[80] When you commit to the relativity principle, events which from the presentist aspect occur at different times, are *co-real* from the relativistic aspect, and eternalism fits in this picture: the co-reality of the past, the present and the future is practically the same as their existence. Compare to Einstein [130] who stated: "People like us, who believe in physics, know that the distinction between past, present and future is only a stubbornly persistent illusion." It would be more objective to say that people who believe that the relativity principle is truly a law of nature are also inclined to believe that the distinction between past, present and future is only a stubbornly persistent illusion. For, DU is physics, DU does not incorporate the relativity principle, and DU does not entail eternalism. Therefore, the distinction between past, present and future is again legitimate, and it is seen that the stubbornly persistent illusion is that relativistic physics is the only available alternative.

As the relativity principle contradicts absolute simultaneity and entails eternalism, but as cosmology requires cosmic time which entails absolute simultaneity, people are left wallowing between different options. Authors such as Wüthrich [420] who are not aware of alternatives such as DU and who consider relativistic physics as the best available, but also see the clash between cosmic time and the relativity principle, can only conclude something like "fundamental physics does not uniquely determine the metaphysics of time, and hence does not entail the denial of presentism" and "the tension between modern physics and presentism can be resolved, but ... all resolutions either require unpalatable metaphysics or speculative science, which our best current knowledge cannot support." For, as pointed out in §5.6.2, if cosmic time and relativistic time contradict one another, relativistic physics is contradictory, and to save it from the contradiction, cosmic and relativistic times must be independent. But if they are independent, the question raises that on which one should be build all the rest? It is misleading to ask which is the correct notion of time in the context of relativistic physics, for relativistic physics especially makes it impossible to understand the nature of time. Thus, instead of giving a clear conception of time that *should be* the foundation for everything else, relativistic physics perfectly confuses the foundations.

[80] See e.g. Rietdijk [334], Putnam [319], Peterson and Silberstein [305] and Saunders [349] for proofs.

There has practically been no chances of reaching a consensus about a theory of temporal existence in the midst of relativistic physics. According to *PhilPapers* survey, when 1803 philosophy faculty members and/or PhDs were asked to select between the A-theory and the B-theory, 34.7% were insufficiently familiar with the issue, 22.6% accepted or leaned toward B-theory, 16.0% accepted or leaned toward A-theory, and 9.8% were agnostic/undecided. Recall that eternalism is a B-theory, whereas presentism and all theories with an objective present are A-theories (§4.4). The survey shows that the conception of time is an open question among philosophers, and the obvious reason is relativistic physics which is considered quite generally as today's fundamental physics. That the relativity principle entails eternalism, which is a B-theory, explains the 22.6% popularity of the B-theories. That an objective present is still needed in explaining the perceived change explains the 16.0% popularity of the A-theories. As the relativistic conception of time cannot be genuinely understood but as an objective present is still needed, it is not surprising why 44.5% are insufficiently familiar with the issue or agnostic/undecided.

THE ENTROPY MAPPING. As the relativity principle entails eternalism and eternalism does not give a direction to time (§4.4), it is not surprising that Arthur Eddington [121] —one of the most influential early proponents of the Theory of Relativity— suggested *entropy* as the anchor which gives direction to time: entropy has increased ≡ time has gone forward. Consider the entropy mapping in steps:

(1) The relativity principle entails eternalism.
(2) Eternalism raises the need for an anchor to the direction of time.
(3) Entropy has been suggested as the anchor.
(4) An intelligible concept of entropy is that of total entropy.
(5) Total entropy of a TSU requires absolute simultaneity.
(6) The increase of entropy must thus be coupled with the increase of cosmic time that is independent of relativistic time (§5.6.2).

In sum, entropy is needed as the anchor for the direction of time because of the relativity principle which implies eternalism and relativistic time, but an intelligible conception of total entropy requires cosmic time, which is independent of relativistic time. This underlines that a proponent of relativistic physics must deal with the soup that consists of relativistic time, eternalism, the entropy mapping and cosmic time. In DU, entropy (or thermodynamics in general) is not needed as the anchor for the direction of time, for intrinsic time can be defined in terms of presentism and change by definition takes time forward (§4.2). A comprehensive understanding of DU's conception of time is not easy, but there is a crucial difference in between hard and impossible.

5.7 Summary: Evaluation of DU and Relativistic Physics

The central ontological commitments of DU and relativistic physics (RP) were explicated in order to defend presentism, to popularise the central issues at stake in physics, and to show that the evolution of RP fits in the Kuhnian picture where the amount of parameters of a theory increases proportionally along with the increase of data. It remains to be concluded that the predictions of DU match perceptions at least as accurately as those of RP, and the metaphysical commitments of DU are economically unified with respect to those of RP. The forthcoming comparison also supports other conclusions of §3: in addition to accuracy of predictions, an objective evaluation of theories must take the metaphysical postulates of theories and their implications into account, i.e., to evaluate their virtuousness. A modified version of Kaila's formula for relative simplicity

(§3.1) is applied in the evaluation, that takes theoretical virtues into account.[81] The formula is initially the fraction $\frac{E}{P}$, where E denotes the phenomena that are explained by the theories, and P denotes the magnitude of metaphysical commitments needed in the explanations. The phenomena to be explained are evaluated in the following order: (1) explaining tests with atomic clocks, compatibility with absolute simultaneity, giving an account of temporal existence, the passage of time and the direction of time; (2) giving a geometrical picture of temporal stages of the Universe (TSUs) as wholes; (3) giving an account of the expansion of the Universe, i.e., explaining the observed redshift/magnitude ratios of Ia supernovae and explaining the faint Sun paradox; (4) explaining how interactions/forces are conveyed; (5) explaining the precession of the perihelion of Mercury.

If DU and RP would indeed explain 1-5 equally well, then E would be the same with both models and the evaluation could concentrate on P: the better model has a smaller P and thus greater $\frac{E}{P}$. However, the models do not explain all of 1-5 equally well. To illustrate, if a model is contradictory, should this be counted as a subtraction from E or as an addition to P? On one hand, as a contradictory explanation is not a genuine explanation, this should be counted as a subtraction from E; on the other hand, whatever contradictions can be explained away by inventing more metaphysics, and in this sense a contradiction could be counted as an addition to P. Likewise, all explanatory failures could be counted as subtractions from E as well as additions to P, for all failures can be explained away by adding more parameters, and thus the selection seems to be a matter of taste. The tactic of adding to P is applied below. Moreover, the basic structures of the models are considered as equally metaphysically complex, which leaves only their implications to be evaluated and added to the P's of DU and RP.

A SUMMARY OF DU'S AND RP'S POSTULATES. The basic structure of DU is the fusion of the zero-energy formulation of the conservation law of energy, 4D spherically closed space, absolute simultaneity, and instantaneous non-mechanistic interactions. The basic structure of RP is the fusion of the relativity principle, the constant velocity of light, the coordinate transformations, the equivalence principle, the concept of space-time (or three space dimensions and one time dimension), mechanistic force-conveying at the velocity of light, and in FLRW cosmology cosmic time which entails absolute simultaneity. See Suntola's [385, p. 125] [384, ch. 1] comparison of the postulates.

CASE 1: ATOMIC CLOCKS, ABSOLUTE SIMULTANEITY, TEMPORAL EXISTENCE, THE PASSAGE AND THE DIRECTION OF TIME. DU and RP explain the tests with atomic clocks equally accurately but differently. In DU, the ticking frequencies of atomic clocks are different at different states of motion and gravitation, as a consequence of the conservation of energy. In RP, the flow of time is different for an object moving relative to the observer (this is called time dilation) and for an object at a different gravitational state (this is called gravitational red/blueshift), i.e., objects in different states of motion and gravitation have their own relativistic times.

FLRW requires absolute simultaneity or cosmic time in addition to relativistic time. As the relativistic time would contradict absolute simultaneity, these must be considered as independent of one another, i.e., there are two fundamental and independent conceptions of time in RP. Relativistic time is counted as an addition to RP's P, whereas in DU, cosmic time is the only time. Further, as the two times are independent, the nature of time is practically an open question in the context in RP. The problem cannot be over-stated. As time is interrelated with most of the physical quantities such as velocity,

[81] A version of this evaluation also in [382].

momentum, energy, force, etc., the formation of a comprehensive and understandable unified theory has been impossible in the context of RP for more than 100 years now.

The relativity principle implies eternalism, which with partial determinism implies some version of branching space-time (§7.4). If branching space-time is evaded by selecting total determinism, the question boils down to whether total determinism is a plausible after all. All versions of eternalism are in any case uneconomical with respect to presentism. Eternalism does not give a direction to time, and therefore it has been coupled with entropy, which is an addition, and the notion of total entropy must be coupled with cosmic time which is independent of relativistic time (§5.6.3). Eternalism does not explain the perceived change or the passage of time, and thus some additional postulate is needed in doing this (§4.4). Eternalism (with or without branching), the entropy mapping and the postulate that explains change are counted as an addition to RP's P. DU is compatible with presentism and does not require eternalism, the fusion of presentism and partial determinism does not entail branching except as present possibilities, presentism explains the perceived change, and DU does not require entropy as time is defined as a measure of change and change by definition takes time forward.

CASE 2: GEOMETRY OF SPACE . In DU, hypothetical homogeneous space (p. 111) has the shape of a perfect 3D surface of a 4D sphere, creating the overall zero-energy condition of motion and gravitation. The process of formation of local mass centers in 3D space conserves the zero-energy balance by tilting the 3D space relative to the 4-radius, i.e., bending the surface of the 4D sphere in the vicinity of mass centers. The local geometry of space is precisely linked to the overall geometry of space. In FLRW's space-time geometry there are 3 space dimensions and 1 time dimension. In the vicinity of mass centers, 3D space is tilted relative to the fourth, time-like dimension, resulting in much the same local geometry of 3D space as in DU. Although FLRW's space-time geometry can somehow be considered initially on par with DU's spherically closed 4D geometry, the space-time geometry does not give any kind of a geometrical form to the temporal stages of the Universe (TSUs). There are three geometrical options for the geometry of a TSU, i.e., the geometrical form of a TSU is an open question in the context of FLRW: on one hand FLRW fails to give a geometrical form to a TSU; on the other hand it gives three alternatives which is a failure. Therefore, RP's P is increased.

CASE 3: EXPANSION HYPOTHESES. In explaining observations about redshifts and magnitudes of distant supernovae, FLRW requires the density parameter with dark energy, which comprises about 70 % of the total energy (§5.4). The hypothesis of accelerating expansion results from dark energy. In addition to this, the early inflatory expansion is assumed. These are counted as an addition to RP's P. DU does not need the density parameter, nor inflation, nor dark energy, nor accelerating expansion, i.e., no hypothetical entities nor exceptional regularities are needed in the expansion hypothesis, which results from the basic structure of DU. In FLRW, gravitationally bonded systems such as galaxies and star systems do not expand along the expansion of space, whereas in DU all gravitationally bonded parts expand equally. As a result, in FLRW additional parameters are required in explaining the faint Sun paradox (§5.5), which is counted as an addition to RP's P. These discoveries are in line with the predictions of DU, without additional parameters.

CASE 4: CONVEYING OF INFLUENCES. RP's mechanistic force-conveying at the velocity of light can be considered as equally complex with DU's non-mechanistic instantaneous conveying of influences. However, based on Laplace's calculations, the Solar System is unstable with gravitation that propagates at the velocity of light, which is the case in RP (§5.2). In DU the Solar System is stable as gravitation is instantaneous. RP's failure

of explaining the stability of the Solar System, is counted as an addition to RP's P, as the failure of explaining something must be compensated by additional metaphysics, although this is not a generally acknowledged problem.

CASE 5: PRECESSION OF THE PERIHELION OF MERCURY. The precession of the planet Mercury's perihelion within a 0.7 million years period can be explained in terms of DU so that Mercury remains on its orbit. In GR the perihelion shift solved for Schwarzschild space comprises a cumulative term which increases the orbital radius, and Mercury is thrown away from the orbit. This is not a generally acknowledged problem, but if the problem will be fixed while sustaining Schwarzschild space, some metaphysical postulate is needed in that fix. Therefore, RP's P is increased. See Suntola [385, pp. 75-6].

SUMMARY. The basic idea in the evaluation was to consider the fraction $\frac{E}{P}$ as initially equal for both models and to count only extra parameters as additions to P, where explanatory failures were counted as additions to P as well, for all failures can be explained away by more parameters. The following additions were made to RP's P: relativistic time which is independent of cosmic time; eternalism with entropy as the parameter for the direction of time, and a another parameter to explain change; a parameter that explains away the instability of the Solar System; special atmospheres in Earth and Mars as parameters that explain away the faint Sun paradox; the big bang hypothesis requires early inflation as a parameter, and the density parameter with dark energy explains the Ia supernova observations, and implies the accelerating expansion hypothesis; the instability of the orbit of Mercury must be explained away by some parameter.

Numeric additions to P would be very approximate or qualitative and thus a numeric quantification could also be misleading. For instance, it is hard to say how should dark energy and a special atmosphere of a planet be weighted with respect to one another. Although the numeric values are approximate, this does not change the fact that the whole case amounts to *just how much greater* is P in RP. Eventually, all phenomena of all scales and all postulates and their implications needed in explaining the phenomena should be counted in conclusively. This is not done here, but looking at all scales and all postulates would not change the general picture that the above evaluation reveals. Thousands of physicists during more than 100 years have applied relativistic physics in explaining various phenomena, and it is natural that one man has not given a detailed analysis of all these phenomena, but this does not mean that DU could not be applied in explaining them. In other words, this is enough for showing that all physics can be built on better foundations. Feyerabend [141, pp. 113-4] maintains that "we must *retain* the new cosmology until it has been supplemented by the necessary auxiliary sciences." When fitted in the case of relativistic physics vs. DU, this can be translated as: we must retain the new unified science even though one man has not shown that it explains absolutely all cases, as this requires many men and women.

How should physicists and philosophers react in the face of this result? If they take progress of science as important and if theoretical virtues have any importance, then they should naturally start shifting into the better theory. This would make physics very much easier:

> The Dynamic Universe offers a unified framework for phenomena currently described in terms of classical physics, electromagnetism, relativistic physics, standard cosmology and quantum mechanics. This unification allows theory structures and the mathematics needed to be greatly simplified. Suntola [385, p. 13]

But the shift is not to be expected to happen very soon, and the reason is stagnation to relativistic physics. The central notion here is that society should react to unconditional

stagnation, for the sake of a faster progress rate of science, which would benefit the society. One way to do this is to teach philosophy of science to students, to prepare them to deal with paradigm shifts. An enlightened future scientist has understood the role of metaphysics in physics and received the goal towards economically unified science by means of theory shifts and reductions in mother's milk, i.e., the idea that progress is not to be stalled, even though there are always stagnated people who wish to stick with their views. This 'future scientist' does not have to be an ideal scientist, but an average person who has been taught the basic idea starting from the elementary level, proceeding through levels such as the junior high and high school into the university.

Now, compare an average contemporary physicist to an enlightened future physicist. It would require a wide survey to reliably state what is the current average attitude towards metaphysics in physics among physicists. Based on observations in the *Finnish Society for Natural Philosophy* and discussions with physicists during several years, I can conclude that there is a wide variety of physicists in the scale from extremely enlightened to extremely unenlightened, but the average is certainly short of the enlightened future physicist. Starting from the unenlightened end, many physicists still seem to go with the old misinterpretation of Mach that has been fitted in defending relativistic physics: there is no metaphysics in relativistic physics, but it is merely the correct description of perceptions. As no metaphysics is admitted to be implicit in relativistic physics and it is the correct description of perceptions, all metaphysical postulates such as gravitons and dark energy are instead called 'empirical facts' and other theories must naturally be false as they fight against the 'empirical facts.' So, the old way is the way of the most unconditional stagnation. But there are also enlightened physicists who accept that there is metaphysics in physics and who are ready to talk about alternative postulates. But those who have grown with the postulates of relativistic physics, even the quite enlightened ones, and who apply them in their work, are almost univocally severely stuck with them, and it seems to be almost impossible for them to genuinely change their thinking even because of good reasons: it is hard to make sudden fundamental changes after decades of thinking about the world-order in one way. Finally, the most enlightened ones have already rejected relativistic physics, but they are unfortunately faced with the majority whose progress is slower. This underlines the need to incorporate philosophy of science in education programs.

6 Definition: Truth

An economically unified theory of truth is defined and defended. The theory is intended function in natural science and typical human social behaviour. The formulation of the theory starts from the definition of the concept *proposition* in terms of EUO, and continues by defining *true proposition* and *correspondence*. These definitions yield an *object-based correspondence theory of truth* (OBC).[82] OBC is complemented by further definitions which incorporate applicable ingredients of e.g. other central theories of truth. The unified theory of truth is the fusion of all these definitions together with EUO as their ontological base. It is shown how some of the central arguments targeted against the correspondence theory can be efficiently exhausted in the context of EUO. OBC complements Rögnvaldur Ingthorsson's [182] project of unifying other theories of truth around the correspondence theory.

6.1 The Fusion of Object-Based Correspondence and Epistemic Theories

All axioms of EUO function directly or indirectly as the metaphysical ground of the forthcoming definitions, but the central axiom is ontological realism.

PROPOSITION: a proposition is a thought[83] which is realized in the mind of a human being, which refers to —or points to or is targeted at or represents— something else than the thought itself,[84] which especially states that the thing to which the proposition refers exists in some way, and is thus capable of bearing a truth value. A proposition is realized in a certain location at a certain time and states that an object exists or more specifically has certain properties in a certain location at a certain time. A proposition itself is a mental property of a physical object and thereby realized in a certain location at a certain time (§4.13). A thing to which a proposition refers is an object, a mental property of an object or any combination of these, i.e., it suffices to say that a proposition refers to an object.

[82]The use of objects instead of facts or states of affairs as truthmakers (§6.1) is a conscious selection. Originally the switch from objects to facts happened in the early 20th century along with the general *linguistic turn* (Künne [210, p. 112]) but here facts are switched back to objects. The switch from objects to facts brought in ambiguity about the ontological nature of truthmakers (§6.8.1). By reverting back to objects there are no ambiguities.

[83]The view of proposition as a thought is endorsed e.g. by McTaggart [260, pp. 15-17], Armstrong [29], Ingthorsson [180], Jubien [191] and James [184, preface]: "The pivotal part of my book named Pragmatism is its account of the relation called "truth" which may obtain between an idea (opinion, belief, statement, ...) and its object. "Truth," I there say, "is a property of certain ideas. It means their agreement, as falsity means their disagreement, with reality. ...." " Sullivan [383, p. 34], in commenting *Tractatus*, maintains that a proposition is a thought. In *Tractatus*[414, 4] Wittgenstein states: "A thought is a proposition with a sense." The definition of proposition as thought is compatible with McGrath [258]: "Propositions, we shall say, are the sharable objects of the attitudes and the primary bearers of truth and falsity." McGrath maintains that this "stipulation rules out certain candidates for propositions, including thought- and utterance-tokens" but McGrath's definition does not rule out thoughts in the sense that different people can share the identical or sufficiently identical thought such as "Urho Kekkonen was bald." In contrast, according to Stoljar [376, p. 60]: "Propositions are abstract objects and so are neither mental nor physical on any ordinary understanding of those notions." Stoljar's definition is incompatible with EUO, where transcendent abstract objects are rejected, although also 'abstract' can be defined as thought (§4.14), which is not the case is Stoljar's definition.

[84]This follows from the impossibility of self-reference as shown in §4.18. However, an idea may in principle point at the concrete aspect of the physical particular whose property the idea is; this is the only case where an idea refers to something which is not independent of itself.

TRUE PROPOSITION: a proposition is true if and only if the object to which the proposition refers exists in the way that the proposition states; otherwise the proposition is either false or indeterminate. (Indeterminate propositions are handled in §7.3.) Consider the proposition P="The Sun exists now." If P is true, then the Sun exists in the mind-independent part of the Universe at the present. (Some ambiguous propositions are handled in §6.7.) This is compatible with the following passages:

> Then that speech which says things as they are is true, and that which says them as they are not is false? Plato, *Cratylus*, 385B
>
> To say of what is that it is not, or of what is not that it is, is false, while to say of what is that it is, and of what is not that it is not, is true. Aristotle, *Metaphysics*, 1011b25

OBJECT-BASED CORRESPONDENCE: that the object to which a proposition refers exists in the way that the proposition states, is abbreviated by saying that *the proposition corresponds to the object*. Object-based correspondence (OBC) has thereby been defined.[85] Saying that 'a proposition is true' is equivalent with saying that 'a proposition is corresponds.' The following passages are compatible with OBC:

> [In] the traditional correspondence theory of truth where something is true if the idea that I have in my head corresponds to an object in the outside world. Stambaugh [372, p. 3]
>
> [A] *correspondence theory of truth* ... suggests that we can speak of truth when there is a correspondence between an object/event and a statement about this object/event. The statement "this metal table is brown" is true, if it corresponds to the object (a brown metal table). Walsh et al. [407, p. 30]

E.g. Armstrong [15, p. 113] and Ingthorsson [182, ch. 2.1] define the correspondence theory as follows: a proposition is true if it corresponds to the reality independent of the proposition itself. Although Armstrong talks about states of affairs and Ingthorsson about facts, their facts and states of affairs are implicitly assumed to be objects or properties of objects.

STATEMENT AND TARGET TIMES. Consider a true proposition where the location-time where the target object is realized is written out: Z="Mount Everest existed at the first instant of the year 2015 approximately in 27.986065 latitude and 86.922623 longitude." Z points to an object which is in this case a particular which supposedly did exist in the location-time where Z proposes it did. Even though the proposed locations are not explicitly written out in the proposition V="There exists currently life forms very similar to human beings in some planet in the Universe *in addition to* the Earth," these are implicit in V. V points to all planets that exist currently, and V is true if there exists life forms very similar to human beings in any of the other planets. The statement and target times are essential with modal statements (§7). That the time when the proposition is stated and the time at which the proposition is targeted are essential was noted by Frege:

> Are there not thoughts (propositions) which are true today but false in six months' time? The thought, for example, that the tree there is covered with green leaves, will surely be false in six months' time? No, for it is not the same thought at all. The words 'This tree is covered with green leaves' are not sufficient by themselves to constitute the expression, for the time of utterance belongs to it as well. Without the time-determination thus given we

[85] The term 'object-based correspondence' is adapted from Künne [210, pp. 5, 94] who notes that paradigmatic elements "of the right field of the correspondence relation thus understood are material objects such as mountains and people" and that for "centuries, 'correspondence' had been wedded to 'thing', or to 'object', rather than to 'fact'."

> have no complete thought, i.e. we have no thought at all. Only a sentence supplemented by a time-determination and complete in every respect expresses a thought. Frege, *Der Gedanke*, p. 76, as translated by Künne [210, p. 7]

TRUTHBEARER: a truthbearer is a true proposition. Armstrong [29, p. 12] maintains that truthbearers are propositions and that "all other suggested truthbearers besides propositions are called truthbearers on account of their relationship to certain propositions." It is indifferent which one of the following expressions is used: a *proposition* is true if and only if it corresponds to nature (cf. Devitt [107, p. 27]); an *idea*, a *thought* or a *belief* is true if and only if it corresponds to nature; a *hypothesis* is true if and only if it corresponds to nature. For, when a proposition or a hypothesis is conceived, it is in any case realized as an idea in the consciousness of a human being. A paper or a screen where the text 'the philosopher Demokritos existed in the past' is written, and a sound or a voice that comes from a loudspeaker and says 'the philosopher Demokritos existed in the past' state the truth in the sense that if an agent would read and conceive the text or hear and conceive the sound, the agent would supposedly be conceiving a true idea.

TRUTHMAKER: a truthmaker is the object to which the truthbearer corresponds. According to Armstrong [29, p. 5] "The idea of a truthmaker for a particular truth, then, is just some existent, some portion of reality, in virtue of which that truth is true." The definition of a true proposition can now be stated in terms of correspondence, truthmaker and truthbearer: a truthbearing proposition corresponds to its truthmaker. Conversely, if a proposition does not correspond to the object it refers to, then the object is the *falsemaker* of the false proposition or the *falsify-bearing* proposition. As EUO starts from presentism, the applied truthmaking principle must conform to presentism: the truthmaker objects of true propositions either have existed in the past, or exist at the present (§§6.6,7.1,7.3). As ideas are properties of objects, also ideas can be truthmakers, i.e., this is just another case of objects being truthmakers. For instance, if the proposition D='Peter is thinking about a circle' is true, then the idea *circle* which is realized in the mind of Peter is the truthmaker of D. As the correspondence relation is asymmetric, a truthbearing proposition cannot be its own truthmaker, and two propositions cannot correspond to one another (§4.18).

COHERENCE THEOREM OF CORRESPONDENCE TRUTHS. The fusion of OBC and the law of non-contradiction implies the coherence theorem: all OBC truths are mutually coherent. In OBC a true proposition corresponds to some specific part of the Universe, i.e., that part exists in the way the proposition states; the law of non-contradiction states that there are no contradictions in the Universe, i.e., an object either exists in a certain absolutely determinate way or not;[86] therefore, two mutually contradictory beliefs about the same part cannot be simultaneously true in the same respect, i.e., all true beliefs are mutually coherent: "while the world can be described in various ways, these descriptions cannot be incompatible" (Pihlström [309, p. 136]). The coherence theorem holds also for theories: "Conflicting theories, if interpreted realistically, cannot be true at the same time" (Niiniluoto [289, p. 176]). Cf. Newman [283, ch. 4.2]. The coherence theorem incorporates the applicable ingredients of the *coherence theory of truth* in OBC.

COHERENCE THEORY OF TRUTH. The coherence theory of truth "states that the truth of any (true) proposition consists in its coherence with some specified set of propositions" (Young [424]). To illustrate that the coherence theory is insufficient for the needs of natural science, consider the collection of all currently known OBC truths C. Whatever

[86] As an exception, if partial determinism holds, then the truth values of some modal propositions about the future are at the present indeterminate (p. 167).

hypothesis which is compatible with C is true in the coherence theory, even if it were false in OBC. The coherence theory alone thus cannot distinguish between what are called true and what are called false hypotheses in OBC:

> A belief may be coherent with all our other beliefs about the world, but nevertheless be false. ... even if coherence were assumed to provide good reasons to believe in something, it would not establish that beliefs never correspond to fact, nor would it provide an alternative understanding of the [correspondence] relation between belief and fact. Ingthorsson [182, ch. 5.3]

Moreover, if verified OBC truths are disregarded altogether, then whatever coherent set of beliefs —such as any set of pure fictions in terms of OBC— is true in terms of the coherence theory. This does not suffice for the needs of natural science nor human social behaviour. In words of McDovell [257, p. 15] "Coherentist rhetoric suggests images of confinement within the sphere of thinking, as opposed to being in touch with something outside it." As the coherence theory is insufficient for the needs of natural science which is especially interested in what goes on in mind-independent reality, it is intelligible to reject the coherence theory as the base theory of truth, and to incorporate its applicable ingredients in OBC in terms of the coherence theorem of correspondence truths.

THE PRAGMATIC THEORY. If the central function of the pragmatic considerations about truth is to sufficiently incorporate verifiability with the correspondence theory, then we would not be dealing with two separate theories in the first place. This is a likely interpretation and it is investigated after the pragmatic *theory* of truth is first rejected. The pragmatic theory can be defined as: proposition X is true if it is useful to believe that X is true. This formulation is compatible with Lewis' [226, p. 275] formulation of the pragmatic theory: "It's true that cats purr iff it's useful to believe that cats purr." It is also compatible with Horwich [174, p. 3] who maintains that the pragmatist definition is "that truth is *what we find it helpful in practice to believe*."

Pragmatic truths can be classified in terms of OBC: (1) pragmatic truths that are true in OBC; (2) pragmatic truths that are false in OBC; (3) pragmatic truths whose truth value is indeterminate in OBC. Examples of (1) are 'it is dangerous to play Russian roulette' and 'it is dangerous to walk on thin ice.' As an example of (2), suppose that a person believes that he will win a sports competition, that this belief is false in terms of OBC, but that by believing in his victory he wins the silver medal, and if he would not have believed in his victory he would not have won any medal. Ingthorsson [182, ch. 5.2] gives another example: "To believe that the stores close at 5 p.m. may prevent a person from ever failing to buy the groceries in time, even though in fact the stores stay open until 9 p.m." As an example of (3), suppose that a person believes that he will win a sports competition, that this belief is indeterminate in terms of OBC, but that by believing in his victory he gets either gold or silver, and if he would not have believed in his victory he would not have got any medal.

The pragmatic theory is insufficient alone without OBC, for without it all useful beliefs would be univocally true: "the pragmatist's definition ... overstates the connection between truth and utility: many, but not all, practically useful beliefs are true; and many but not all, true beliefs are useful" (Horwich [174, p. 3]). A pragmatist who commits to ontological realism must in any case make a classification of beliefs in events that actually took place and beliefs in events that did not take place in the mind-independent reality, i.e., a pragmatist must appeal to something that is practically equivalent with OBC. For, suppose that a pragmatist believes that X will take place and it is useful to believe so; however, when the pragmatist perceives that X does not take place, there are no plausible alternatives than to admit that the belief that X will take place was not true after

all, even though it was useful to believe that X will take place. While pragmatic truths are best seen as 'locally useful beliefs' for some individuals at some times, it is useful to accept OBC in the scale of general philosophy of science. To illustrate why, consider the reasoning: the progress of science is useful; economical unification is useful because it feeds the progress; accepting EUO is useful as it is a prerequisite for applying the method; committing to OBC is useful as it is the only theory which genuinely functions in the context of EUO; therefore, the belief that OBC is the most fruitful background theory of truth in the scale of general philosophy of science, *is* a pragmatic truth.

Again, the above definitions of the pragmatic theory of truth by Lewis and Horwich contradict OBC. However, William James' definitions leave space for interpretation:

> The true is the name of whatever proves itself to be good in the way of belief. William James [185, Lecture I]
>
> [B]oth pragmatists and anti-pragmatists believe in existent objects, just as they believe in our ideas of them. The difference is that when pragmatists speak of truth, they mean exclusively something about the ideas, namely their workableness; whereas when anti-pragmatists speak of truth they seem most often to mean something about the objects. Since the pragmatist, if he agrees that an idea is "really" true, also agrees to whatever it says about its object; and since most anti-pragmatists have already come round to agreeing that, if the object exists, the idea that it does so is workable; William James [184, preface]

In his review, Sami Pihlström notes that it is erroneous to see James' definitions as definitions of a reductive theory of truth that competes with the correspondence theory. Likewise, Ingthorsson [182, ch. 5.2] maintains that the coherence theory and the pragmatic theory should not be seen as rivals of the correspondence theory: they should not be seen to "deny the possibility that beliefs correspond" but to merely state that "we should use the term 'truth' to denote warranted beliefs" where being coherent with other beliefs and being supported by empirical evidence makes the beliefs warranted. Given this interpretation, there is no pragmatic *theory* of truth, but the pragmatic considerations about truth can be seen as demands to sufficiently incorporate verifiability or rational assertability together with the correspondence theory. Putnam's notions about assertability are handled in §6.3.

NONDESCRIPTIVIST VIEWS. OBC presupposes a descriptivist view of propositions, as a true proposition especially describes reality, whereas nondescriptivist propositions express people's attitudes or motivations. Therefore, it does not seem intelligible to see the nondescriptivist views as as theories of truth. Schmitt [353, p. 195] characterises expressivist and motivational views as examples of nondescriptivist views: "On an expressivist view, talk of truth does not describe the world but expresses an attitude. On a motivational view, talk of truth motivates behavior." Consider a motivational belief Y: *I will not jump into the sea.* Y describes an attitude of a human being: it is true in OBC that the person has decided that he will not jump into the sea. Consider the expressivist proposition X: *sharks are vicious animals.* X only describes the attitude of some human beings: it is true in OBC that some people consider sharks as vicious animals; this is completely independent of whether sharks in fact are vicious or not and what viciousness exactly means. If it means that 'a hungry bull shark will bite you if you go swimming with it' then we are not dealing with a nondescriptivist proposition.

The expressivist views clearly require OBC, for otherwise it would not be true that people have attitudes and motivations. To illustrate, ethical judgements or moral evaluations such as "The people in that village are bad" are expressivist propositions. In order to objectively determine whether such propositions are true or false, universally objective goals or ethical principles should be defined first. The primary remark about ethical

propositions is that ethics is not a completed research program and this should not be interpreted to threaten the empirical sufficiency of OBC. OBC is in any case required as the overall background framework of to-be-objective moral evaluations which are based on the to-be-discovered objective goals. For, such evaluations must in any case be based first on a non-moral account of what some people did, and after this their actions can be morally evaluated with the to-be-discovered objective goals.

6.2 The Solipsism/Comparison/Treadmill Argument

In economical unification the order is clear: first ontology, then applications such as the definition of a true proposition. Once the order is mixed, the analysis is mixed. One example of mixed analysis is the argument from solipsism against correspondence, which is denoted as the *comparison objection* and as the *treadmill* argument by Künne [210, pp. 126-133]. In all three versions the marching order of economical unification is turned upside down:

> I can only compare the object with my judgement by making a judgement about the object. Thus my judgement is supposed to be confirmed by itself, which is not at all sufficient for its truth. For since the object is external to my mind and my judgement is in my mind, I can only judge whether my judgement about the object agrees with my judgement about the object. Kant, *Logik*, Introduction, ch. VII, B, init. As translated by Künne [210, p. 127]
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> What ought we to do so as to decide whether something is true? We should have to enquire whether it is true that an idea and something real, say, correspond. ... And then we should be confronted with a question of the same kind, and the game could begin again. Thus the attempted explanation of truth as correspondence breaks down. Frege, part 60 of *Der Gedanke*, as translated by Künne [210, p. 130]
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> [T]he objection is that a correspondence theory of truth must inevitably lead into skepticism about the external world because the required correspondence between our thoughts and reality is not ascertainable. David [97]

(i) Ontological realism where the mind-independent reality exists was postulated in §4.12 as a minimal and sufficient explanation of perceptions. It was concluded that an empirically sufficient version of solipsism is at best equivalent with ontological realism.
(ii) OBC is defined in terms of ontological realism. Therefore there is no use to appeal to solipsism in criticising OBC.
(iii) A justified true belief about the mind-independent reality requires to be reliably verified. According to Chisholm [84] and Lammenranta [215], P qualifies as a justified true belief when the following conditions are met: a person believes that P; the belief that P is true; the belief that P is reliably verified.
(iv) David transforms the requirement of reliable verification into skepticism about the external world, whereas Frege and Kant note that perception cannot in the end verify beliefs with an absolute certainty.
(v) These arguments are not intelligible in the light of economical unification where the starting point is a minimal ontology *that must be accepted implicitly in any case, even if it is explicitly denied*. There is no use to deny what you must in practice accept, whereas it is robust to define all the rest in terms of that what you in any case must accept even if you deny it. In this case, the only alternative to accepting the existence of the external world is some version of solipsism. However and again, as an empirically sufficient version of solipsism is at best equivalent with ontological realism, the appeal to solipsism cannot be used as a weapon against OBC.

To illustrate, when you look out your window you see e.g. a tree or a building. It helps in no way to maintain that beliefs in their existence cannot be ascertained, for there are no other alternatives for people than to rely on their perceptions, and most of the people *do* rely on their perceptions. If someone wishes to stick with the idea that perceptions after all verify nothing with an absolute certainty and that this leads into skepticism about the external world, this should not be considered as a threat to OBC, but as an argument for solipsism, which, again, has no force. Ingthorsson says the same:

> We cannot with absolute certainty know whether any property ascribed to any object is really possessed by the object (or if the object really exist), and hence all words used to denote properties should be judged useless/meaningless; ... either we demand absolute certainty for the application of any term, or make due with a degree of uncertainty about them all. Since we do accept some degree of uncertainty about ascriptions of knowledge—in so far as we accept that knowledge is fallible—and about the ascription of every property known to mankind, then why should we not accept such uncertainty about truth? Ingthorsson [182, ch. 5.1]

Again, arguments for solipsism should be on the level of ontology, and as these do not genuinely threaten ontological realism, solipsism should not leap on the level of applications. Another equally intelligible strategy is to maintain that we live in a computer simulation operated by Descartes' evil scientist. The hypothesis about an evil scientist can be rejected by economy, for it is not needed in explaining perceptions. According to Syropoulos [388, p. 2]) "this is an entirely different problem, which should concern ... science fiction authors." People must in practice rely on observations, for even if everything is just an illusion, people must rely on observations *within the supposed illusion*:

> The meaning of our words will be causally tied to *whatever* reality is ultimately causing us to have the experiences that we do, and so we *just will* end up holding true beliefs about *that* reality. Thus, brains in vats will hold true beliefs about electrical impulses. Anderson [8, p. 76]

In contrast to propositions that are verifiable by perception, consider a proposition which is not in practice verifiable: P='There existed a flock of thousand unicorns a billion years ago in the distance of a billion light years from the Earth.' This proposition is either true or false in OBC, but it is not verifiable. So, what is the use of OBC now? Anything that is supposed to exist but which has not been verified to exist by perception is counted as a metaphysical commitment when theories are evaluated by economy: of two theories which are otherwise equal, economy favours the theory which gets by without committing to the truth of P. OBC functions as the background theory or as a pre-scientific conception in evaluating other theories: specific theories with metaphysical postulates are induced based on perceptions which do correspond, and the measurable predictions of a worthy theory verifiably correspond. The notion that verifiability fits perfectly together with OBC is the main theme of the next section.

6.3 Correspondence of Sensations vs. Theories: Putnam's Arguments

A proposition is true and corresponds when the object to which the proposition refers exists in the way that the proposition states. The question of what correspondence is has thus been answered. The following allegations that the correspondence relation is mysterious, vacuous or occult either miss their target or find their correct places in the context of OBC, or both. Consider the first allegation:

> The correspondence relation is very mysterious: it seems to reach into the most distant regions of space (faster than light?) and time (past and future). How could such a relation possibly be accounted for within a naturalistic [scientific] framework? What physical relation could it possibly be? David [97]

In economical unification ontology comes first, then applications such as truthmaking. Presentism was selected as an axiom by economy, and truthmaking is fitted in the context of presentism, where there are no viable alternatives to accepting present and past objects as truthmakers of propositions targeted at the past, present and future (§6.6). Therefore, OBC has no difficulties with propositions targeted at past and future. The correspondence relation is not like any physical relation of influence such as gravitation, and therefore it is misleading to think that it 'reaches' anything in any kind of a velocity or instantaneously. However, the expression 'the correspondence relation reaches into the most distant regions of space faster than light' can be interpreted as a figure of speech which is equivalent with the proposition that the size of the present temporal stage of the Universe is billions of light years, which is accepted in contemporary cosmology (§5).

It is wrong-headed to ask how the correspondence relation can be accounted for in a scientific framework, for the validity of a scientific theory requires that its verifiable predictions verifiably correspond and scientific theories have been deduced based on perceptions which by definition correspond, i.e., the question seems to be involved with circularity. On the other hand, if the question is not involved with circularity and only asks just what is the role of correspondence in the context of a scientific theory, then the answer is likewise that the validity of a theory requires that its verifiable predictions verifiably correspond and that scientific theories have been deduced based on perceptions which by definition correspond. In either way, the correspondence relation is firmly present, applied and accounted for in the context of scientific theories. Consider a slightly more exhaustive characterization:

(i) Theories are built by reasoning from sensations that result from perceptions (§8.1) and there are no viable alternatives for supposing that these direct sensations correspond[87] to something external to the perceiver's mind, for the only alternative to accepting this is solipsism, which is in any case at best equivalent with ontological realism (§§4.12,6.2). This is one way of how correspondence is accounted for in a naturalistic framework.
(ii) The validity of a scientific theory requires that it gives verifiable predictions which verifiably correspond, and again, there are no viable alternatives for supposing that these verifications correspond. This is another way of how correspondence is accounted for in a naturalistic framework.
(iii) The truth of a theory which incorporates unverifiable and unfalsifiable metaphysical commitments cannot be verified. Therefore it is not asked whether such theories are true or false, but they are evaluated by economy: it is first asked which theories give the most accurate predictions that are measured to correspond; then all theories with equally accurate predictions are evaluated based on their metaphysical weights and other theoretical virtues, i.e., economy goes over and above verifiable correspondence, but only after verifiable correspondence has first been guaranteed.

[87] Rasmussen [327, p. 54] aims to explain what correspondence means and characterises the *problem of matching* as "the problem of seeing how truth-bearers may connect with the portions of reality they describe." Suppose that you perceive a tree and a mental image of the tree is realized in you mind. Now, how does the mental image connect to the mind-independent tree? It is one thing to give an account of the neurological processes which eventually yield the mental image in your mind; it is very different to maintain that the mental image does not genuinely reflect the tree. The problem of explaining how mental states exactly reflect reality is equally a challenge for all who commit to ontological realism, i.e., the problem of matching is not especially a problem of OBC.

PUTNAM'S ARGUMENTS. Hilary Putnam's criticism of the correspondence theory can be seen as a continuation of William James' project (§6.1) of bringing pragmatic sense into theorising about truth. The aim is to show that Putnam's arguments do not threaten OBC, and that the central relevant content of his critique is incorporated in OBC when it is applied in the context of the method of economical unification, where the principle of economy can be characterized as a criterion of rational assertability. Consider Putnam's version of Michael Dummett's *language acquisition argument*:

> To say that truth is "correspondence to reality" is not false but *empty*, as long as nothing is said about what the "correspondence" is. If the "correspondence" is supposed to be utterly independent of the ways in which we confirm the assertions we make (so that it is conceived to be possible that what is true is utterly *different* from what we are warranted in *taking to be true*, not just in some case but in all cases), then the "correspondence" is an occult one, and our supposed grasp of it is also occult. Putnam [322, p. 10]

The only conditions for rationally asserting p are epistemic, i.e., the empirical evidence of the truth of p, and the coherence of p with other propositions which are supported by empirical evidence. However, as in the correspondence theory truth is defined entirely non-epistemically as correspondence to reality, "we are nowhere near a theory which could account for how finite language-speakers could come to grasp realist truth-conditions and thus know what p means" (Anderson [8, p. 52]). The argument can be answered similarly as David's above argument, resulting into the conclusion that the principle of economy is a criterion of rational assertability of theories, whose application entails the acceptance of correspondence.

OBC is defined in terms of ontological realism. There are practically no alternatives to ontological realism, as solipsism is at best functionally equivalent with ontological realism (§4.12).[88] Putnam did not deny the existence of the mind-independent reality, nor that direct perceptions correspond (Anderson, *ibid*, p. 77). Correspondence and rational assertability coincide in the case of direct perception which is not involved with interpretation, as characterized in §8.1. For instance, the reason why the realist makes e.g. the assertion that *it is snowing outside* is that the realist perceives that it is snowing. Thus, in the case of direct perception, that what is true is not at all different from what we are warranted in taking to be true.

As there are no difficulties in fitting together OBC and warranted assertability regarding direct perception, it is intelligible to look at Putnam's notions about assertability in the context of theories. First, theories are deduced based on perceptions, i.e., their metaphysical commitments are deduced and their function is to explain perceptions; that a theory explains perceptions is thus a sign of rational assertability. Second, when evaluating two or more theories by economy, correspondence of their verifiable predictions is the first criterion, and metaphysical simplicity and virtuousness in general the second. Economy can thus be seen as a criterion of rational assertability, i.e., the most economically unified theory is the most rationally assertable. However, it is not suggested here that the currently most rationally assertable theories should be correspondence-true, for the mind-independent existence of their unverifiable metaphysical commitments by definition cannot be known. But the current theories are still at least stepping stones towards an ideally economically unified theory.

[88] According to Anderson [8, p. 53], some have demanded that the realists should prove that the mind-independent world exists, but its existence cannot be proved as we are dealing with mutually exclusive metaphysical interpretations.

According to Khlentzos [196], Putnam [321] aims to show with one version of his *model-theoretic argument* "that an ideal theory of the world could not be false, a conclusion flatly inconsistent with realism." Consider Medina's formulation of the argument:

> Imagine a possible formalization T_I of ideal scientific theory, that is, the best theory of the world possible for us humans, a theory at the limit of scientific investigation which fits all possible observational evidence and satisfies all possible theoretical constraints. Putnam's contention is that no sense can be made of the claim that such an ideal theory might be false, for, by definition, that theory will come out true in all possible models. The metaphysical conception of truth as correspondence with the language and mind-independent world makes truth inaccessible for us, and is ultimately unintelligible. Medina [263, p. 76]

The argument seems to rest on the claim that a non-problem should be considered as a problem. For, why should it make correspondence-truth inaccessible to us that no sense can be made out of an ideal theory —an ideally economically unified theory of nature— being false? Perhaps, because in this case ideally rational assertability (IRA) would entail correspondence-truth (CT)? Suppose that IRA(x)→CT(x) holds, which is read as: if x is an ideally economically unified theory, then x corresponds completely and exhaustively. It is hard to see why should IRA(x)→CT(x) make correspondence-truth inaccessible to us, for correspondence is applied in verifying the measurable predictions of the ideal theory, and the ideal theory has been deduced based perceptions which correspond. Also CT(x)→IRA(x) holds, or no economical sense can be made out of the idea that a completely and exhaustively corresponding ideal theory does not e.g. give the correct predictions. If both hold, then IRA(x)↔CT(x) holds. Perhaps the most important notion where Putnam's argument leads to is that there are good reasons for supposing that if one accepts economy, one is also inclined to believe that IRA(x)→CT(x) holds. There are three alternatives: (a) IRA(x)→CT(x); (b) IRA(x)→not-CT(x); (c) IRA(x)→CT(x) or not-CT. If it can be shown that (b-c) are uneconomical with respect to (a), it has been shown that economy favours (a).

(b) Suppose that IRA(x)→not-CT(x) holds, i.e., that the diachronic possibility of arriving at an ideal theory through historical development entails that the ideal theory is false, i.e., that at least one ideal theory is possible, all possible ideal theories are false, and it is impossible to arrive at a true ideal theory. This would require that nature is so complex that even a false ideal theory is possible. Moreover, such complexity of nature would not explain why a true ideal theory would not be even possible. In order for a true ideal theory to be impossible, nature should be so complex that the human kind could not even in principle guess its structure. The hypothesis IRA(x)→not-CT(x) thus requires a more complex nature than IRA(x)→CT(x).

(c) Suppose that IRA(x)→CT(x) or not-CT(x) holds, i.e., that at least one true ideal theory and at least one false ideal theory are possible. Two possible ideal theories are genuinely different on the level of ontology and not just terminologically different versions of the same theory. Nature would thus be so complex that it would lead us in believing in the truth of a true ideal theory as well as in the truth of a false ideal theory. The hypothesis IRA(x)→CT(x) or not-CT(x) thus requires a more complex nature than IRA(x)→CT(x).

Economy thus favours (a) over (b) and (c). It can be concluded that on the basis of economy, Putnam was correct in the hypothesis IRA(x)→CT(x), but this does not threaten OBC. Ideal economy must be distinguished from economy of contemporary theories. History shows that theories have been rejected and replaced (§3.3), i.e., contemporary verifiability or rational assertability has not counted as an indicator of truth.

Medina contemplates Putnam's *internal realism*:

> Reference and truth have to be internalized, i.e. relativized to a theory, point of view, or ≪conceptual scheme≫. The result of this internalization is that the idea of a single true picture of the world, the God's Eye View of metaphysical realism, is abandoned. Internal realism urges us to give up the old ideal of the One True Theory. Medina [263, p. 75]

Putnam's arguments give no reasons for abandoning the ideas that it is possible to gradually arrive at an ideally economically unified theory, and that nature exists in some absolutely determinate way even though we do not know just how. Instead, it was pointed out above that Putnam's model-theoretic argument only substantiates the idea that if an ideal theory is found, then it is more economical to suppose that it is the only one of its kind and correspondence-true. However, when Putnam's internalization is applied only to contemporary theories which are non-ideal, the notion that truth is theory-dependent —dependent on a conceptual scheme— makes perfect sense. To illustrate, in the conceptual scheme where relativistic physics is *supposed* to be true, it is also *supposed* to be true that dark energy exists (§5.4), for this way new empirical data in the 1990's could be fitted in the pre-existing conceptual scheme of relativistic cosmology. In contrast, given the principle of economy, there are no reasons to suppose that dark energy exists, because the data of 1990's could be fitted in the conceptual scheme of a more economically unified theory (DU) without having to postulate dark energy. When analysing the case in terms of the conceptual scheme of DU, what happened is that relativistic cosmology did not agree with reality, but instead of rejecting it, the reality was forced to agree with relativistic cosmology by adding dark energy, i.e., by supposing that dark energy exists in reality. In sum, although interpretations of observations are in many cases heavily theory-dependent, this does not threaten OBC which is applied primarily on observations.

Finally, consider Niiniluoto's [288, p. 46] comparison of Putnam's [320] internal realism with truth as rational assertability (IR), and ontological realism with truth as correspondence (OR). Some of Niiniluoto's formulations (in italics) are complemented.

(OR1) *The world consists of some fixed totality of mind-independent objects.*
(OR2) *There is exactly one true and complete description of "the way the world is".* No economical reasons have been found which would deny that an ideal theory could be invented, which would capture the laws of nature and the overall causal structure of the Universe. However, in the context of EUO a description that contains e.g. information of the locations of all atoms in a single temporal stage of the Universe (TSU) could not actually exist, for its existence would require more space than a TSU.
(OR3) *Truth involves some sort of correspondence relation between words and external things or sets of things.*
(IR1) *What objects does the world consist of? is a question that it only makes sense to ask within a theory or description.* The question "What objects does the world consist of?" can be translated as "What is your theory about the Universe?" We can evaluate theories by economy.
(IR2) *There is more than one 'true' description of the world.* If two descriptions contradict one another, they cannot correspond simultaneously and in the same respect. This is the coherence theorem of correspondence truths (§6.1). However, if Putnam means that there are or that one could in principle invent two theories that are equally rationally assertable on the basis of contemporary empirical data, then it is hard to deny this. Then again, the hypothesis that two genuinely different ideal theories are possible was shown to be uneconomical.

(IR3) *Truth is some sort of idealized rational acceptability.* It was concluded above that economy favours the hypothesis IRA(x)→CT(x), but only with ideal theories. With contemporary theories, assertability is the first evaluation criterion, but even the most economically unified contemporary theory is not called true. Given economy, approaching the ideal theory is approaching the truth, but the stepping stones are nevertheless strictly speaking false by definition, as only the genuinely ideal theory is true.

In sum, the principle of economy not only fully incorporates Putnam's requirement of rational assertability, but it *is* a criterion of rational assertability, which can be applied only together with correspondence, as the correspondence of verifiable predictions is the first criterion by which theories are evaluated. Putnam's notion that an ideal theory cannot be false is remarkable, and compatible with OBC. His notions about theory-ladenness are important but do not threaten OBC. Whether his internal realism is compatible with OBC seems to be a matter of interpretation, but hopefully it has been shown that the central import of Putnam's critique is built-in in the team play of OBC and the principle of economy.

6.4 Locating Truthmakers: the Slingshot Argument

The slingshot argument —also called the big fact argument— aims to undermine correspondence theories by showing that all true propositions correspond to the same thing, and that therefore correspondence is vacuous. Consider one formulation of the argument:

> [C. I. Lewis[89]] challenged the correspondence theorist to locate the fact or part of reality, or of the world, to which a true sentence corresponded. One can locate individual objects, if the sentence happens to name or describe them, but even such location makes sense relative only to a frame of reference, and so presumably the frame of reference must be included in whatever it is to which a true sentence corresponds. Following out this line of thought led Lewis to conclude that, if true sentences correspond to anything at all, it must be the universe as a whole; thus, all true sentences correspond to the same thing. The correct objection to correspondence theories is . . . that such theories fail to provide entities to which truth vehicles (whether we take these to be statements, sentences or utterances) can be said to correspond. If this is right, and I am convinced it is, we ought also to question the popular assumption that sentences, or their spoken tokens, or sentence-like entities or configurations in our brains, can properly be called "representations," since there is nothing for them to represent. If we give up facts as entities that make sentences true, we ought to give up representations at the same time, for the legitimacy of each depends on the legitimacy of the other. Davidson [98, pp. 303-4]

There are two central steps in the above argument. (1) Showing that every true proposition must correspond to the Universe as a whole. (2) Concluding that therefore OBC must be dropped, for it is essential to its validity to locate the truthmakers. The argument can be exhausted by showing that (1) cannot hold in EUO. In EUO, a true proposition cannot even in principle correspond to the whole Universe, as this would entail that the proposition corresponds to itself: a true proposition can correspond to any part of the Universe but not to itself (§4.18). Therefore, given any two propositions A and B which are not the same proposition, where A correspond to the whole Universe discluding itself, and where B correspond to the whole Universe discluding itself, A and B do not correspond to the same thing, and therefore (1) cannot hold.

Alternatively, suppose that Davidson means a single temporal stage of the Universe (TSU) instead of the whole Universe, so that (1) is transformed into: (1') Every true

[89] *An Analysis of Knowledge and Valuation*, La Salle, IL: Open Court, 1946 pp. 50-5.

proposition about a part of a TSU must correspond to that TSU as a whole. It can be shown that (1') does not hold in the relevant sense, although it holds in a very narrow sense that does not threaten OBC. Consider a single TSU t which is realized at time t, and two propositions P and M which are realized at time $t+1$ and which are pointed at different parts of TSU t:

P=Peter has a coin in the pocket of his trousers at time t.
M=Maria has a coin in the pocket of her trousers at time t.

In the narrow sense TSU t as a whole is indeed the truthmaker of both P and M. This is the sense that all parts of t are causally connected by gravitation and other influences. This is explicitly stated by the causality axiom. But surely, the acknowledgement that we are living in the Universe whose parts are causally connected does not threaten OBC. Why this is so can be understood by classifying the truthmakers of P and M in two proper parts, the *change-dependent part* and the *change-independent part*, as follows.

CDP: the change-dependent part of t with respect to P.
CIP: the change-independent part of t with respect to P.
CDM: the change-dependent part of t with respect to M.
CIM: the change-independent part of t with respect to M.

CDP is clearly relevant with respect to the truth of P, whereas CIP is clearly irrelevant. CDP consist of Peter, his trousers and the coin in the pocket of his trousers, whereas CIP consists of the other parts of t, including CDM. The gist is that CDP is the relevant truthmaker of P disregarding of CIP, i.e., it is irrelevant to the truth of P how CIP happens to be. CIP could have existed in an extremely different way while CDP would have made P true. For instance, millions of far away galaxies could have been realized in different ways, but the plain CDP would still have made P true. Likewise for CDM. CDM is clearly relevant with respect to the truth of M, whereas CIM is clearly irrelevant. CDM consist of Maria, her trousers and the coin in the pocket of her trousers, whereas CIM consists of the other parts of t, including CDP.

In sum, CDP is relevant to P and CDM is relevant to M. Therefore, P and M correspond essentially to different parts, and therefore (1') does not hold. The CD-CI dichotomy helps to see that our beliefs are typically targeted at their change-dependent truthmakers. Therefore, all true propositions do not correspond to TSUs as wholes in the relevant sense, although they do in the narrow sense that all parts of a TSU are causally connected.

6.5 An Argument from Abundancy

Asay [31, p. 107] maintains that there "is no metaphysically substantive property of truth, no matter how one understands the metaphysics of properties. Truth is at best a mere abundant property." It is shown in the following that truth is not an abundant property of a proposition in OBC, but the truth of a proposition results from the fusion of the proposition and its truthmaker object. Consider Asay's argument:

> Take again our sample true proposition, <Phil is six feet tall>. The "familiar" truthmaker F here is either the realist's state of affairs composed of Phil and the universal *six feet tall*, or the moderate nominalist's six feet tall trope that belongs to Phil. The "redundant" truthmaker R is either the state of affairs composed of <Phil is six feet tall> and *truth* or the truth trope belonging to <Phil is six feet tall>. F and R are fully distinct existences. Either F and R can exist independently of each other, or there are necessary connections that obtain between them. Both ways lead to trouble. If F and R are not necessarily connected, then it is possible for R to exist and for F to fail to exist. Notice just what

> this possibility is. We have the proposition <Phil is six feet tall> instantiating *truth*, and so we have a true proposition. But this is also a possibility where Phil does not instantiate *six feet tall*. What we have, in other words, is a possible scenario in which Phil is not six feet tall, even though the proposition <Phil is six feet tall> is true. But that is impossible, since, necessarily, the proposition that Phil is six feet tall is true if and only if Phil is six feet tall. In effect, taking F and R not to be necessarily connected amounts to rejecting the necessary truth of a propositional T-sentence. Even the substantivists accept the legitimacy of the propositional truth schema (i.e., necessarily, <p> is true if and only if p). If F and R are not necessarily connected — which, recall, I argue is the "default" view, given that they are fully distinct — then substantivism about truth reduces to absurdity. Suppose instead that F and R are necessarily connected, in spite of being fully distinct; their existence is tied up with one another, such that R cannot exist unless F also exists. ...this view is surprising and suspect; there are no obvious independent grounds for taking F and R to be necessarily connected, and so to find them so connected must involve positing a brute necessary connection between them. ...we should posit entities like R, and their brute necessary connections to more familiar things like F, only when there are compelling metaphysical reasons for doing so, such as accounting for resemblance, causality, and truthmaking. R is not needed for any of those things, so positing its existence and its brute connection to F is unmotivated. Hence, if F and R are not necessarily connected, then contradiction results. If F and R are necessarily connected, then we have an unjustifiably ontologically expensive view. Metaphysical substantivism is either contradictory or unmotivated. The substantivist road is a costly one, and offers no benefits to justify the expense. Asay [31, pp. 122-4]

Asay's argument about correspondence truths being abundant and the argument about positing brute existence of necessary connections between distinct existences rely on ambiguous time mappings, and they are accordingly resolved by disambiguating the time mappings, under the following setting. The terms 'Universal,' 'realized trope' and 'state of affairs' in Asay's quote are translated as 'object which is realized in the past, present or future.' P is the proposition <Phil is six feet tall>, which is stated in some specific time in some specific location and which refers to F, where F is Phil at a certain time, i.e., a temporal part of Phil.

Suppose that P and F have both been realized at time 1. In the context of presentism, everything that has been realized in the past has been necessarily realized from the aspect of the present time (§7.1). When P was realized at 1, it referred to and corresponded to F which was also realized at 1. This is the sense in which P and F are necessarily connected, given presentism and that 1 is in the past. There are no extra abundant truthmakers, for the truth of P is nothing over and above the fusion of P and F: that P was realized at 1 and corresponded to F which was realized at 1, implies that P is necessarily true from the aspect of the present time. There is no *uneconomical brute* necessity involved. For instance, it is not uneconomical and brute either to require that the truth of the proposition that the Moon was in the sky yesterday requires that the Moon was in the sky yesterday.

As another example, suppose again that P was realized at time 1 and that P refers to F, but F is Phil at time 2 which is not yet realized at 1. Suppose also that Phil's being six feet tall at 2 is contingent: it is possible from the aspect of 1 that Phil will be six feet tall at 2, and it is possible from the aspect of 1 that Phil will not be six feet tall at 2. Therefore, from the aspect of 1 it is possible that P which is realized at 1, will turn out to be false when 2 will be realized. Asay is thus correct in the sense that in this case P at 1 is not necessarily true: the truth value of P is indeterminate from the aspect of 1 (§7.3). However, brute necessity is not involved, for necessity is not involved at all. There are no abundant truths either, because the truth value of P is indeterminate.

6.6 Truthmaking in Presentism

Recall that presentism is the doctrine that only present entities exist, past entities did exist but do not exist at the present, and future entities will exist but do not exist at the present. Many authors have pointed out that presentism is incompatible with the principle that the truthmaker of a true proposition must exist:[90]

> If there really are no non-present objects, then it is hard to see what we are referring to when we use expressions such as 'Socrates' and 'the year 3000'. ... for every truth, there is a truth-maker. The problem is that it is hard to see what the truth-makers could be for such truths as that there were dinosaurs and that there will be Martian outposts. Markosian [250]

> The problem is that, in order to be able to accept the proposition <dinosaurs existed>, say, one must accept that <dinosaurs existed> is true. But according to truthmaker maximalism ... for any true proposition P, there exists at least one entity E that makes P true.... But what makes <dinosaurs existed> true? It can't be dinosaurs, since dinosaurs are nowhere to be found in the presentist's ontology. Asay and Baron [32, p. 315]

Such arguments can be exhausted by recalling the marching order in economical unification: ontology first, applications second. Presentism was postulated as the most economical axioms for temporal existence (§4.4). Therefore, presentism is not fitted in the context of an arbitrary truthmaking principle nor rejected if it is incompatible with such a principle,[91] but truthmaking is fitted in the context of presentism by formulating a truthmaking principle that is compatible with presentism: *the truthmaker objects of true propositions either have existed in the past, or exist at the present.*[92] Virtually all arguments against truthmaking in presentism can be exhausted by taking presentism seriously and applying this truthmaking principle.

PAST TRUTHMAKERS. By the above truthmaking principle, truthmakers of the propositions 'dinosaurs did exist' and 'Julius Caesar died' *did* exist in the past, but do not exist at the present. The proposition 'X *did* exist' does not state that X exists at the present. If X would exist at the present, the proposition 'X *did* exist but does not exist at the present' would be false. In presentism the past did exist and the past also caused the present, as stated by the causality axiom of EUO. The present could not exist without having been caused by the past. The past is essentially different from something that has not existed in the past. Past truthmakers are thus as viable as the fusion of presentism and the causality axiom. In contrast, one who denies their legitimacy has the problem of giving an account of one's own past and the history of the Universe in general. The denier's problem can be illustrated by investigating Leininger's [218] argument that presentism cannot explain the passage of time. In presentism the passage of time is defined as the transition from one temporal stage of the Universe (TSU) into another, where only one of these is present at a time and where the TSUs are in forward directed temporal and causal succession. Consider the core of Leininger's argument:

[90] Such truthmaking principles can be found e.g. from Armstrong [29, p. 5], Bigelow, [48, p. 133], Lewis [224, pp. 206-7], Davidson [99, p. 154], Briggs and Forbes [59, ch. 4.1], and Kierland [197, p. 175].

[91] Compare to Merricks [270, ch. 5] who sustains presentism and rejects a truthmaking principle that is incompatible with presentism.

[92] This resembles Sanson and Caplan's [77, p. 198] *wide-based truthmaking* (truth supervenes on what was, is, or will be) except for 'will be.' Future objects are not needed as truthmakers in presentism (§7.1).

> [F]or the contents of the present moment to change, there must be a difference in the character of each successive present moment. But in order to establish that two successive moments are different, both must exist.... the presentist could reply that we can compare the difference between things that exist and things that do not exist. ...This way of comparison, however, is hypothetical comparison. That is, when we compare a horse to a unicorn, we consider what (concrete) properties the unicorn would possess if the idea of a unicorn were concretely instantiated. In the same way, comparing the present moment to a formerly existing moment involves invocation of what properties the formerly existing moment would possess if it were concretely instantiated. This may allow us to compare differing possible moments, but it does not allow us to compare the difference in successive moments. Nothing guarantees that the moment we are hypothetically considering is actually a formerly existing moment, which is why this reply does not allow the presentist to avoid the need for the existence of more than one moment in order to establish temporal change. Leininger [218, p. 730]

Leininger leans on the idea that in presentism, past objects are ontologically analogous to hypothetical entities which have not existed in the past. This is not the case in EUO, where the ontological status of the past is essentially different from anything that has not existed in the past: the past did exist and it caused the present, where the past includes physical objects and their mental properties; things that did not exist did not affect the present in any way. Leininger's argument fails along with the analogy of things that did exist and things that did not exist.

Baia [37, p. 345-6] concludes that the allegation that presentism cannot be the ontological basis for past and future truths rests on a prior choice of ontology, and maintains that "the presentist can say that while that there were dinosaurs doesn't depend for its truth on how the world is, it does depend for its truth on how the world was." Likewise, Sanson and Caplan [348, pp. 25-30] maintain that it is sufficient for the presentist to hold that truthmakers of propositions about the past are how things were in the past. Fiocco aims to undermine this result:

> [A]n individual that is supposed *not to exist* at present, nevertheless is aptly characterized or truly described in certain ways, because it *was* (or *will be*) that way. ...such an account is objectionably incomplete in that it fails to provide any sort of explanation of how or why statements about temporal reality are true, that is, it makes no attempt to ground the structure of temporal reality. Fiocco's [144, pp. 197-8]

Presentism is an axiom for temporal reality, i.e., it states what exists temporally. Axioms are selected by economy; no axiom for temporal reality explains how or why statements about *temporal reality* are true, for axioms are unexplained explainers. Perhaps by saying that 'it makes no attempt to ground the structure of temporal reality' Fiocco means that in presentism the past and the future do not exist? If so, then he is merely restating presentism. In contrast, if Fiocco tries to say that presentism fails to give truthmakers to propositions targeted at the past, then he is wrong, for in presentism these truthmakers are past objects. Again, one who argues that a past object cannot function as a truthmaker in presentism has the problem of giving an account of one's own past and of the history of the Universe in general. And again, the selection of axioms should be on the level of ontology, not on the level of applications.

The same solution resolves the alleged problem of *cross-temporal relations*. According to Fiocco [144, p. 199] the problem "arises in the light of claims that seem to attribute

relations among entities that do not exist at the same moment(s)." Take an example proposition from Baia [37, p. 353]: *The birth of Napoleon preceded the birth of Elvis.* How can this be made true in presentism without cross-temporal relations? That both births did take place is made true by some past objects. The temporal ordering of these objects can be defined in terms of presentism (p. 59): when the time t of Napoleon's birth was the present, Elvis' birth had not yet been present, but it was only a future possibility, which was made a possibility by the temporal stage of the Universe t. No physical cross-temporal relation is needed here.[93] Baron argues that this is circular, for the presentist truthmaking principle —which he calls the *tensed supervenience view*— appeals to true propositions about the past, as was done with Elvis and Napoleon:

> This cannot be used to flesh out the tensed supervenience view. For the truth of such claims is precisely what is at stake when offering the tensed supervenience view as a solution to the truthmaker objection in the first place, and so cross-temporal supervenience cannot be analysed in this fashion, on pain of circularity. Baron [42, ch. 3]

Baron seems to mean that truthmaking in presentism cannot be defended by truthmaking in presentism, for this is circular. In economical unification presentism is postulated as the most economical available axiom for temporal existence, and truthmaking is fitted accordingly. Truthmaking is *defined* in terms of presentism, and presentism is *defended* by economy.

ALTERNATIVE APPROACHES TO PAST TRUTHMAKERS. There are basically two paths of saving the view that truthmakers of propositions targeted at the past must strictly exist. One is to reject presentism and replace it by an axiom where the past exists. This is a no-go, for these axioms are uneconomical with respect to presentism. Another is to sustain presentism but replace past objects by their presently existing surrogates/proxies. Also this is a no-go, for presentism with the surrogates is uneconomical with respect to plain presentism. Various different surrogates have been proposed on the top of presentism. Bigelow [49] adds *tensed world-properties*: the property of *having once possessed dinosaurs* makes the proposition 'dinosaurs existed' true. Sider [357, p. 41] calls the appeal to presently existing past-directed properties *cheating*, as such properties point beyond themselves; whether this is called cheating or just uneconomical is a matter of taste. Markosian [249] and Crisp [96] add *abstract entities*. Rhoda [332] appeals to *God's memories* about past event. Sanson and Caplan [348, 77] have argued that such strategies do not work, for only genuine past entities qualify as truthmakers of propositions about the past, whereas the surrogates are hypothetical. Recently, Ingram [178] has proposed new kinds of present surrogates of non-present entities, that are supposed to get over the previous counter arguments. The surrogate strategies and arguments against them do not have to be investigated here in detail, as any surrogates are uneconomical additions to plain presentism, even if they would work. Finally, Ingthorsson [181, p. 134] maintains that he is happy with the view that propositions about the past do not have truth-values in the context of presentism, as some propositions about the past can be justified in the epistemic sense based on their traces. This line of thought resembles the pragmatic theory of truth (§§6.1,6.3), but Ingthorsson himself maintains that the epistemic notions function in the context of the correspondence theory.

TRUTHMAKERS OF PROPOSITIONS ABOUT THE FUTURE. The proposition 'X will be realized at the future time f' does not state that X exists now. If X would exist now, the proposition 'X *will* exist in the future but does not exist now' would be false. Unlike past

[93] See also Bourne's [56, pp. 97-8] solution.

objects which did exist and which function as truthmakers as such, 'future truthmaker' is a figure of speech which means that the genuine truthmaker is the present or in the past, for the present determines the future, partially or totally (§7.2). As the present determines all future possibilities, the truth value of the modal proposition 'It is possible at the present that X will be realized at the future time f' is determined by the present to be either true or false, i.e., the present functions as the truthmaker or falsemaker of such propositions. If total determinism holds, there is exactly one possible future, and thus in the context of total determinism the present also qualifies as the truthmaker (or falsemaker) of propositions such as 'There will be Martian outposts.' As indicated in §7.3, if partial determinism holds, some propositions of the form 'X will be realized at the future time f' are indeterminate at the present, i.e., the present functions as their *indeterminate-maker*. Kierland's [197, p. 174] notions are equivalent.

6.7 Funny Fact Arguments

Consider the overall form of the funny fact arguments:

> Given the great variety of complex truthbearers, a correspondence theory will be committed to all sorts of complex "funny facts" that are ontologically disreputable. Negative, disjunctive, conditional, universal, probabilistic, subjunctive, and counterfactual facts have all given cause for complaint on this score. David [97]

In OBC facts are true propositions (p. 150), and an 'ontologically disreputable fact' is merely an ambiguous formulation of a true proposition. To illustrate, consider the proposition W='there does not exists unicorns.' W is ambiguous because it is unclear where it refers to. Is it pointed at the surface of the Earth at the present time? Is it pointed at the whole Universe —excluding itself— or at the present temporal stage of the Universe or where? Likewise, consider the proposition Q='Snow is white.' One way to understand Q is that if Q is true, then all objects in the past, present and future which fall under the definition of 'snow without too much impurities' reflect most of the wavelengths of visible light (§8). However, W and Q leave much space for interpretation: truthmakers of a proposition are by definition ambiguous when it is not known where the proposition refers to. The central notion here is that it is not the fault of OBC that people formulate propositions ambiguously. In contrast, if a proposition is formulated unambiguously, it has a truth value, even when its surface structure is involved with something negative, disjunctive, conditional, universal, probabilistic, subjunctive or counterfactual. Conditional, probabilistic and counterfactual propositions are involved with modalities and therefore these are handled in §7.3.

POSITIVE AND NEGATIVE PROPOSITIONS. Compare a positive proposition A to a negative proposition B. A='There did exist living unicorns at the first instant of the year 2015 on the surface of the planet Earth.' B='There did not exist living unicorns at the first instant of the year 2015 on the surface of the planet Earth.' There is no ambiguity about where the propositions are pointed at, and therefore no ambiguity about the truthmaker/falsemaker: it is the surface of the Earth at the first instant of the year 2015, which is abbreviated as E2015. If there did exist unicorns at E2015, then E2015 is the truthmaker of A and the falsemaker of B; if there did not exist unicorns at E2015, then E2015 is the falsemaker of A and the truthmaker of B. In contrast, propositions such as C='there are no unicorns' are ambiguous because it has to be guessed where these are pointed at. Cheyne and Pigden [82] maintain that the truthmaker of C is the way in

which the 'universe' actually is. In EUO, the truthmaker/falsemaker of C is the present temporal stage of the Universe (TSU), if C is pointed at the present TSU. Parsons [301] maintains that Cheyne and Pigden's [82] strategy fails, because the actual universe is merely one of two island universes, and even if C is true in the actual universe, it is false in the other universe. In EUO, there is no need for island universes or transcendent worlds; as 'true' is defined in terms of EUO, it is illegitimate to try to disqualify such a definition by appealing to an uneconomical ontology where island universes are dragged in out of the blue.

DISJUNCTIVE PROPOSITIONS. Consider a proposition whose surface structure is disjunctive. C='Peter came here either by walking route 1 or route 2 or ... or route n." While C is disjunctive, its truthmaker/falsemaker is not. C is pointed at some locations during some period of time in the past. If Peter actually did take one of the routes $1-n$ at that time, then C is true; otherwise C is false.

UNIVERSAL PROPOSITIONS. A universal proposition can be seen to propose that a universal fact is indeed a universal fact, i.e., that something is a uniformity of nature or even a law of nature. If this is the correct interpretation, then a universal proposition is a theory. The role of correspondence in inducing theories and in evaluating them was already handled in §6.3.

SUBJUNCTIVE PROPOSITIONS. Unless a subjunctive proposition is a conditional proposition, it expresses wishes, suggestions, and other attitudes. Such subjunctive propositions are close to non-descriptivist propositions which were discussed in p. 133, i.e., these do not strictly speaking propose anything else than that someone said or thought something. Consider a subjunctive proposition D='The doctor insisted that she walk at least a mile a day.'[94] If D is true, then the Doctor insisted that she walk at least a mile a day. That is, D only proposes that the Doctor said to a female that she walk at least a mile a day.

In sum, ambiguously formulated propositions should not be interpreted as threats to OBC, whereas unambiguous propositions whose surface structure involves something negative, counterfactual, conditional, disjunctive, universal, probabilistic or subjunctive have truth values in OBC.

6.8 Analytic Truth

The goal has been to formulate an economically unified theory of truth which is applicable in natural science and human social behaviour. Although this goal and the above analysis are very different from how the concept of truth has been *mostly* handled in the context of philosophy during the last 100 years or so, various authors have meant basically the same with 'correspondence.' According to Künne [210, p. 112] "It was about 1910 in Cambridge that G. E. Moore and Bertrand Russell married 'correspondence' with 'fact', and Ludwig Wittgenstein was soon to give his blessing to this union." OBC —where there are mental propositions that correspond to physical objects— was shifted into analyzing different meanings of 'fact' and 'state of affairs' and the nature of the truthmaking relation. The challenge here is that different philosophers have given different meanings to 'fact' and 'state of affairs' while correspondence fits together only with some meanings. OBC (1) is contrasted to the central theories of truth (2-7) which were created in the era of analytic philosophy in figure 19. Their analysis amounts to the following conclusions.

[94]The citation is from http://www.grammarmudge.cityslide.com/articles/article/1026513/13029.htm

THEORY	TRUTHBEARER	TRUTHMAKING RELATION	TRUTHMAKER
1. CORRESPONDENCE	proposition	correspondence	object
2. CORRESPONDENCE	proposition	correspondence	fact as object or its property
3. CORRESPONDENCE	proposition	correspondence	state of affairs as object or its prop.
4. CORRESPONDENCE	proposition	ambiguous	fact as true proposition
5. DEFLATIONISM	proposition	being	instance of the equivalence schema
6. IDENTITY THEORY	proposition	identity	fact as true proposition or object
7. PRIMITIVISM	proposition	having	truth-property

Figure 19: Some theories of truth .

(1) If the truthmakers are objects, then we are dealing with OBC. The truthmaking relation is correspondence and the theory works.
(2-3) If the truthmakers are facts or states of affairs that are in any case objects or properties of objects, then we are dealing with a version of OBC with different terminology. The truthmaking relation in a correspondence theory is correspondence, and the theory works. However, in the context of EUO facts or states of affairs as truthmakers provide no special advantages with respect to plain objects as truthmakers. If facts or state of affairs differ ontologically from objects EUO, they are evaluated by economy.
(4) If the truthmaker facts are true propositions only, then the notion that a proposition corresponds to a fact does not work, because the notion that a proposition corresponds to a proposition does not work, except in a special case. Therefore the truthmaking relation is 'ambiguous' in figure 19. Although correspondence does not work with facts as true propositions, in the course of unification, we can translate *correspondence with facts as true propositions* into *deduction based on known true propositions* that works in the context of OBC.
(5-7) If deflationism, the identity theory and the primitivist theory of truth are not even intended to function in the focal contexts, then these do not compete with OBC. If these are intended to function in the focal contexts, then they succeed only by being definitions in the context of a correspondence theory.

6.8.1 Correspondence/Truthmaking with Facts and States of Affairs

WITTGENSTEIN'S FACTS AND STATES OF AFFAIRS. Wittgenstein defines facts and states of affairs:

> 1 The world is everything that is the case.
> 1.1 The world is the totality of facts, not of things.
> 2 What is the case—a fact—is the existence of states of affairs.
> 2.01 A state of affairs (a state of things) is a combination of objects (things).
> 2.011 It is essential to things that they should be possible constituents of states of affairs.
> Wittgenstein [414]

According to Baker and Hacker [39, p. 85], for Wittgenstein 'object' is a simple object without proper parts. As a fact is the existence of a combination of simple objects, Wittgenstein's fact is equivalent with an existing object in EUO that consists of two or more proper parts (at one time, i.e., these parts are not temporal parts). If this is the correct interpretation, then Wittgenstein's facts function as truthmakers in what is practically OBC with different terminology: EUO's objects cover Wittgenstein's 'fact' and 'simple object.' That the world is the totality of facts, not of things, can be understood as follows:

> [T]he world is more than just a collection of objects; it is objects *in particular arrangements*. If you know of all the objects in the world, have a complete inventory of everything there is — you still have only a very inadequate idea of what the world is like. A satisfactory account of the world would have to contain not only a list of all the objects, but descriptions of where they are and in what relations they stand to each other. Schroeder [354]

Again, the difference is terminological: in this thesis e.g. the present temporal state of the Universe is an object whose parts are interrelated in a certain specific way.

ARMSTRONG'S STATES OF AFFAIRS. Armstrong sustains correspondence, switches truthmakers from facts into states of affairs, and especially distances states of affairs from propositions:

> My hypothesis is that the world is a world of states of affairs. I think that I am saying the same thing as those who have held that the world is a world of facts not things. ... In my view the word 'fact' is much too closely tied to the notions of statement and proposition. ... A state of affairs exists if and only if a particular has a property, or a relation holds between two or more particulars. ... The states of affairs, which includes their constituents, constitute the ultimate truthmakers for all truths. Armstrong [25, pp. 429, 435]

It is odd to maintain that 'the world is a world of states of affairs' as if states of affairs were somehow primitive, for they are defined in terms of particulars, which thus appear to be the genuine primitives. In any case, as states of affairs are defined in terms of particulars, there are no obstacles in interpreting that states of affairs are ontologically nothing over and above objects in EUO. Also relations between two objects are always included in an object: e.g. all relations between two galaxies at time t are included in the temporal stage of the Universe which is realized at t. In Armstrong's [16, II p. 4] vocabulary, 'particular' seems to be equivalent with EUO's object that exists during a period of time, whereas in this thesis 'particular' especially exists at one time only. For Armstrong a *thin particular* is "the thing taken in abstraction from all its properties" (*ibid*, I p. 114), whereas a *thick particular* is the "particular taken along with all and only the particular's non-relational properties" [26, p. 124]. A thick particular is thus a state of affairs: a particular having all its non-relational properties. As in the vocabulary of this thesis a particular is a thick particular in an environment with all its relational properties too, it seems plausible to interpret that Armstrong's states of affairs are ontologically nothing over and above EUO's objects. Further, as an object in EUO qualifies as Armstrong's state of affairs, states of affairs may be used as truthmakers in OBC.

The following example reveals an appeal of states of affairs in truthmaking. Suppose that particular x has properties m and c, which means that the states of affairs $m(x)$ and $c(x)$ exist. The proposition 'x has the property c' is true, although the proposition does not indicate anything about the property m of x, and therefore the state of affairs $c(x)$ can be seen as the convenient truthmaker of the proposition. However, x as a particular can be used as the truthmaker as well, and as states of affairs are involved with unnecessary terminological and ontological complexity, it is hard to find good reasons to apply them in the first place. Consider the terminological complexity in steps.

(1) Armstrong starts with the common-sensible conception of particular with properties, defines states of affairs as property-particular fusions and maintains that they are the basic building blocks of reality.
(2) In order to distinguish states of affairs from particulars, properties are abstracted away from particulars, which leaves over the abstraction of a thin particular.

(3) The thin particular is only an abstraction, but it creates confusion. Keller [195, p. 114] maintains that a state of affairs is a thin particular with one to all properties; on one hand this is understandable; on the other hand this is confusing, for a state of affairs is not a thin-particular-with-properties, but a property-particular fusion, for once a particular has a property, it is not thin: the conception of a basic building block of reality as an abstraction-property fusion makes no sense. Dodd [111, pp. 9-14] aims to undermine the correspondence theory by attacking states of affairs, maintaining that states of affairs are the most plausible candidates to be truthmakers in a correspondence theory, but as the unity of states of affairs —the unity of properties and particulars— is unexplained a correspondence theory of truth can only be the 'product of bad faith.' Armstrong maintains that the primitiveness of states of affairs is itself the explanation, but it is certain that states of affairs are the source of the confusion.
(4) We may classify states of affairs e.g. in particulars with some but not all their properties, and in particulars with all non-relational properties which are also thick particulars. It is hard to see why the terms 'thin particular,' 'thick particular' and 'state of affairs' should be deployed in the first place, for truthmaking with only particulars with properties is a lot less confusing.

The unnecessary ontological complexity of states of affairs can be illustrated by comparing these with objects in EUO. In EUO, an elementary particular x can be considered without difficulties as an indivisible particular which has properties, such as charge c, mass m and the sum of all nonrelational properties P of x. The properties m and c are ways in which x exists, and the expressions $m(x)$ and $c(x)$ are means of talking about x. In terms of states of affairs, there exists states of affairs $m(x)$, $c(x)$, $P(x)$ and states of affairs for all combinations of properties of x. As states of affairs are the ultimate building blocks of reality, the thick particular and a state of affairs $P(x)$ is divisible in states of affairs $m(x)$, $c(x)$ and in all other state of affairs combinations. Thus, there is a greater number of basic building blocks with Armstrong's states of affairs approach than in EUO's object approach. These building blocks are redundant, for e.g. the state of affairs $m(x)$ is partially redundant with the state of affairs $m\&c(x)$. There is no empirical evidence that would favour this complexity, as there is no evidence that would demand separating all properties of e.g. electrons and photons into separate building blocks of reality.

In sum, if states of affairs are ontologically nothing over and above objects, then these can be used as truthmakers in a correspondence theory. But the orientation behind using them is unclear, as at least Armstrong's states of affairs are terminologically and ontologically more complex than plain objects. The analysis of Textor [394] shows that there are conceptions of what a state of affairs is that differ from Armstrong's, but there is no urgent need to review these.

FACTS AS TRUE PROPOSITIONS. Fact has been defined as a true proposition e.g. by Frege:[95] "What is a fact? A fact is a thought that is true." And by Dodd [111, p. 80]: "my view is that facts are ... *true thoughts*." If facts are true propositions, then in fact-based correspondence a true proposition corresponds to a true proposition. The problem is that this does not work except in a special case, whereas in the general case the link to mind-independent reality is lost *and* correspondence does not work as the truthmaking relation.

Consider the special case first. In OBC, when a true proposition corresponds to a true proposition, this means that a true thought Q which is realized in the mind of a human

[95]Part 74 of *Der Gedanke* as translated by Künne [210, p. 7].

being corresponds to another true thought U realized in the mind of a human being. For instance, person A proposes that Q="person B is conceiving the thought U"; person B happens to conceive U and U happens to be a true thought. In this special case Q is true proposition that corresponds to the true proposition U.

Then consider the general case. The first problem is that a true proposition cannot corresponds to a true proposition, except in the special case above. Let the sample proposition P=*Mount Everest is the highest mountain on Earth* correspond to the fact F=*Mount Everest is the highest mountain on Earth.* As facts are true propositions, P is identical to F. This does not work: as proved in §4.18, given that non-wellfounded structures are rejected, P cannot correspond to anything that is identical to itself. Armstrong's and Frege's remarks that a proposition cannot correspond to a fact make sense when fact is translated as a true proposition:

> The traditional correspondence theory holds that p is true if, and only if, it corresponds to reality. Propositions correspond, or fail to correspond, to *facts* or to *states of affairs*. But a relation of correspondence demands that the correspondents be distinct from each other, and for true propositions this demand is not met. Suppose that the proposition in question is 'that the earth is round'. The fact or state of affairs to which this proposition corresponds is the fact that the earth is round or the state of affairs of the earth's being round. But the proposition does not correspond with this fact or state of affairs, rather it coalesces with it. Armstrong [15, p. 113]
>
> It would only be possible to compare an idea with a thing if the thing were an idea too. And then, if the first did correspond perfectly with the second, they would coincide. But this is not at all what people intend when they define truth as the correspondence of an idea with something real. For in this case it is essential precisely that the reality shall be distinct from the idea. Frege [149, p. 3]

Any way you put it, correspondence does not function as the truthmaking relation when the truthmakers are true propositions, except in the special case. Armstrong says that the proposition 'coalesces' with the fact, Frege says it 'coincides' with the fact and Dodd [111] maintains that the proposition is identical to the fact. The notion that P cannot correspond to a fact but that P is identical with a fact can be seen as the guiding intuition behind Dodd's identity theory of truth (§6.8.3). The difficulty with the identity theory —and the second problem of a correspondence theory where propositions correspond to facts as true propositions— is that if facts as true propositions are the only truthmakers, this leaves the mind-independent reality out of the picture. This would make facts themselves primitive, which would be practically equivalent with deflationism (§6.8.2). Dodd (*ibid*, p. 132) explicitly states that "the modest identity theory complements a deflationary attitude towards truth." In order to sustain the link to mind-independent reality, all facts should eventually correspond to objects. This would be OBC where propositions are identical with facts and where facts correspond to objects.

In sum, if the truthmaking facts are true propositions, the correspondence theory does not work, for the notion that a proposition corresponds to a proposition does not work, except in a special case. Then again, when correspondence is switched into identity, the mind-independent reality is left out of the picture, unless we are after all dealing with OBC, where propositions are identical with facts and where facts correspond to objects.

DEDUCTION BASED ON KNOWN FACTS? Again, correspondence does not work with facts as true propositions as truthmakers. However, in the method of economical unification the goal is to dig out applicable ingredients of all approaches and to incorporate them in the unified theory. The notion of 'correspondence with facts as true propositions' can be translated e.g. as 'deduction based on known true propositions' that works in the context

of OBC. A proposition can be *deduced* to be true based on the known facts, although the proposition is always *made true* by objects. Based on the known facts about the temperature of the Sun, it can be deduced that S=*there is no ice in the Sun* is a true proposition. When language is used vaguely, it can be said that the facts about the Sun *make* S true; when language is used accurately, it is said that the physical object Sun makes the proposition S true, and we deduced that S is true based on the known facts.

6.8.2 Deflationist Theories of Truth

The goal of this section is to show how the linguistically oriented deflationist theories are not competitors of OBC as the central empirically sufficient theory of truth, and to show that when viewed in the context of OBC as not theories of truth, the deflationist 'views' have some applicable ingredients. They are not competitors of OBC because they do not even aim to do the same job, as they are not concerned at all with the link between propositions and the mind-independent reality (cf. Ingthorsson [182, ch. 6]). This holds for all versions of deflationism, although Paul Horwich's *minimalism* is the only version that is looked at a little more detail. Horwich orientates deflationism by sweeping fact-based correspondence theory and the epistemic theories aside:

> The common-sense notion that truth is kind of 'correspondence with the facts' has never worked out to anyone's satisfaction. Even its advocates would concede that it remains little more than a vague, guiding intuition. But the traditional alternatives—equations of truth with 'membership in a coherent system of beliefs', or 'what would be verified in ideal conditions', or 'suitability as a basis for action'—have always looked unlikely to work, precisely because they don't accommodate the 'correspondence' intuition, and this air of implausibility is substantiated in straightforward counterexamples. Hence the peculiarly enigmatic character of truth: a conception of its underlying nature appears to be at once necessary and impossible. Horwich [173, pp. 1-2]

Horwich's critique is in place if 'fact' means 'true proposition' for in this case the resulting correspondence theory does not work (§6.8.1). However, if fact is an object or a property of an object, then the resulting correspondence theory does work. Horwich characterises the epistemic theories as rivals of fact-based correspondence instead of seeing them as its allies. Also this is natural, for at the time when Horwich published his book —1st edition in 1990 and 2nd edition in 1998— Ingthorsson had not yet unified them. Also ideal verifiability was shown to be compatible with OCB (§6.3. Horwich continues by claiming that something that OBC provably manages to do is based on a misconception.

> I believe that this impression is wholly wrong and that it grows out of two related misconceptions: first, that truth *has* some hidden structure awaiting our discovery; and secondly, that hinging on this discovery is our ability to explain central philosophical principles such as those just mentioned, and thereby to solve a host of problems in logic, semantics and epistemology. ... unlike most other predicates, 'is true' should not be expected to participate in some deep theory of that to which it refers—a theory that articulates general conditions for its application. Horwich [173, p. 2]

In the light of the disambiguation of the concept of truth in terms of OBC where the 'hidden structure' is successfully brought into light, the central applicable ingredients of the epistemic rivals of the OBC have been unified together and various alleged problems of OBC have been resolved, it can be concluded that Horwich's assessment does not touch OBC in any way. It remains to be shown that deflationism does not compete with OBC as an empirically sufficient theory of truth. Armour-Garb and Beall [14, pp. 6-7]

define three versions of deflationism, or three versions of the *equivalence schema*, also called *truthmaking schema*:

MINIMALISM: The proposition *that A* is true if, and only if, A.
DISQUOTATIONALISM: '*A*' is true if, and only if, *A*.
REDUNDANCY THEORY: 'It is true that A' means no more than A.

They (*ibid*, p. 3) maintain that the difference of deflationism and the substantivist theories (such as correspondence, coherence and the Jamesian pragmatic theory) is that deflationism takes instances of the equivalence schema[96] "to be *fundamental*, both conceptually and explanatorily." This means that truthmakers in deflationism are instances of the equivalence schema. Horwich [173, p. 5] gives examples of instances of the equivalence schema of minimalism: "The proposition *quarks really exist* is true if and only if quarks really exist, the proposition *that lying is bad* is true if and only if lying is bad, ... and so on." There is an instance of the equivalence schema for every true proposition, i.e., the proposition *that A* is true if and only if A is an instance of the equivalence schema, or deduced by instances of the equivalence schema as explained by Horwich (*ibid*, pp. 104-5).

ECONOMY OF DEFLATIONISM?[97] Is deflationism an empirically sufficient theory of truth? Horwich [173, p. 5] seems to think so: "The entire conceptual and theoretical role of truth may be explained on this basis. ... This sort of deflationary picture is attractively demystifying." How can the deflationary picture be de-mystifying when it especially leaves the deep meaning of 'true' open and simply replaces it with instances of the equivalence schema? The obvious difficulties of minimalism in natural science and typical human social behaviour are revealed by the following reasoning:

(i) In minimalism absolutely all truthmakers are instances of the equivalence schema.
(ii) If minimalism is empirically sufficient, the instances should suffice in determining truth values of propositions about the mind-independent reality.
(iii) Deflationism should not lead people astray, i.e., if a proposition about the mind-independent reality is true in deflationism, then this should be meaningful, i.e., this should tell something about the mind-independent reality.
(iv) Thus, e.g. the true proposition that the Moon is in the sky in the mind-independent reality should be a truth about the mind-independent Moon.
(v) Although in minimalism the proposition that the Moon is in the sky in the mind-independent reality may concern the Moon —or this is not explicitly denied— this proposition is not *made* true by the mind-independent Moon but by an instance of the equivalence schema.
(vi) Deflationism thereby puts common sense between a rock and a hard place: if deflationism is empirically sufficient, the instances of the equivalence schema must make propositions about the mind-independent reality true; but if they make such propositions true, this is in any case unnecessary as the mind-independent reality itself makes the propositions true.

In other words, if deflationism is intended to function in the focal contexts where the mind-independent reality is admitted to exist, some empirically sufficient ontology such as EUO is in any case required, and in the context of such ontology objects are sufficient truthmakers. However, the deflationist commits to instances of the equivalence schema,

[96]Depending on the version of deflationism, instances of the equivalence schemas may also be called *truthmaking sentences* and *basic acceptance properties*.

[97]E.g. Lynch [235, p. 191], Niiniluoto [288, p. 47], Unwin [403, p. 264] and Gupta [158, p. 78] criticise deflationism, but they do not talk about OBC and therefore it is hard to build on their arguments.

which are equivalent with metaphysical commitments (cf. Gupta [159, pp. 365-6] and Wyatt [421]). If the instances make propositions about the mind-independent reality true, then they are in any case unnecessary and deflationism is uneconomical with respect to OBC; if the instances do not make propositions about the mind-independent reality true, then deflationism is not even intended as an empirically sufficient theory, and OBC is needed.

DEFLATIONISM IN THE CONTEXT OF OBC AS NOT A THEORY. In the light of the above analysis it can be concluded that deflationism does not threaten OBC as the central empirically sufficient theory of truth. The remaining task is thus to incorporate applicable ingredients of deflationism in OBC by definitions. It should of course be understood what the applicable ingredients are before they can be defined. Two very different interpretations of minimalism are presented, Young's interpretation and Ingthorsson's summary of Wright's [417, ch. 1] interpretation, where their difference is another sign of the ambiguity of deflationism:

> On Wright's reading, minimalism is a pluralism about what kind of property the word 'true' ascribes to propositions. In some contexts it may be correct to say that something is true because it is coherent (e.g., in mathematics), sometimes because it is scientifically verified to correspond to reality (natural science), sometimes even because it fits to some moral or aesthetic norm. That is, the relevant property may vary with the context, and may not always belong to the proposition in question in virtue of corresponding to some fact. This is why we should not expect, or look for, a single metaphysically significant property that all true propositions have in common (like correspondence). This could be the motivation behind the minimalist claim that all we can ever hope to achieve is a general schema that fits all the uses of the word 'true', and which is consistent with the intuitions underlying the different ontologies, so to speak, of the various properties. So understood, the theory says absolutely nothing to undermine the thesis that sometime our beliefs correspond to reality, or that correspondence is at the heart of our epistemic practices. Ingthorsson [182, ch. 6]
>
> If the minimal theory has ever been thought to be anything other than a correspondence theory, perhaps this is because its advocates have not found it necessary to explicitly state this consequence of their view: A consequence that nicely encapsulates all that is essential to the correspondence theory. Young [423, p. 571]

Young quotes Horwich [173, p. 104] who states that minimalism "does not deny that truths *do* correspond—in some sense—to the facts; ... It is indeed undeniable that whenever a proposition or an utterance is true, it is true *because* something in the world is a certain way...." On the other hand, Horwich's main orientation to deflationism was the rejection of the correspondence theory, as indicated above. So, which interpretation is correct, Young or Wright-Ingthorsson? Armour-Garb and Beall [14, p. 2] are compatible with the Wright-Ingthorsson reading as they maintain that the deflationist theories focus "on the *concept* of truth and on how that concept gets employed in our talk and thought."

Given the Wright-Ingthorsson reading and when the status of a theory is removed from deflationism, instances of the equivalence schema can defined in the context of OBC as classifications of *what is assumed to be true by some people at some time in some context*, disregarding whether it is true in OBC. Consider some examples. (i) The belief that *wolves are vicious animals* has been and still is a pragmatic truth for some people who enjoy staying in the wilderness, and thus in the context of some people in the wilderness this can be classified as a belief which is made true by an instance of the equivalence schema. (ii) That an alms relieves the pains of one's relatives in the purgatory can be classified as a belief that is made true by an instance of the equivalence schema in the context of several medieval Christians. (iii) That there are talking trees can be classified

as a belief which is made true by an instance of the equivalence schema in the context of a fiction. (iv) That the Moon is in space in the mind-independent reality can be classified as a belief which is made true by an instance of the equivalence schema in the context of most of the people living today, and it supposedly is made true also by the Moon.

6.8.3 The Identity Theory and the Primitivist Theory of Truth

Baldwin [41, p. 35] defines the identity theory as follows: "It is basically the thesis that the truth of a judgement consists in the *identity* of the judgement's content with a fact." In other words, a proposition is true if and only if it is identical to a fact. In the context of EUO or just ontological realism, this makes sense only when 'fact' is translated as 'true proposition.' Accordingly, the resulting identity theory can be defined as: proposition a is true if and only if a is identical to a true proposition. This is also what Dodd [111, p. 80] means by his *modest identity theory*: "my view is that facts are not states of affairs but ... *true thoughts*." This way, it becomes intelligible to say e.g. that *the proposition that snow is white is true if and only if it is a true proposition that snow is white*. This raises a question: What makes a fact a fact? Dodd does not worry about this for he (*ibid*, p. 132) explicitly states that "the modest identity theory complements a deflationary attitude towards truth."

On one hand, if Dodd's identity theory —in the spirit of deflationism— is not even intended to function in natural science and human social behaviour where the link to mind-independent reality is essential, then it does not compete with OBC. Also Engel [132] concludes that the modest identity theory is truistic —in the sense that fact is a fact but it is not explained why— and it is very hard to distinguish it from deflationism. However, if it ought to function in these contexts, then the problem becomes to explain what makes a fact a fact. And this cannot be done without correspondence: the postulation of some kind of an axiom schema which gives the facts only makes the identity theory deflationism. Adding correspondence on the top of Dodd's modest identity theory makes a full circle:

(i) Objects were switched into facts in the early 20th century.
(ii) Fact-based correspondence does not work when facts are true propositions.
(iii) Dodd acknowledges that facts are true propositions, and therefore it makes sense that a true proposition is identical to a fact.
(iv) This does not answer why a fact is a fact.
(v) In order to answer why a fact is a fact, a fact needs to corresponds to an object that is external to the fact itself.
(vi) This makes a full circle.

Also other versions of the identity theory have been presented. In both of the following versions the border between a proposition and an object that makes the proposition true vanishes, and their difference is in the nuance of whether a proposition is pushed towards an object or whether an object is pushed towards a proposition. In the first mapping, the ontology is Bradley's[98] idealism where propositions are pushed towards objects. In the second mapping, the ontology is that of early Russell and G.E. Moore[99] where objects are pushed towards propositions. Engel [132, p. 443] maintains that these mappings are about "nudging thought towards the world" and "nudging the world towards thought." Engel (*ibid*, p. 447) also notes that the difference of these versions is unclear, for if an

[98]See e.g. Bradley [57] and Candlish [75, pp. 210-2].
[99]See e.g. Russell [344, §51], Candlish [75, p. 206] and Moore [277, p. 21].

idea (a proposition) is equivalent with the object that makes the idea true, then also the object is equivalent with the idea, i.e., the difference is only in where the nudging starts. These mappings do not have to be investigated further, for in ontological realism a proposition about object X —such as a mountain or a tree— is never the same nor identical to X (§4.18). Commitment to solipsism may be the only way of making sense out of the notion that a proposition is identical to the *object* that makes the proposition true. If so, the debate should be on the level of ontology, not on the level of defined concepts. Also Candlish and Damnjanovic [76] note that "the identity theory of truth may turn out to be best thought of as comparable to solipsism."

THE PRIMITIVIST THEORY OF TRUTH. Also primitivism about truth has its origins in the writings of G.E. Moore [275] and Russell [342]. In primitivism truth is an unanalysable property of a proposition. According to Moore [276, p. 284]: " "Truth," therefore, would, on this view, be a simple unanalysable property which is possessed by some propositions and not by others." As such primitivism is uneconomical and is not needed, because we already have OBC where the truth of a proposition results from the existence of its truthmaker. Then again, it is in no way empirically convincing that someone argues that his proposition is true because it has such a property, for typically and in OBC the case is on the other way around: if a proposition corresponds it is true, and this can be translated by saying that the proposition has the 'property' of being true. In contrast, suppose that someone argues that the proposition 'the Sun is very hot' is true because the proposition has the property of being true. Someone could as well argue that the proposition 'the temperature of the Sun is -20 Celsius' is true because the proposition has the property of being true. The primitivist theory reminds that metaphysical entities such as truth-properties which are invented out of the air without no empirical support are plainly inconvincing.

Although primitivism may look very much like deflationism —instances of the equivalence schema may look like primitive truth-properties— Asay [31, p. 3] maintains that he is not a deflationist, and that in his version of primitivism truth is a metaphysically substantive property, although a primitive one. Asay (*ibid*, p. 138) takes arguments against fact-based correspondence and state-of-affairs correspondence as convincing and "rejects the claim that truth can be understood in more fundamental terms like correspondence, coherence, or utility." Asay basically raises hands in the air and concludes that there are no other alternatives than to take truth as primitive. Against this strategy, in the unified theory truth is understood in more fundamental terms and where the central arguments against correspondence have been resolved.

6.8.4 Semantical Problems with Presentism?

Some semantical allegations against presentism are handled here because their scope is as far from anything that touches empirical sufficiency as the scope of the analytic theories of truth.

Fiocco [144] lists two semantical allegations against presentism. First, the problem of *there being only one moment* is a problem because we obviously talk about different moments whereas in presentism only the present moment exists. The resolution is that we talk about moments which did exist, about the present moment which exists, and about future moments which will exist. Second, consider the problem of *singular propositions*. The proposition *Urho Kekkonen existed in the past* is singular as it denotes a single object. Fiocco maintains that such propositions only name a single object without referring to any of its specific properties and thus such propositions are ambiguous. The resolution

that in EUO objects always come with all their properties (§4.7). The proposition *Urho Kekkonen existed in the past* is not ambiguous, for it refers to an object which existed in the past with all its properties.

Markosian [249] characterises the problem of singular propositions in a different way: "A singular proposition depends for its existence on the individual object(s) it is about. Thus, Presentism entails that there are no singular propositions about non-present objects." Markosian seems not to distinguish two things clearly enough: propositions; objects to which propositions refer. In EUO a proposition is a mental thing conceived by a human being; the existence of my present proposition about Kekkonen depends in no way of the present non-existence of Kekkonen, although its truth requires that Kekkonen did exist in the past. Then again, as propositions are mental things and as mental things are properties of physical objects (§4.13), singular propositions as well as all propositions in general go in and out of existence similarly as objects do. But the truth value of my proposition will never change. When analyzed from the aspect of any future time, the conclusion will always be the same: the true proposition *Urho Kekkonen existed in the past* was realized on April 1st 2016.

A third semantical argument against presentism is the claim that presentism is either trivial or false. Consider Meyer's formulation of the argument.[100]

> P1: Nothing exists now that is not present.
>
> On this reading, presentism is true, but utterly trivial. To exist now and to be present are the very same thing. ... To get a non-trivial account of the thesis, we would need a more inclusive notion of existence. Say that an object exists temporally just in case it exists at some time or other. By regarding the 'exists' in P as expressing temporal existence, we then get a second reading of the presentist's thesis:
>
> P2: Nothing exists temporally that is not present.
>
> Since it does not follow from an object's existing temporally that it exists now, this thesis is indeed non-trivial. But consider:
>
> JC: Caesar crossed the Rubicon.
>
> Caesar only could have crossed the Rubicon if he did exist. Yet if he did exist then he does exist at some past time, and therefore does exist temporally. But Caesar does not exist now; he died on the Ides of March in 44 BC. Hence if Caesar crossed the Rubicon (and he did) then there is an object (namely Caesar) that exists temporally, but is not present. If JC is true (and it is) then P2 is false. Meyer [271, pp. 214]

Consider first a positive and comprehensive formulation of presentism which is complemented by some clarifying further definitions, P: *only the present exists, the past did exist and the future will exist; the present is an unchanging temporal stage of the Universe whose all parts exist absolutely simultaneously; change and the passage of time are transitions from one present into another; the present moments are in temporal and causal succession.*

P1 follows from P: to exist now and to be the present are the very same thing. P1 is a strange negative formulation of something and fails to be a sufficient formulation of presentism for it fails to state what exists: it only states what does not exist. As P1 is insufficient in the first place, it is not hard to turn it into a triviality. Also Deasy [104] reviews various definitions of presentness and presentism, such as: *always, everything is present*; *always, everything exists now*; *always, everything always exists*; *always, everything is a part of a maximal slim object that includes as a part every event that is occurring now.* Deasy maintains that these are all somehow problematic. The central

[100] See also Lombard [228] and Savitt [350].

notion here is that it is more progressive to stick with an unambiguous and comprehensive definition of presentism, than to give a list of ambiguous and incomprehensive definitions are review their problems. Once again, Meyer [272, p. 68] maintains that the definition 'nothing exists now that is not present' is trivial, for it states "that everything that exists now, exists now. Everybody must accept *this* thesis, irrespective of their views about the metaphysics of time." Although trivial and ambiguous definitions can be given, these do not threaten the validity of the comprehensive definition.

Once definitional ambiguities and charges of triviality along with them have been replaced by the comprehensive definition, the focus may be turned on the allegation of falsity, which relies on the conception that past objects cannot function as truthmakers in presentism. This allegation was resolved in §6.6. In sum, the trivial-or-false argument turned out as a *charge against ambiguous definitions* or *charge against non-present truthmakers* -argument.

6.9 Summary

OBC was built by defining various concepts in terms of EUO: proposition; true proposition; correspondence; truthbearer; truthmaker. The coherence theory of truth is alone empirically insufficient and incompatible with OBC, but its applicable ingredients were incorporated in OBC by the coherence theorem of correspondence truths. The pragmatic theory of truth alone is empirically insufficient and incompatible with OBC, but its applicable ingredients were incorporated by a classification of useful beliefs in terms of OBC. The non-descriptivist views were shown to be compatible with OBC.

Facts and states of affairs can be applied as truthmakers in a correspondence theory if these are objects or their properties, but they do not provide special advantages with respect to objects. If facts are true ideas, then fact-based correspondence does not work as such, but can be translated into deduction based on known truths that works in the context of OBC. Deflationism, the identity theory and primitivism are not even intended as empirically sufficient theories of truth, and their correct roles are best understood by first accepting OBC as the primary theory of truth. Thereby, the deflationist theories could be seen as schemes of classifying what is supposed to be true in an arbitrary context, disregarding whether it is true or false in OBC. The only intelligible version of the identity theory —that does not make thoughts objects nor vice versa— is a version of deflationism, so it does not have to be analyzed separately. It is hard to find anything applicable from primitivism in the context of OBC, but it is a natural result of the culture of uneconomical pluralism: hands are raised in the air in the face of the unresolved allegations against the correspondence theory that *should* be taken as primary, and as a way out truthmaking properties are invented out of the air. In contrast, the way in which OBC resolves arguments targeted against the correspondence theory (or theories) speaks of the efficiency of the method of economical unification.

(i) The argument that correspondence leads into skepticism about the external world does not have force as OBC is defined in terms of EUO where ontological realism especially postulates the external world, and where an empirically sufficient version of solipsism is at best practically equivalent with ontological realism. This reminds of the clarifying nature of the method, where the solipsism-realism debate is on level of ontology, not on the level of applications.
(ii) The argument that the correspondence relation is mysterious resulted from confusing it with a relation of influence such as gravitation.
(iii) The question of how correspondence is accounted for in a scientific framework and

Putnam's queries about assertability were answered: (a) there are no viable alternatives to accepting that perceptions yield verified beliefs which correspond; (b) scientific theories are built to explain verified beliefs and to give verifiable predictions; (c) there are no viable alternatives to accepting that the verified predictions of theories correspond; (d) the correspondence of metaphysical postulates of theories cannot be verified, but they are taken in account when evaluating competing theories by economy; (e) there are no economical reasons to deny that the only possible ideal theory is true.
(iv) The slingshot argument only reminds that parts of the Universe and all parts of a single temporal stage of the Universe are causally connected, and that all parts are not relevant truthmakers when a proposition is pointed at a tiny part.
(v) The abundancy argument shows that leaving temporal mappings open leads into confusions, whereas unambiguous conceptions of time and possibility and the notion that truthbearing ideas are properties of objects which are realized at certain locations at certain times resolve confusions.
(vi) The allegations about past and future truthmakers and cross-time relations resulted from not taking presentism seriously and from trying to impose a truthmaking principle that does not fit with presentism. These allegations were exhausted by formulating a truthmaking principle which is compatible with presentism. That the past and the present function as truthmakers also for propositions targeted at the future reminds that OBC and the given theory of modalities overlap and complement one another.
(vii) The funny fact arguments result from formulating propositions ambiguously and then maintaining that this requires funny facts, whereas plain common sense requires that a meaningful proposition must be formulated in a way that it can be understood, and then its truth conditions can be investigated. Propositions that are involved with counterfactuals and conditionals also remind that OBC is inseparable from the given theory of modalities.

OBC can be justifiably called a unified theory of truth. It was built by defining mutually compatible concepts in terms of an economically unified ontology; it is empirically sufficient, unambiguous and easily understandable; it incorporates applicable ingredients of other theories of truth; it manages to resolve the central arguments targeted against it. Compare the unified approach to the current situation in the field. According to the *PhilPapers* survey, when 1803 philosophy faculty members and/or PhDs were given three options —correspondence, deflationary, epistemic— 48.9% accept or lean toward correspondence, 23.0% accept or lean toward deflationary, and 10.9% accept or lean toward epistemic. If progress is the goal, then the most promising path is the switch from competing theories into a unified theory that in any case does all jobs of the previously competing theories. This saves from unnecessary controversy that results from dealing with theories that are thought to compete when in reality they do not, and this enables investing more time and efforts on advanced topics.

7 Definition: Modalities

This section complements the unified theory by *modalities*: an unambiguous modal proposition states that it is *possible, contingent, necessary* or *impossible* from the aspect of one time that an object has certain properties at a target time. The general form of a modal proposition can be represented accordingly as $(\alpha, O, \tau)=M$, where α is the aspect time, τ is the target time, O is the object with certain properties at target time τ, and M is a modality. Von Wright's [418] equivalent notation $M_\alpha O_\tau$ is used whenever it is more convenient. The modal proposition "it is possible from the aspect of time α that object O will be realized at time τ" is thus written either as (α, O, τ)=possible, or as $\text{possible}_\alpha O_\tau$. Modalities defined in terms of aspect and target times are called *diachronic modalities*.[101]

The scope is on propositions which have a genuine importance in the contexts of natural science and typical human social behaviour. In the most typical assessments the goal is to guess correctly from the aspect of the present time what will happen at some more or less specific time in the future and what happened during some period of time in the past. Among typical assessments about the future are assessments about the weather, the outcome of a war, the outcome of political elections, etc. Among typical assessments about the past are assessments about what some person or people did in the past and more generally about how the present came about. Consider how the unified theory functions in the focal contexts.

First, modal proposition P is given with an arbitrary combination of α, O, τ, M. Second, the unified theory gives the knowledge of which temporal stages of the Universe (TSUs) qualify as the truthmakers/falsemakers of P. For instance, suppose that it is deduced based on the unified theory that the truthmaker/falsemaker of P was realized on January in the year 2016. This is where the application of the unified theory ends and where epistemology takes over. It is asked which objects in January 2016 *seem* to be probable candidates of being the truthmakers/falsemakers of P. After this empirical inquiry takes over: the present is investigated in order to find traces of the events that took place in January 2016, which would verify or falsify P.

The other primary function of the unified theory is to serve as a nexus which unifies different aspects to the topic of modality. As always, these aspects are incorporated in the unified theory by definitions in terms of EUO. It will be shown that the unified theory is sufficient for dealing with contemplations about counterfactuals, fictions, logical possibilities and epistemic possibilities, and that it can be seen as an application of possible worlds semantics in the context of presentism and the causality axiom. The causal structure of the Universe has been applied as a foundation of a theory of modalities by Briggs and Forbes [59, ch. 1], McCall [255, chs. 4-5, pp. 88-92] and Belnap [46]. This section complements their work and suggest presentism as a simpler foundation.

7.1 Deducing Truthmakers of Modal Propositions

In EUO the Universe is a single non-branching sequence of temporal stages (TSUs) which are in a forward directed temporal and causal succession. The past TSUs have been realized in the past, the present TSU is realized now, and future TSUs will be realized

[101] According to Knuuttila [205], diachronic modality is "the model of antecedent necessities and possibilities with respect to a certain moment of time." See also Knuuttila [203]. See Von Wright's definition of the diachronic-synchronic dichotomy in p. 166.

one at a time. This portion of EUO suffices in giving an account of the truthmaker TSUs of a modal proposition with an arbitrary combination of aspect and target times. Table A represents nine combinations which are the nine (α, τ) pairs where $\alpha, \tau \in \{$past, present, future$\}$. The deduction of the truthmakers is started from the most common propositions (1-3). After this the general rule of deducing the truthmaker for all combinations (1-9) is presented.

	aspect time α	**target time** τ
1.	present	past
2.	present	present
3.	present	future
4.	past	past
5.	past	present
6.	past	future
7.	future	past
8.	future	present
9.	future	future

Table A: 9 combinations of aspect and target times.

1. ASPECT=PRESENT; TARGET=FUTURE. In perhaps the most common modal propositions the aspect time is the present and the target time is in the future. Consider the first example: *It is possible from the aspect of the present time that it will rain tomorrow in Helsinki*. In this proposition the aspect time is the present time p, the target time is f tomorrow, O=*it rains in Helsinki* and M=*possible*. The proposition can be represented as (p, O, f)=*possible*. If the proposition is true what is its truthmaker, and if it is false what is its falsemaker? The answer is: TSU p. For, in EUO the TSUs are in a forward directed temporal and causal succession, and therefore TSU p is the cause of the TSUs that come after it, i.e., TSU p determines[102] which TSUs are *realizable* in the future. Realizability in the future is equivalent with future possibility. For instance, the present TSU p determines which TSUs are realizable at time $p+1$: those TSUs which are realizable at $p+1$ from the aspect of p are possible at $p+1$ from the aspect of p.

In the following, when $p \leq f$, $\{p \to f\}$ denotes the collection which contains all TSUs that are realizable at the target time f from the aspect of p. The truth value of (p, O, f)=*possible* is determined by $\{p \to f\}$. If the proposition is true, then O corresponds to at least one element of $\{p \to f\}$. If the proposition is false, then O corresponds to no element of $\{p \to f\}$. Note that the expression 'O corresponds to an element of $\{p \to f\}$' is a figure of speech which means that the proposition (p, O, f)=*possible* corresponds to TSU p, for p determines the contents of $\{p \to f\}$, i.e., p is the genuine truthmaker of the proposition. Consider (p, O, f)=M with each modality M.

POSSIBILITY: (p, O, f)=*possible* is true if and only if O corresponds to at least one element of $\{p \to f\}$; (p, O, f)=*possible* is false if and only if O corresponds to no element of $\{p \to f\}$.
NECESSITY: (p, O, f)=*necessary* is true if and only if O corresponds to all elements of $\{p \to f\}$; (p, O, f)=*necessary* is false if and only if there is at least one element in $\{p \to f\}$ to which O does not correspond.
IMPOSSIBILITY: (p, O, f)=*impossible* is true if and only if O corresponds to no element of $\{p \to f\}$; (p, O, f)=*impossible* is false if and only if there is at least one element in $\{p \to f\}$ to which O corresponds.

[102]The meaning of 'determines' is further qualified in §7.2: TSU p determines the future disregarding if total determinism or partial determinism holds.

CONTINGENCY: $(p,\ O,\ f)$=*contingent* is true if and only if O corresponds to one or more but not to all elements of $\{p \to f\}$; $(p,\ O,\ f)$=*contingent* is false if and only if O corresponds either to all elements of $\{p \to f\}$ or to no element of $\{p \to f\}$.

The above scenario is shown to be an application of *possible worlds semantics* in §7.5, and it is compatible with how Divers [110, pp. 3-4] interrelates modalities:

POSSIBILITY rules out impossibility, allows contingency and necessity.
NECESSITY requires possibility, rules out impossibility and contingency.
IMPOSSIBILITY rules out possibility, necessity and contingency.
CONTINGENCY requires possibility, rules out impossibility and necessity.

Although the truthmaker/falsemaker is known to be p, truth values of modal proposition about the future are often strictly speaking not known, even when it seems to be extremely probable that they are true, for often we cannot predict with *absolute certainty* that these are true.

2. & 3. ASPECT=PRESENT; TARGET=PAST OR PRESENT. In EUO, the past has already been realized in exactly one way: the past is not realizable any longer and cannot be influenced from the present. Both of the following propositions are equivalent with the proposition that X *was realized* in the past at time $p-1$: X was possibly realized in the past at time $p-1$ from the aspect of the present p; X was necessarily realized in the past at time $p-1$ from the aspect of the present p. Also the present is necessarily realized from the aspect of the present, i.e., the past *was* and the present *is* necessarily realized from the aspect of the present.[103] Consider the proposition S=*It is possible today that it rained in Helsinki in 1100*, which can be represented as (p, It rains in Helsinki, 1100)=*possible*, and where 1100 denotes an instantial moment in the year 1100. As the past has already been realized, the collection $\{p \to 1100\}$ contains exactly one TSU, 1100, which is the truthmaker/falsemaker of S. If S is true, then it did rain in Helsinki in 1100, and also (p, It rains in Helsinki, 1100)=*necessary* is true. If it did not rain in Helsinki in 1100, then S is false, whereas (p, It rains in Helsinki, 1100)=*impossible* is true. In this sense nothing about the actual past is contingent.[104] Propositions whose aspect and target times are both present are equivalent with propositions whose aspect time is the present and target time is the past, with the exception that the present *is real* while the past *was real*: that object Y is possibly realized at p from the aspect of p is equivalent with that Y is necessarily realized at p from the aspect of p.

In sum, when the aspect time is the present p and the target time $\tau \leq p$, it follows that $\{p \to \tau\}$ contains exactly one TSU. When $p = \tau$, the collection $\{p \to \tau\}$ contains exactly

[103]That past existence is necessary from the present aspect is characterized by Rice [333]: "Is what is true of the past necessary? Well certainly pretty well everyone thinks that what happened in the past cannot be undone. The past cannot now be altered." But, given partial determinism, the present and the past could have been differently (§7.3). Aristotle's notion that the present is necessary (*On Interpretation*, 19a23-7) is congenial with the presentist-diachronic view of possibility, and this does not require total determinism. For, although the present exists necessarily from the present aspect p, this does not entail that p could not have been different from the aspect of a time before p. Compare to Knuuttila [205]: "Another interpretation is that Aristotle wanted to show that the necessity of an event at a certain time does not imply that it would have been antecedently necessary." The necessity of the past reflects step (1) of the *Master Argument* of Diodorus Cronus, whereas step (3) reflects partial determinism as will be revealed in §7.2: (1) every past truth must be necessary; (2) an impossibility does not follow from a possibility; (3) something is possible which neither is nor will be true. (2) can be interpreted in may ways; see Akama et al. [6] for different guesses of what it may mean.

[104]Again, in the context of partial determinism some propositions of the form *something that was not realized in the past could have been realized in the past* are true as they do not concern the actual past, whereas in the context of total determinism all such propositions are false (§7.3).

one TSU τ which *is realized*. When $p > \tau$, the collection $\{p \rightarrow \tau\}$ contains exactly one TSU τ which *was realized*. Consider the two cases with all modalities:

POSSIBILITY: $(p, O, \tau \leq p)$=*possible* is true if and only if O corresponds to at least one element of $\{p \rightarrow \tau \leq p\}$, i.e., to its only element.
NECESSITY: $(p, O, \tau \leq p)$=*necessary* is true if and only if O corresponds to all elements of $\{p \rightarrow \tau \leq p\}$, i.e., to its only element.
IMPOSSIBILITY: $(p, O, \tau \leq p)$=*impossible* is true if and only if O does not corresponds to the single element of $\{p \rightarrow \tau \leq p\}$.
CONTINGENCY: $(p, O, \tau \leq p)$=*contingent* is true if and only if O corresponds to one or more but not to all elements of $\{p \rightarrow \tau \leq p\}$, i.e., it is never true.

CASES 1. - 9. The classification gets slightly more complex. As in combination 4 α and τ are both in the past and as in 9 α and τ are both in the future, there are three sub-combinations in both cases: $\alpha > \tau$; $\alpha = \tau$; $\alpha < \tau$. These combinations are written out in table B, as well as the TSUs which are the truthmakers of the propositions. When partial determinism is supposed, the truth value of some propositions is indeterminate and therefore we are dealing with indeterminate-makers as well as with truthmakers and falsemakers. Accordingly, the term *truth-value-maker* is used in the remainder of this section. The general rule is straightforward: the truth-value-maker is always the earliest of α, τ, p. This reminds that in presentism the present is always the ultimate viewpoint.

	past	**present**	**future**	**truth-value-maker**
1.	τ	α		τ
2.		$\alpha = \tau$		$\alpha = \tau = p$
3.		α	τ	$\alpha = p$
4.1	$\alpha < \tau$			α
4.2	$\alpha = \tau$			$\alpha = \tau$
4.3	$\tau < \alpha$			τ
5.	α	τ		α
6.	α		τ	α
7.	τ		α	τ
8.		τ	α	$\tau = p$
9.1			$\alpha < \tau$	p
9.2			$\alpha = \tau$	p
9.3			$\tau < \alpha$	p

Table B: 13 combinations of aspect and target times and truth-value-makers.

In cases 1, 2, 4.2, 4.3, 7 and 8 the target time τ is the earliest and it has been realized; as these propositions state that a part of TSU τ has certain properties, τ determines their truth values and is thus their truth-value-maker.

In cases 2, 3, 4.1, 4.2, 5 and 6 the aspect time α is the earliest and it has been realized; as these propositions state that TSU α has certain properties —that it makes or made this and that necessary, contingent or impossible— α determines their truth values and is thus their truth-value-maker.

In cases 2, 3, 8, 9.1, 9.2 and 9.3 p is the earliest and it *is* realized; as these propositions state that TSU p has certain properties —that it makes or made this and that necessary, contingent or impossible— p determines their truth values and is thus their truth-value-maker.

In sum, EUO implies which TSU is the truth-value-maker of all 13 types of propositions, including propositions whose truth value is indeterminate. In some of the cases $\tau = \alpha$,

in some cases $\tau = p$, in some cases $\alpha = p$ and in one case $\alpha = \tau = p$, but the general rule stands.

7.2 Partial and Total Determinism. Diachronic vs. Synchronic Modalities

The mutually exclusive versions of determinism are qualifications of the causality axiom which states that the TSUs are in a forward directed causal succession, i.e., qualifications of how the present p determines what is realizable at $p+1$, $p+2$, $p+3$, and so on. Total determinism is depicted on the top of figure 20 and partial determinism on the bottom.[105] (The dichotomy of 'total determinism' and 'partial determinism' is applied instead of e.g. the dichotomy of 'determinism' and 'indeterminism' because the total-partial dichotomy characterises the intended meanings very well: in both cases the present clearly affects the future in *some degree* and therefore the term 'indeterminism' would be misleading.)

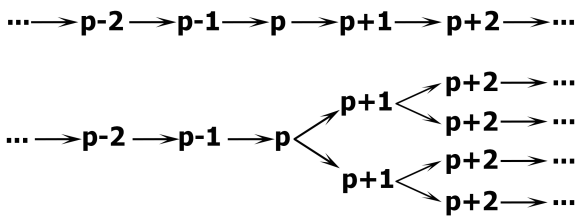

Figure 20: Total determinism on the top and partial determinism on the bottom.

FUTURE IN TOTAL DETERMINISM:[106] the present TSU p totally determines the unique TSU which will be realized at $p+1$. As $p+1$ totally determines $p+2$, as $p+2$ totally determines $p+3$, and so forth, it follows that p totally determines all TSUs that will be realized after p. In total determinism, if TSU x is possibly realized at $p+1$ from the aspect of p, x is necessarily realized at $p+1$. Accordingly, if it is possible that TSU x is not realized at $p+1$ from the aspect of p, then it is necessary that x is not realized at $p+1$, i.e., it is impossible that x is realized at $p+1$. This means that in total determinism no future possibility is contingent. The future time x can be equated with the TSU that *will be* realized at time x, and the period of time $[p+1\ x]$ can be equated with the sequence $p+1, p+2, \ldots, x$ of TSUs which *will be* realized in the future. In total determinism, the past and the future are equally determined.

FUTURE IN PARTIAL DETERMINISM: the present TSU p determines totally the *collection* of all TSUs which are realizable at $p+1$. This collection is denoted as $\{p \to p+1\}$. Similarly for later times: p determines totally the collection $\{p \to p{+}2\}$ of all TSUs which are realizable at $p+2$, i.e., p determines all realizable *chains* or unbroken sequences of causally connected TSUs which start from p. While the elements of $\{p \to p{+}2\}$ are single TSUs which are realizable at $p+2$ from the aspect of p, a separate notation for sequences

[105]Both options are contemplated because it turned out difficult to make a selection between them by economy. Although total determinism clashes with genuine free will (Honderich [172]), e.g. Wegner [409] notes that free will might be just an illusion, and this would be compatible with total determinism. On one hand, partial determinism does not require that the experience of free will is an illusion, but on the other hand partial determinism is more complex than total.

[106]Total determinism is analogous to *causal determinism* or "the idea that every event is necessitated by antecedent events and conditions together with the laws of nature" (Hoefer [171]) and it is compatible with the definitions of e.g. James [183], Thomason [395] and Moya [280, p. 130].

is sometimes handy: $\{[p \to p{+}2]\}$ contains all chains of TSUs which are realizable at $p{+}2$ from the aspect of p. As in partial determinism it is not determined at the present which TSUs will be realized in the future, the future time x can be equated with the collection $\{p \to x\}$. The period of time $[p\ x]$ can be equated with the collection of sequences $\{[p \to x]\}$. In partial determinism it is necessary that *some* element of $\{p \to p+1\}$ will be realized at time $p+1$ and in this sense the future is necessary, but no individual element of $\{p \to p+1\}$ is necessarily realized at time $p+1$.[107] Partial determinism thus allows future contingents (§7.3). If the Universe is partially deterministic, then future possibilities branch. Naturalism implies that the Universe does not branch: only possibilities do, and only if partial determinism holds.[108] Kripke's illustration in figure 21 and his explanation are compatible with diachronic modalities in EUO:

> The point 0 (or origin) is the present, and the points 1, 2, and 3 (of rank 2) are the possibilities for the next moment. If the point 1 actually does come to pass, 4, 5, and 6 are its possible successors, and so on. The whole tree then represents the entire set of possibilities for present and future; and every point determines a subtree consisting of its own present and future. Letter from Saul Kripke to A.N. Prior, dated September 3, 1958, kept in the Prior Collection at Bodleian Library, Oxford, Box 4. As quoted in Øoslash and Hasle [299]

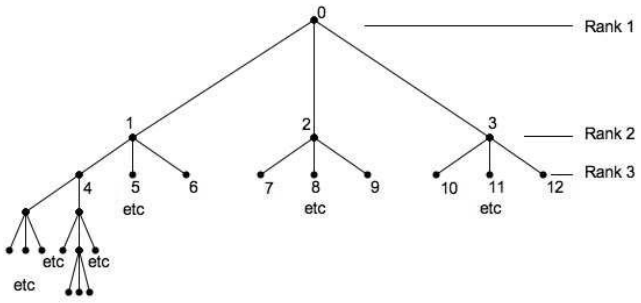

Figure 21: Kripke's illustration of partial determinism.

ASYMPTOTICAL DETERMINISM. In asymptotical determinism, the realization of a particular at time t implies that a particular which is an element of a more or less homogeneous collection of realizable particulars, will be realized at some more or less specific time after t. Earman commits to partial determinism:

> A feature can be said to be asymptotically fated if it emerges in the limit as time goes on far enough. ... I take it, for instance, that the laws of biology dictate that I am naturalistically fated to die; but I also take it that the particular time and manner of my death are not fated by any of the laws of nature. Earman [117, p. 18]

For comparison, Aristotle's (*Metaphysics* 1027b10-14) statement "it is necessary that he who lives shall one day die" is alone compatible with both partial and total determinism, but it is seen that Aristotle presupposes partial determinism as he states: "But whether he dies by disease or by violence, is not yet determined, but depends on the happening of something else."

[107] Another interrelated approach to future necessity is that that what is from the aspect of p necessarily realized at $p+1$ is what is common to every element of $\{p \to p+1\}$.

[108] It is crucial to understand the difference of partial determinism in EUO which directly entails that only future possibilities branch and e.g. Belnap's [46] *branching space-time* theory where the branching of possibilities means that all branches literally exist in some substantive sense (§7.4).

DIACHRONIC VS. SYNCHRONIC MODALITIES. Von Wright's [419, p. 92-3] characterisations of diachronic modalities are largely compatible with the unified theory, such as: "By a set of possible histories up to t we shall mean all the alternative ways in which the world from its actual state at time t' in the past might have developed up to time t." Von Wright uses the diachronic-synchronic dichotomy as follows:

> I shall say that $\ll M_t p_t \gg$ expresses a *synchronic* modality meaning that the attribution of modal status is for the same time as the possible truth of the proposition to which the modal status is attributed. And I shall say that $\ll M_{t'} p_t \gg$ in the formula expresses *diachronic* modality because of the temporal difference between the asserted validity of the attribution of the modal status and the possible truth of the proposition whose modal status is involved. Von Wright [418, p. 43]

In the context of the unified theory, the synchronic-diachronic dichotomy is not ontological nor logical: in a synchronic modal statement the statement and target times are the same, whereas in a diachronic modal statement they are different, but the logic and ontology of both types of statements is the same. In contrast, Von Wright [418] is dealing with two different logical systems, and he does not give clear ontological groundings for neither. Modalities in the below equations are complemented as follows in order to distinguish Von Wright's definitions (1-3) from those of the unified theory:

S: Von Wright's synchronic expression.
SU: synchronic expression in the unified theory.
D: diachronic expression.

(1) S.$possible_t O_t = \exists t' < t(\text{D}.possible_{t'} O_t)$.
(1') SU.$possible_t O_t = O_t \& \exists t' < t(\text{D}.possible_{t'} O_t)$.

In (1), it is S.possible at t that O is realized at t, if and only if (iff) some time before t it was D.possible that O will be realized at t. (1) does not fully capture the meaning of (1'). It must be added that O was or is or will be realized at t. When t is the present, O is realized now. When t is in the past, O was realized in the past. When t is in the future, O will be realized in the future, i.e., if (1') is true and t is in the future, then D.$possible_t O_t = O_t \& \text{D}.necessary_{t'<t} O_t$.

(2) S.$strongly\_necessary_t O_t = \forall t' < t(\text{D}.necessary_{t'} O_t)$.
(2') SU.$necessary_t O_t = O_t \& \exists t' < t(\text{D}.possible_{t'} O_t)$.

In (2), O is realized S.strongly-necessarily at t, iff at all times $t' < t$ it was D.necessary that O will be realized at t. (2) is incompatible with (2'), where SU.$necessary_t O_t$ is equivalent with SU.$possible_t O_t$, i.e., as in (1').

(3) S.$weakly\_necessary_t O_t = \exists t' < t(\text{D}.necessary_{t'} O_t)$.
(3') SU.$necessary_t O_t = O_t \& \exists t' < t(\text{D}.possible_{t'} O_t)$.

In (3), O is realized S.weakly-necessarily at t, iff there exists at least one time $t' < t$ when it is D.necessary that O will be realized at t. (3) is incompatible with (3'), where SU.$necessary_t O_t$ is equivalent with SU.$possible_t O_t$, i.e., as in (1'-2').

Von Wright (*ibid.* pp. 46-8) concludes that the logic of his synchronic modalities is S5 and that of diachronic modalities is S4 or S4-like. The unified theory is compatible with the reduction formula of S4 but not with that of S5, where $t1 < t2 < t3$.

S4 reduction: D.$possible_{t1}$D.$possible_{t2} O_{t3} \rightarrow$ D.$possible_{t1} O_{t3}$
S5 reduction: D.$possible_{t1}$D.$impossible_{t2} O_{t3} \rightarrow$ D.$impossible_{t2} O_{t3}$

The reduction formula of S4 holds in the unified theory, for if D.$possible_{t2}O_{t3}$ is true, then D.$possible_{t1}O_{t3}$ is true for all times $t1 < t2$. The reduction formula of S5 does not hold in the unified theory, for the truth of D.$possible_{t1}$D.$impossible_{t2}O_{t3}$ does not imply that D.$impossible_{t2}O_{t3}$ is true.

7.3 Future Contingents, Counterfactuals, Conditionals, Probabilities

FUTURE CONTINGENTS. The fusion of EUO and partial determinism implies that various propositions of the form (present p, O, future)=*contingent* are true. Consider the propositions:

Q: (p, It rains in Helsinki, tomorrow)=*contingent*
X1: It will rain tomorrow in Helsinki; (p, It rains in Helsinki, tomorrow)[109]

Suppose that Q is true. In this case, X1 is not true nor false at the present. Likewise, its negation 'It will not rain tomorrow in Helsinki' is not true nor false at the present. Briggs and Forbes arrive at the same conclusion:

> Exactly one day into the future, there will be a sea battle. ... Sometimes, the past, the present, and the laws of nature are not enough to settle whether there will be a sea battle one day into the future. ... If something is not settled by the past, the present, and the laws of nature, then it is not settled. Where nothing in the world settles whether a sentence is true or false, that sentence must not have a truth value—there is no truth without some sort of truthmaking. Briggs and Forbes [59, ch. 2]

The *principle of bivalence* (BI) and the *law of the excluded middle* (LEM) do not hold for propositions such as X1 in EUO. According to BI every declarative sentence expressing a proposition has exactly one truth value, either true or false. If partial determinism holds, BI does not hold for propositions such as X1 and its negation. According to LEM, for any proposition, either that proposition is true, or its negation is true. If partial determinism holds, LEM does not hold for propositions such as X1 for X1 is not true and its negation is not true. But this does not mean that the law of non-contradiction is violated: whatever is ever realized is realized in exactly one way, but partial determinism entails that it is partially open what will be realized at some future time. In sum, the violation of LEM and BI is only another way of formulating the commitment to partial determinism in the context of EUO. According to Øoslash and Hasle [299], Jan Lukasiewicz advocated rejection of the principle of bivalence in discussing the topic already in 1920's and that such interpretation had been formulated already by the Epicureans. Knuuttila [204] reveals that the topic has been discussed since the age of Aristotle.

There are many approaches future contingents. Akama et al. [5, pp. 1,3] classify three approaches: (1) the paraconsistent approach where a proposition may be both true and false; (2) the partial approach with the truth value 'indeterminate' and which is subdivided in (2.1) partial semantics and (2.2) partial tense logic which "is based on some partial logic like three-valued logic." E.g. Ciuni and Proietti [87] explore a paraconsistent approach where "statements about the future do not lack truth-value, but may

[109] A modality was not written out in X1, but it can be translated into a form where the modality is written out, the meaning preserved, such as X2: ($\alpha \geq \tau$, It rains in Helsinki, tomorrow τ)=*possible*, or X3: ($\alpha \geq \tau$, It rains in Helsinki, tomorrow τ)=*necessary*. X1-3 have exactly the same meaning *when these are analyzed from the aspect of the present* $p < \tau$: they all propose that it will rain in Helsinki at τ, and therefore they propose that this is possible at p, but they leave open whether this is contingent or necessary at p.

instead be glutty, that is both true and false." Briggs and Forbes [59] evaluate three approaches: a *supervaluationist* approach which belongs to class (2.1); an approach inspired by Lukasiewicz's three-valued logic and an intuitionist approach which both belong to class (2.2). Any unambiguous mapping of logic or semantics to EUO can be applied, but the partial tense logic approach with three-valued logic is very straightforward.

COUNTERFACTUALS. As in EUO objects are all that ever exist, a counterfactual is not an object. Instead, a proposition of the form 'X is not realized at time τ' is equivalent with the proposition 'X is a counterfactual at time τ.' 'Counterfactual' has thereby been defined in terms of EUO. If counterfactuals are figuratively used as truthmakers of propositions of the form *something that was not realized at time τ could have been realized at τ*, this means that something which actually was realized is the genuine truthmaker. Consider six[110] examples of propositions whose surface structures are involved with counterfactuals. In all examples the times are related as $\alpha <$ present $p \leq \tau$.

(i) X does not exist at p but X was realizable at p from the aspect of α. If (i) is true, then X is not a part of TSU p, but is a part of at least one element of $\{\alpha \rightarrow p\}$. α is thus the truthmaker/falsemaker of (i). In examples (ii-iv) it is supposed that (i) is true.

(ii): (i) & if X would have been realized at p, then Y would have been realized necessarily at τ. (ii) is true if and only if all elements of $\{\alpha \rightarrow p\}$ whose part X is, are such that they determine that Y will be necessarily realized at τ. α is the truthmaker/falsemaker of (ii).

(iii): (i) & if X would have been realized at p, then Y would have been realized at τ. (iii) is true if and only if all elements of $\{\alpha \rightarrow p\}$ whose part X is, are such that they determine that Y will be necessarily realized at τ. (iii) is false if and only if all elements of $\{\alpha \rightarrow p\}$ whose part X is, are such that they determine that it is impossible that Y will be realized at τ. Otherwise (iii) is indeterminate; this case with the truth value indeterminate is analogous to the above case with future contingents. In all cases, α is the truthmaker/falsemaker/indeterminate-maker of (iii).

(iv): (i) & if X would have been realized at p, then it would have been possible that Y will be realized at τ. (iv) is true if and only if all elements of $\{\alpha \rightarrow p\}$ whose part X is, are such that they determine that Y will be possibly realized at τ. (iv) is false if and only if all elements of $\{\alpha \rightarrow p\}$ whose part X is, are such that they determine that Y will not be realized at τ. Otherwise (iv) is indeterminate. α is thus the truthmaker/falsemaker/indeterminate-maker of (iv).

(v): X does not exist at p and X was not realizable at p from the aspect of α. (v) is true if and only if X is not a part of any element of $\{\alpha \rightarrow p\}$. If so, X is an impossible particular at p from the aspect of α. It is supposed in (vi) that (v) is true.

(vi): (v) & if X would have been realized at p, then Y would have been realized at τ. In this case the counterfactual analysis makes sense only as a fiction. For, asking *What if something which has not even been a possibility would have been realized in any case?* is not intelligible unless one contemplates about pure fictions. Useful fictions do not require transcendism (§7.6). If it is not known that X is an impossible particular, then the case can be analyzed similarly as case (iii).

CONDITIONAL PROPOSITIONS. Künne [210, p. 111-2] targets a funny-fact argument (§6.7) against object-based correspondence, calling this the *Procrustes Problem*. He takes a conditional proposition as an example: "(S) As it was rather cold, it may have

[110]Examples (ii-iv) are inspired by Lewis [221, p. 2]: if it were the case that X, then it would be the case that Y; if it were the case that X, then it might be the case that Y.

been snowing for many hours. Take any utterance of (S): which property could be said to be ascribed in this utterance to which object(s)?" The truthmakers of (S) can be explicated without difficulties when object-based correspondence is complemented with modalities and temporal mappings. It is supposed that (S) has the following meaning: 'it was' refers to some more or less specific location within some period of time [x y] from the past time x to the past or present time y, and this location-time is denoted as L; 'rather cold' means something below zero; 'it may have been snowing for many hours' means that from the aspect of time $x-1$ it is possible that it will snow for many hours in L. Given these assumptions, (S) may be translated into an unambiguous modal proposition which is stated at time $y \leq$ present and which is targeted at the interval [$x-1$ y]: the temperature was below zero in L *and* it was possible from the aspect of $x-1$ that it will snow for many hours in L. In other words, (S) can be translated as (A *and* B) where A='the temperature was below zero in L' and B='it was possible from the aspect of $x-1$ that it will snow for many hours in L.' If A is false then (S) is false. If A is true the attention may be turned to B, whose truthmaker/falsemaker is a part of the TSU which was realized at $x-1$. In sum, Künne's question about the truthmaker object has been answered: it is the fusion of the property *below zero* which belongs to L, and the property *makes snowing possible for several hours in L* which belongs to some part of TSU $x-1$.

PROBABILISTIC PROPOSITIONS. As all propositions, also probabilistic propositions can be targeted at the past, present or future, such as E whose aspect time is the present p and which is targeted at the future time f: E=*There is at least a 50% chance that Peter will be the president at* f. TSU p determines totally the collection $\{p \rightarrow f\}$ of all TSUs which are realizable at f from the aspect of p. E is true if and only if Peter is the president in 50% or more of the elements of $\{p \rightarrow f\}$; otherwise E is false. This straightforward probability mapping is basically the same as McCall's [255, chs. 4-5, pp. 88-92], except for the differences in EUO and McCall's *shrinking tree view* (§7.5).

7.4 EUO vs. Alternative Ontological Foundations for Diachronic Modalities

Four alternative naturalist ontological foundations of diachronic modalities are depicted in figure 22. These are fusions of different axiom for temporal existence with naturalism, partial determinism and forward directed temporal and causal succession.[111] It was concluded in §4.4 that presentism is the most economical axiom for temporal existence as such. The economy of EUO is revealed very clearly when coupling its competitors with partial determinism. The alternatives of presentism are reviewed from the newest to the oldest, where a newer alternative happens to be more economical than an older: the 2012 version of the *growing-block theory* by Briggs and Forbes [59]; the 1994 version of the moving spotlight theory by McCall [255] which he calls the *shrinking tree theory*; the 1992 version of eternalism by Belnap [46] which he calls the *branching space-time*.

BRIGGS AND FORBES' GROWING-BLOCK THEORY. The growing-block theory is the closest to presentism, as their only ontological difference is that in presentism the past does not exist while in the growing-block theory the past does exist. Briggs and Forbes [59, ch. 1.4] seem to presuppose partial determinism and they denote future possibilities

[111] None of the reviewed alternatives except EUO commit directly to absolute simultaneity and therefore they do not commit directly to causal succession of temporal stages of the Universe either, although they do commit to some versions of forward directed causal succession, as in all versions the earlier determines the later.

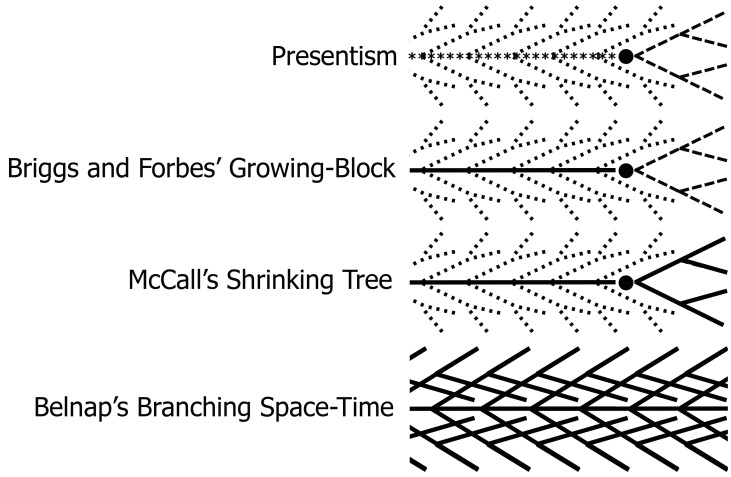

Figure 22: Theories of temporal existence coupled with partial determinism. The round dot represents the objective present which exists in all A-theories. The solid black lines represent what exists (in addition to the present). The dashed lines represent future possibilities. The dotted lines represent what have been possibilities from the aspect of a past time but which are not possibilities at the present. The starred line in presentism represents what was realized in the past but is not realized at the present.

as *feasible timelines*: "For all that the world determines, any feasible timeline might be actualized in the future, but the world does not determine which feasible timeline will be actualized in the future." They do not directly state that the past and the present *cause* the future, but as they do maintain that everything is settled by the past, the present and the laws of nature, this seems to be their background idea:

> But according to the Growing-Block theory, there is nothing but the past, the present, and the laws of nature. If something is not settled by the past, the present, and the laws of nature, then it is not settled. Where nothing in the world settles whether a sentence is true or false, that sentence must not have a truth value—there is no truth without some sort of truthmaking. ... There are (or could be) propositions about the future whose truth values are not settled by the past, the present, and the laws of nature. For Growing-Block theorists, this means that there are (or could be) propositions whose truth values are not settled at all. Briggs and Forbes [59, ch. 2]

Apart from the difference to presentism, Briggs and Forbes' growing-block theory looks very much like the unified theory of possibility. Briggs and Forbes do not defend the growing-block theory against the central arguments targeted against it, whereas presentism is defended exhaustively in this thesis. They do not give an account of the truthmakers with an arbitrary modal statement, i.e., the unified theory is worked out further also in the truthmaking sense, whereas they concentrate more on formalism and logic. It will be emphasised below how Briggs and Forbes take full advantage of the uneconomicality of McCall's version of the moving spotlight theory with respect to their growing-block theory, for this underlines that as much advantage can be taken out of the uneconomicality of the growing-block theory with respect to presentism.

McCall's shrinking-tree theory. McCall [255, 256] aims to characterize the ontology of the fusion of the Theory of Relativity —which entails eternalism (§5.6)— and the *many-worlds interpretation* of quantum mechanics where the Universe branches. McCall suggests a version of the moving spotlight theory, where the past, present and future

exist, where only one non-branching past exists, and an absolute and moving present exists. McCall thus couples an A-theory with the Theory of Relativity whereas Belnap (below) couples it with a B-theory.

Unlike in presentism and the growing-block theory, also the future possibilities exist in the shrinking-tree theory. The branching of the future starts from the present. The present is moving, and some branches cease to exist as the time goes forward: the top of the tree is shrinking in the sense that its branches are being cut off.[112] Briggs and Forbes attack McCall with Michael Tooley's arguments, who in turn defends Broad's [60] 1923 version of the growing-block theory against McCall's theory:

> McCall defines the present as the point at which branching occurs. So, unless there is branching, there is no absolute present. This rules out the possibility of there being only one feasible future, on McCall's view, which means, as Tooley points out, the shrinking-tree theory is incompatible with determinism. More than that, the Shrinking-Tree view cannot cope with a world which is deterministic for five minutes, since time could not pass for those five minutes, but rather would skip until the first branching-point. McCall's view rests on a strong claim, then: The laws of nature are, and always will be, indeterministic. Such assumptions should be avoided if we can do the same work without them. Briggs and Forbes [59, ch. 4.2]
>
> Broad's model of a dynamic world [the growing-block theory] seems preferable to McCall's, for at least two reasons. First, it allows one to make sense of the idea of dynamic worlds that are deterministic, and this seems desirable, since deterministic worlds can, no less than indeterministic ones, be worlds where states of affairs come into existence. Secondly, given that a world containing no future states of affairs at all is rather more austere than one that contains states of affairs corresponding to all future possibilities, Broad's model is also to be preferred on grounds of simplicity. Tooley [399, p. 239]

The shrinking-tree theory is compatible with partial determinism but has problems with total determinism, whereas the growing-block theory and presentism are compatible with both total and partial determinism and their mixtures. Again, the economy issue is taken very seriously by Briggs and Forbes:

> It is not just that McCall is committed to more than a Growing-Block theorist, but that McCall is committed to any number of as yet unborn children, who continually drop out of existence when they cease to become feasible. ... On the Growing-Block something comes into existence which rules out the possibility, whereas on the Shrinking-Tree the possibility literally ceases to exist. This lends the Shrinking-Tree a destructive air. It might seem as though we are all guilty of mass-murder for wiping all the possibilities that did exist out of the universe. ... it seems odd that we should treat our prize-winning first novels, which we have not yet thought of and may never write as being just as real as the first short-stories that we wrote at school. That is the sense in which it seems the Growing-Block is more austere than the Shrinking-Tree. ... The Growing-Block view does not need as much, ontologically, as the Shrinking-Tree. Briggs and Forbes [59, ch. 4.2]

If the allegations about mass-murder are viable, then so should be allegations against the growing-block theory such as that Briggs and Forbes are guilty of bringing eternal torture to the victims of the Holocaust. Your every head ache and sorrow is eternal, as the past exists. Although the growing-block theory is more economical than the shrinking-tree theory, it is still uneconomical with respect to presentism. On one hand, the growing block and the shrinking-tree theories fail to satisfy common-sense intuition where it is unintelligible that the past and/or future exist. On the other hand, 'common sense' is subjective and therefore an objective criterion is needed, which brings take case right back to economy.

[112] McCall's version where most of the previously existing branches cease to exist, differs from Deasy's [103, p. 2075] version with permanentism where "it is always the case that everything exists eternally."

A PROBLEM FOR GROWING-BLOCK AND SHRINKING-TREE THEORIES. Merricks maintains that the growing-block theory requires further metaphysical postulates and Sider maintains that the moving spotlight theory (and thus also the shrinking-tree theory) has the same problem:[113]

> For consider that you think "I am reading this paper at the present time." If 'the present time' refers to the growing edge of being, you ought to conclude that your own thought is false. After all, given growing block, once you have a thought, you continue to have that thought forever. That thought is on the growing edge of being for just the briefest moment and is thereafter and forever not on the growing edge. As a result, the probability that your thought is on the growing edge is vanishingly small. ... Happily, there is a ... reply that does not imply that each and every thought explicitly about the present is virtually always—and so almost certainly—false. This reply invokes the above distinction between the objective present and the subjective present. Growing blockers should say that Nero's thoughts like "I am sitting here at the present time" are always about the subjective present. Such thoughts can be true even though Nero is not at the growing edge of being. Similarly, growing blockers should also say that nearly all of everyone else's thoughts about "the present" are about the subjective present too. Merricks [269, p. 105]

> We believe that we exist in the present; indeed, we take ourselves to know this. But given the spotlight theory, there are ever so many people, with similar evidence to our own, who also think they are in the present but are wrong–they're wrong because the times at which they are located do not have monadic presentness. George Washington, for example, thinks in 1776 that 1776 is present; we think, here in 2011, that 2011 is present... ... And our evidence is no better than Washington's ... so it's hard to believe that we're more likely to be right than Washington. ... The spotlight theory leads to scepticism about whether we're in the present. Sider [359, p. 261]

In order to function properly the growing-block and moving spotlight theories require two conceptions of the present: subjective and objective. The 'subjective present' moments do not directly increase the metaphysical weights of these theories, for 'subjective present' is only a name for an existing non-present moment. However, the subjective present moments have counter-intuitive implications, despite Deasy's counter argument for the defence of the moving spotlight theory (which can be used also in defending the growing-block theory):

> [T]he following is true given the moving spotlight theory (remember that 'Presento' names the current instant): at some instant t in 1776, George Washington thinks that t is (absolutely) present, and at Presento, Dan thinks that Presento is (absolutely) present. Now, notice that there is no disagreement here: George Washington thinks *as of* t that t is present and I think *as of Presento* that Presento is present. Given that every instant is present relative to itself, as of our respective instants we are both right: t is indeed present at t and Presento is indeed present at Presento... as the argument relies on the premise that there is massive disagreement between individuals located at past, present, and future instants about which instant is present ... But as we have seen, there is no such disagreement, and therefore no argument against the moving spotlight theory. Deasy [103, pp. 2087-8]

Deasy maintains that there is no problem of disagreement, as a person in the past does not have to think that she is experiencing the objective present: she thinks that she is experiencing the objective present only *when* the moment she is experiencing happens to be the objective present. This does not change the fact that while a presentists can always rely that she is situated at the objective present, the growing-blockers and moving spotlighters can never know whether they reside under the objective or a subjective present. They must accept the following line of thought: "I experience change constantly,

[113] See also the argument of Bourne [55].

but this does not indicate whether I am at the objective or at a subjective present. I do not have to think that I am experiencing the objective present, for it suffices that I think that I experience the objective present only *when* the moment I am experiencing happens to be the objective present." In other words, the growing block and moving spotlight theories are A-theories where the objective present explains the passage of time, but they also have the subjective present moments, which result in the unwanted state where you can never know whether you are situated at the present moment.

Moreover, these theories also seem to require subjective *moving* present moments or something that does their jobs. For, people at all subjective present moments experience the passage of time similarly as people at the objective present, but the objective present explains only the experiences of people at the objective present. Therefore, e.g. subjective-moving-presents are needed in explaining the passage of time as the transition from one subjective present into another. In sum, the growing block and moving spotlight theories are A-theories where the objective present explains the passage of the objective present into another objective present, but the objective present does not explain most of the cases, i.e., all cases where people at a subjective present experience the passage of time. So, how should George Washington explain the change he is experiencing, and how should I? Some parameter is needed, which increases the weights of the growing block and moving spotlight theories.

BELNAP'S BRANCHING SPACE-TIME. Belnap's [46] branching space-time theory (BST) is a fusion of the Theory of Relativity and partial determinism. As the relativity principle entails eternalism where the past, the present and the future exist (§5.6), BST is the fusion of eternalism and partial determinism.[114] Let $\{[p \rightarrow]\}$ contain all chains of TSUs which are realizable in the future from the aspect of p. If BST is true, the reality which is the branching space-time B can be defined as $\{[-\infty \rightarrow]\}$ which is the limit[115] of the sequence of collections of timelines $\{[p \rightarrow]\}, \{[p-1 \rightarrow]\}, \{[p-2 \rightarrow]\}, \{[p-3 \rightarrow]\}, \ldots$, or equivalently a collection of point-events in predecessor-successor relations. According to Belnap (*ibid*, pp. 386-7) B consists of "those point events that either are now future possibilities or were future possibilities" and related by a causal order, which is equivalent to the definition of B as $\{[p \rightarrow]\}$. Although Belnap does not intend BST primarily as a foundation of diachronic modalities, he is constantly talking about possibilities, and the causal succession relation is their ontological ground.

As Belnap does not couple eternalism with an objectively existing present, all point-events in B are tenselessly real. BST is interpreted to be a version of naturalism. There are various timelines in B but they all seem to intersect at least on one point. To illustrate, given the point event p in Our World,[116] suppose that there are two possible futures, $p + 1_I$ and $p + 1_{II}$, which are thus both parts of B. These have a common predecessor p and may also have a common future successor $p + n$, and if so both $p + 1_I$ and $p + 1_{II}$ would belong to the history of $p + n$. Belnap (*ibid*, p. 392) makes it clear that events have many possible histories which are all parts of B. This allows that all timelines/worlds that branched in the past will eventually intersect. In any case, all parts of B can be interpreted to be causally connected at least by a common predecessor point event. This means that B is compatible with naturalism as the doctrine that all parts

[114]Belnap does not explicitly mention the commitment to eternalism, but as this follows from the relativity principle, there are no other alternatives.

[115]Belnap leaves open whether the Universe came into existence out of nothing and whether it will end or whether the past is infinite and the future potentially infinite, and so it is open whether $-\infty$ denotes finite or infinite past.

[116]Our World is "the set of point events that are 'in suitable external relations' to us" (Belnap [46, p. 387]).

of the Universe (B) are directly or indirectly causally connected and all that ever exists is a part of the Universe (B). However, BST contradicts EUO's Universe as a *single and non-branching* chain of causally connected TSUs. It also contradicts directly the causality axiom which states that the present TSU is all that exists and all its parts are causally connected at the present time. For, if there are several branches in B, then all that exists currently is not currently causally connected; on the other hand, the meaning of 'exists currently in another branch' is ambiguous.

For comparison to BST, Rietdijk [334] shows that the relativity principle implies eternalism, i.e., that events at different times are co-real, but concludes that this shows that the Universe is totally deterministic: if a seemingly future event is co-real with a seemingly present event, then the seeming present cannot affect the seeming future event which has already happened, and this can be made intelligible by supposing total determinism. Rietdijk does not note that total determinism is required as the explanation only if you reject versions of branching space-time; if you accept these, then eternalism can be coupled with partial determinism, resulting into BST or something like it. The rejection of branching space-time seems to be a hidden premise is Rietdijk's reasoning, for otherwise he could have come up with the following conclusion chain of reasoning.

(a) The relativity principle implies eternalism.
(b) Eternalism + partial determinism entails a branching space-time.
(c) Eternalism + total determinism does not entail a branching space-time.
(d) The relativity principle implies *either* total determinism or a branching space-time.

7.5 Lewis, Armstrong and Possible Worlds Semantics

In possible worlds semantics the modality of a proposition is defined in terms of the collection of all possible worlds:

A POSSIBLE PROPOSITION is true at least in one world.
A NECESSARY PROPOSITION is true in all worlds.
AN IMPOSSIBLE PROPOSITION is false in every world.
A CONTINGENT PROPOSITION is true in one or more worlds but not in all worlds.

In Kripke's [207, 208] version the collection of possible worlds itself is undefined and it is not given explicitly a metaphysical status. Kripke [208, p. 68-9] states that a "normal model structure ... is an ordered triple (G,K,R)" where K is an arbitrary non-empty set of possible worlds, G $\in$ K is the real world, and R is a reflexive relation defined on K. Kripke stays on the formal level, without grounding his semantics. Consider one way of grounding Kripke's semantics on EUO. The collection of possible worlds K is defined as $\{\alpha \rightarrow \tau\}$ where α is the aspect time and τ is the target time, i.e., 'the collection of possible worlds' is transformed into a collection of collections of possible temporal stages of the Universe (TSUs) where the contents of each collection is determined by the given values of α and τ and their relation to the present. The real world G may be defined either as the present TSU or as the Universe, where in presentism only the present TSU exists, the past TSUs did exist, and the future TSUs become into existence one at a time. The relation R is defined as the arrow in $\{\alpha \rightarrow \tau\}$ and its meaning depends on the temporal ordering of α, τ and the present, as classified in §7.1.

Hintikka [168, 169] developed semantics for modal logic based on *model sets*. According to Sowa [369, p. 324] "Hintikka's model sets could be considered descriptions of Kripke's worlds." Accordingly, a model set can be considered as a collection of all true propositions about a possible world. When grounded on EUO, the propositions in Hintikka's model

sets can be defined as true propositions about the elements of $\{\alpha \to \tau\}$. The model set which describes e.g. the present TSU contains propositions such as 'there are human beings living on Earth.'

TEMPORAL MAPPINGS AND ACCURACY. Consider assessments where the goal is to guess correctly from the aspect of the present time p what will happen in the future time f. In such considerations the goal is to guess correctly what is the content of the collection $\{p \to f\}$ which contains all TSUs that are realizable at the future time f from the aspect of the present p. This testifies very clearly that temporal mappings are indispensable: without these a theory of possibility is practically inapplicable in the focal contexts. Further, if the ontology with which the temporal mappings are coupled is excessive, the resulting theory of possibility may be inaccurate. To illustrate, consider the difference of the collection $\{p \to f\}$ in EUO, and the collection of all logically possible TSUs LP, which contains all non-contradictory TSUs. Anything over and above $\{p \to f\}$ is unrealizable at f from the aspect of p, and therefore excessive when all that is needed is $\{p \to f\}$. The excessive subset of LP may be called the collection of *merely* logically possible TSUs with respect to $\{p \to f\}$ (ML). ML contains all elements of LP which are not elements of $\{p \to f\}$: ML=LP$\backslash\{p \to f\}$. All elements of ML are unrealizable at f from the aspect of p and therefore excessive. The left side of figure 23 depicts the true and the false propositions which are stated at p and targeted at f. $\{p \to f\}$ on the right side is the truthmaker of the true propositions and the falsemaker of the false propositions. The correspondence arrow denotes correspondence of the true propositions. The idea

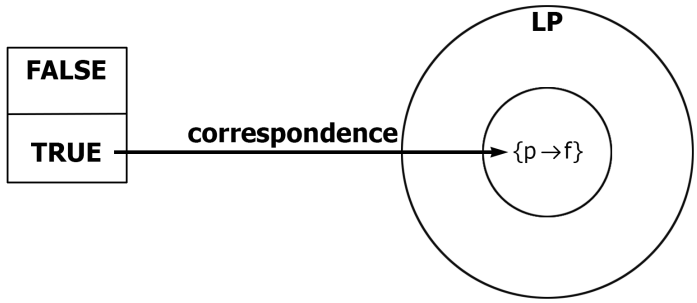

Figure 23: modal propositions where the aspect time is p and the target time is f.

that ML could function as a truthmaker of propositions which are targeted at f confuses thinking. For, if the elements of ML were truthmakers, these should be realizable at f from the aspect of p. As every realizable TSU is already an element of $\{p \to f\}$, the proponent of ML should replace naturalism e.g. by transcendism and maintain that in addition to the elements of $\{p \to f\}$, there are transcendent possible TSUs.

This is the reason why Lewis' modal realism was rejected in §4.9: because it is excessive and inaccurate if applied the ground. Lewis [221, pp. 84, 88] makes it clear that his intention is to give ontological foundations for modal notions such as that the actual world could have been differently and he maintains that "Realism about possible worlds is an attempt, the only successful I know of, to systematize these modal opinions." It has been widely noted that Lewis' ground for possible worlds semantics is outright uneconomical with respect to all naturalist alternatives: "the notion of 'all the possible worlds' is not the one we need in order to give an account of the physical possibilities of systems" (Armstrong [21, p. 68]); "Truth is supposed to be a relationship between a statement and the real world, not an infinite family of fictitious worlds" (Sowa [371]). As

logical possibility or modal realism is helplessly uneconomical and inaccurate in practical predictions or epistemic considerations, and as EUO is essentially more accurate, the principle of economy favours it in this sense, and thus LP and any version of transcendism such as modal realism can be rejected as the ontological foundation of a theory that is capable of handling temporally quantified modal propositions. On the other hand, the applicable ingredients of LP are incorporated in the unified theory in the sense that all elements of $\{p \to f\}$ are non-contradictory, which is guaranteed by the law of non-contradiction.

ARMSTRONG'S COMBINATORIAL THEORY OF POSSIBILITY. Armstrong [18, p. 3] explicitly commits to eternalism and naturalism, and in his version a 'possible world' is a complete eternalist spatio-temporal system. He rejects non-naturalist theories of possibility, Leibnizian and Lewisian (*ibid*, ch. 2) and notes (*ibid*, ch. 3) that the roots of his theory are in Wittgenstein's *Tractatus* 3.4, and that he aims to complement Skyrms' [365] *Tractarian Nominalism*. Armstrong (*ibid*, p. 2) defines modalities in terms of possible worlds:

POSSIBILITY: the actual world is a possible world; the other possible worlds, the merely possible worlds, are ways that the actual world might have been.
NECESSITY: a necessary truth is true in all possible worlds.
IMPOSSIBILITY: a necessary falsity is false in all possible worlds.
CONTINGENCY: a contingent truth is true in the actual world but false in some possible world; a contingent falsity is false in the actual world but true in some possible world.

In Armstrong's combinatorial theory of possibility, those possible worlds that are not the actual world, are conjunctions, contractions, transformations or recombinations of the elements of the actual world (*ibid*, pp. 47-9). Lycan [234, p. 4] characterises the other possible worlds as "combinatorial rearrangements of whatever are in fact the basic elements of our actual world." Again, Armstrong [27, p. 187] remains strictly in the domain of naturalism: "The actual world, and it alone, is genuinely a world. The possible is determined by the actual, and so, saving recombination, cannot outrun the actual." You may thus take anything that exists in the actual world —past, present, future— and multiply it, cut it in two halves or basically transform it in any way that is not contradictory nor does not violate the laws of nature, and you have a possible world. Armstrong constrains the collection of all combinatorially possible particulars by discluding particulars whose realization would directly violate the laws of nature:

> I like to focus on the difference between the sphere of gold that is a mile in diameter and a sphere of uranium of the same diameter. It is unlikely that the former will ever exist, but there seems no nomic impossibility involved. The laws of nature, if we know them, tell us that the second sphere is nomically impossible, or (if all fundamental laws are probabilistic only) near enough to nomically impossible. Armstrong [24, p. 174]

The possibility aspect of the unified theory was originally formulated by incorporating presentism and temporality in Armstrong's combinatorialism. However, once Armstrong's eternalism is changed into presentism, the theory changes essentially, and once temporality is added, the relevant sense of combinatorialism follows as a side product: all elements of $\{p \to f\}$ —where p is the present and f is in the future— are automatically combinatorial rearrangements of p; compatibility with the laws of nature is guaranteed as whatever that is realizable after p is automatically compatible with the laws of nature that hold in the TSUs in the sequence from p to f. Armstrong's combinatorial theory was not designed to function with specific temporal mappings. Therefore, it is a matter of guessing what he would have answered if he were presented the question of

what determines the contents of $\{p \rightarrow f\}$. Armstrong [18] talks about causality and causation but does not apply causality as the ground of possibilities. All Armstrong's theory of possibility says about the contents of $\{p \rightarrow f\}$ is that one of these is a temporal part of the actual world. Armstrong [18, p. 109] accepts temporal parts and maintains that their acceptance is natural for a combinatorialist. However, he does not entertain possible temporal parts in any way. Perhaps the merely possible temporal parts would be recombinations of the actual temporal parts? Again, this is a matter of guessing, but even one additional recombination in $\{p \rightarrow f\}$ would make the resulting theory inaccurate and uneconomical, for all these are unrealizable. The more extensively the temporal mappings are brought along, the more Armstrong's combinatorial theory would be moving towards one of the temporally quantified theories where past, present and future exist (§7.4).

Armstrong came half way through: he rejected Lewis' transcendism but did not incorporate temporal mappings. He was stuck to the discussion of possibility that circulated around possible worlds, as it still does, and only aimed to give a naturalist foundation for possible worlds. He was also affected by the relativistic-eternalist conception of time, that fits together with whole possible worlds with past, present and future existing tenselessly.

7.6 Fictionalist, Epistemic and Logical Considerations

It is shown that EUO is a sufficient background for whatever epistemic, fictionalist and logical considerations. Showing this is another way of naturalising Platonism (§4.9). The naturalisation can be done in two steps.

1. Let the collection P contain all particulars which are ever realized or realizable. P contains all temporal stages of the Universe (TSUs) which have been realized plus their proper parts, and all TSUs which have ever been realizable and all their proper parts.
2. Some elements of P have mental properties (§4.12). Let the set $\mathbb{A}$ contain all those particulars whose mental properties include a consciously experienced thought that is realized in the mind of a human being, where $\mathbb{A} \subset P$ holds.

Three equivalent examples are given of how $\mathbb{A}$ suffices. In all examples the basic idea is that as $\mathbb{A}$ contains all realizable thoughts, everything that is in principle conceivable is in $\mathbb{A}$, and as $\mathbb{A}$ is in P, EUO is a sufficient ontological background for whatever epistemic, fictionalist and logical considerations. In other words, conceivability is defined first in terms of EUO, and then used.[117]

QUANTIFYING OVER CONCEIVABLE LOGICAL POSSIBILITIES. When possibility is analyzed in terms of EUO, we are no longer talking about the collection of all logically possible worlds as if these were modal realist worlds, but we are instead talking about its naturalised 'mental' version which is in $\mathbb{A}$. $\mathbb{A}$ is sufficient for logical contemplations because it is sufficient for quantifying over *those* logical possibilities or over those elements of the Platonic heaven which are in principle ever needed. All ideas that will ever

[117]The given explication of conceivability seems to be needed. Fiocco [143, p. 388] notes that there is "no standard explication of conceivability." That conceivability is reduced to physical possibility is independent of the question of whether conceivability entails physical possibility in any other way: that x is conceivable does not have to entail that x is realizable in any other way. Chalmers [81] and Yablo [422] ask whether conceivability entails metaphysical possibility, but do not reduce conceivability to metaphysical possibility, which is in EUO physical possibility. Tidman [398] concludes that conceivability equals to what can be imagined, and that conceivability does not entail possibility, but does not reduce conceivability to physical possibility.

be thought of are in $\mathbb{A}$. Once you conceive x, it is known that x is and has always been in $\mathbb{A}$: if it is even possible to ever think about something, it is in $\mathbb{A}$. If you consider adding something in $\mathbb{A}$, it was already included before the addition: if you actually add something then you must think about what you add, and whatever thinkable is in $\mathbb{A}$. $\mathbb{A}$ resembles the *Library of Babel* (Borges [54]) and in some respects also Ehrlich's [122] *absolute arithmetic continuum*.

EPISTEMIC CONSIDERATIONS. To illustrate what it means that $\mathbb{A}$ is sufficient for epistemic considerations, suppose that all we know is that either particular a or b or c was realized in the past at time t in location l. In EUO exactly one of these was actually realized, but we do not know just which one. Therefore, we must quantify over the collection (a, b, c). As all these epistemic possibilities are conceivable, they are in $\mathbb{A}$. Armstrong's combinatorial theory of possibility (§7.5) finds application with epistemic possibilities in the sense that any intelligible a, b, c are combinatorially possible particulars, whereas it cannot always be guaranteed that all of them were possible in terms of the unified theory e.g. from the aspect of one day before t. The order is this: economy; EUO; possibility in terms of EUO; conceivability in terms of possibility; combinatorialism as the overall scheme of practical border conditions of epistemic guesses about what was, is, or will be realizable.

FICTIONS. Armstrong [18, pp. 49-50] calls for "an Actualist, one-world, account of fiction, and one that will accept both the merely possible and the impossible as fictions. I do not know in detail what account to give, but it would be truly surprising if no satisfying account were available." The unified theory of possibility qualifies as a naturalist account of fictions. Consider realizable fictions-as-fictions (FAFs). A realized FAF is an idea which is realized in the mind of a human being, such as a mental representation of the fictional world of Sherlock Holmes. As all FAFs are in $\mathbb{A}$, it is sufficient for quantifying over all realizable FAFs. $\mathbb{A}$ includes what Armstrong calls the merely possible as well as the impossible fictions. By 'impossible fiction' Armstrong means a FAF which does not correspond to any combinatorially possible world. By 'merely possible fiction' he means a fiction which corresponds to a combinatorially possible world but does not correspond to anything which is realized in the actual past, present or future. In sum, as all fictions are thoughts and all realizable thoughts are in $\mathbb{A}$, EUO is a sufficient ontological base for realizable fictions.

SUMMARY. If one wishes to apply something beyond $\mathbb{A}$ as the ontological base for fictions, logical possibilities, epistemic possibilities, any ideas, creative constructions, intentions to behave and the contents of the Platonic heaven, then one actually wishes quantify over something that is never in fact thought of and is never even in fact thinkable, because everything that is in principle thinkable has been a possibility at some time and all those possibilities are in $\mathbb{A}$.

7.7 Summary

The unified theory was complemented by defining modalities in terms of EUO, by grounding them on the causal structure of the Universe. It was shown how the truthmaker TSUs of modal propositions can be deduced, how counterfactuals and conditionals are handled in the unified theory, how the concept of probability can be defined in terms of EUO, pace McCall, and how the unified theory of possibility can be seen as a grounding of possible worlds semantics or 'possible TSUs semantics' on EUO. It was shown how the dichotomy of total and partial determinism fits in EUO and how the selection between these affects the resulting theory of possibility; e.g. future contingents follow from coupling EUO with

partial determinism. It was shown that EUO is a sufficient background for epistemic, fictionalist and logical considerations. Applicable ingredients of plain logical possibility are incorporated in the sense that the law of non-contradiction implies that a possibility is non-contradictory and in the sense that we can quantify over fictions and conceivable logical possibilities in the context of the unified theory. The unified theory incorporates the grounding of modalities on the causal structure of the Universe from the versions of Briggs-Forbes, McCall and Belnap, but replaces their past and future existents by present and past possibilities and by what has been realized. Applicable ingredients of Armstrong-Skyrms combinatorialism are incorporated in the sense that all possible TSUs are recombinations of some TSU that has been realized, and combinatorialism can be applied also in epistemic considerations. These remarks underline that we are dealing with a genuinely unified theory of modalities

The development of theories of modality in the 20th century fits in the overall development of analytical philosophy. (i) Metaphysics was rejected by the positivists in the 1920's and possibility was handled formally without ontological foundations e.g. by Kripke's possible worlds semantics and Hintikka's model sets in the 50's and 60's. (ii) Positivism was rejected by the 60's, and metaphysics made a comeback in the 60's and 70's. (iii) Lewis saw in the 70's that possibility requires a metaphysical foundation; he gave it by grounding possible worlds on modal realism, but modal realism is extremely uneconomical, and thus belongs to the wave of excessive metaphysics that came after positivism. (iv) Philosophers started reacting to the excessive metaphysics. D.M. Armstrong rejected modal realism and naturalised possibility in the 80's, but came only half way through because he was still talking about full worlds without temporal mappings. (v) Since the 90's, suggestions have been given of how the causal structure of the Universe functions as a foundation for possibility, and this can be seen as the process of getting back down to diachronic possibility which is most directly needed in the focal contexts. While the ontologies of Briggs and Forbes, McCall and Belnap are uneconomical with respect to presentism but function equally accurately as foundations of possibility, modal realism or logical possibility as the foundation of possibility is also helplessly inaccurate when dealing with practical predictions. The multiplicity of alternative theories of temporal existence shows how strongly philosophers have been influenced by the Theory of Relativity which entails eternalism. This reminds of the importance of having a genuine alternative: the unified theory naturalises possibility in terms of unambiguous and economical conceptions of temporal existence and causality, whose empirical foundation is the Dynamic Universe model.

8 Definition: Colour

This section complements the unified theory by the concepts *perception*, *colour perception* and interrelated concepts which together yield a unified colour theory. The unified colour theory is basically the same theory as David Rosenthal's [338, 339] *double-property theory* and David Armstrong's [20] colour realism.

8.1 Colour Perception, Colour Families, Colour Science

PERCEPTION. Perception is the process where a conscious agent interacts directly or indirectly with a mind-independent object in an environment, where the interaction yields in the agent a sensation of the object, and where the sensation is in correspondence with the object. Armstrong [28, p. 4] calls this *immediate perception*. This is the basic setting under which it is legitimate to say that "sensation is surely not the sensation of itself, but there is something beyond the sensation, which must be prior to the sensation" (Aristotle *Metaphysics*, 1010b35-37), and that "I do not think that we experience any qualities that are qualities of the brain" (Armstrong [22, p. 188]). The cognitive machinery of the perceiving agent, the mind-independent object which is perceived by the agent with material senses and the environment of perception are structural objects, whose temporal parts are structural particulars.

COLOUR PERCEPTION AND COLOUR FAMILIES. When perception yields a colour sensation in the perceiving agent, the following chain of events takes place. A mind-independent structural colour object interacts with the environment. As a result of the interaction, the object reflects or emits or transmits photons with a certain wavelength-intensity combination. Interaction with light of the environment and the resulting reflection is by far the most common case, but also e.g. heat radiation which causes emission of light is a form of interaction. The reflected/emitted/transmitted light with a certain wavelength-intensity combination reaches the cognitive machinery of the perceiving agent and interacts with it, resulting in a colour sensation in the perceiving agent. The colour sensation is in correspondence with the perceived mind-independent object.

Elements of colour families (1-3) participate in the process of colour perception: (1) Mind-independent colour objects such as those which reside in surfaces of solid objects; these are typically capable of interacting with and reflecting visible light. (2) Colour sensations of human agents; also the sensations of other animals and insects could be counted in. (3) Lights in the environment, i.e., different wavelength-intensity combinations of photons; this includes lights which interact with colour objects and lights that are reflected/emitted/transmitted by the colour objects. Although light in the environment is mind-independent, the term 'mind-independent colour object' denotes only the elements of (1) in the following.

ROOTS OF THE UNIFIED COLOUR THEORY. The unified colour theory is oriented by ontological realism and it is basically the same theory as David Rosenthal's [338, 339] double-property theory of colour and David Armstrong's [20] colour realism, with slightly different naming conventions. All three versions are grounded on ontological realism and all deal with the same colour families, although *all* of the three families are not specifically called colour families by Armstrong nor Rosenthal. Armstrong [20, p. 270] distinguished two colour families: "I hold that to have a red sensation is to acquire the information (the term is meant to cover misinformation) that there is something red at some more or less specific place in the perceiver's environment." While Armstrong did not especially

concentrate on the difference of families (1) and (2), Rosenthal[118] especially unified *colour physicalism* where (1) is the only colour family, and *color subjectivism* or *eliminativism* where (2) is the only colour family:

> It could be that there are two families of color properties, one a family of mental qualities of visual sensations and the other a family of visible properties of physical objects and processes. Color subjectivism and color physicalism, on this third alternative, are both partly correct, since color properties of both kinds exist. The mistake subjectivism and physicalism both make is to assume that colors are exclusively of one kind, either mental or physical but not both. Rosenthal [339, p. 90]

THE GOAL OF COLOUR SCIENCE. The *ideal* goal of colour science is to fully discover the contents of the three colour families and their relations. The actual goal of colour science is to get as close to the ideal goal as possible. Relations of the colour families (and colour predicates) are exemplified in terms of functions F1 and F2. Below, reflection is understood to include emission and transmission and all definitions are supposed to be ideally accurate and complete.

F1: (*environment e, object o, reflection r*).

Given any two values, the function outputs the third. Given definitions of environment e and object o as inputs, F1 outputs the definition of the light r that o would reflect in e; given definitions of e and r as inputs, F1 outputs definitions of all epistemically possible objects which would reflect r in e; given definitions of r and o as inputs, F1 outputs definitions of all epistemically possible environments where o would reflect r. Consider a function which takes the perceiving agent along.

F2: (*agent a, reflection r, colour predicate p*).

It is supposed that all agents speak a common translatable language and are average in all ways, for otherwise the colour predicates would be meaningless. The colour object and the environment are not written out in the function, although light always comes from some source in some environment. The colour sensation of agent a is not written out, but it is included as a names the sensation by the colour predicate p. Given a and r as inputs, F2 outputs the colour predicate p by which a would name the sensation that results when r interacts with the cognitive machinery of a. Given a and p as inputs, F2 outputs definitions of all epistemically possible lights which would cause sensations in a which a would name with the predicate p. Given p and r as inputs, F2 outputs the definitions of all epistemically possible human agents which are such that when interacting with r, they would name the resulting sensation with the colour predicate p.

Various ideal functions can be entertained whose inputs are combinations of agent, reflection, colour predicate, environment and colour object. This shows that the colour families of the unified theory are indispensable in defining the goal of colour science.

8.2 Experience of Similarity

One of the central tasks of a colour theory is to give a plausible explanation of the experienced similarity of the colours of the perceived objects. It is shown how the general case and some special cases fit in the framework of the unified theory.

THE GENERAL CASE. When mind-independent objects x and y seem to have a similar colour to the perceiving human agent A in environment e, the agent A gets sensation $s1$

[118] Although Rosenthal uses the term 'double-property theory' and does not call family (3) a colour family, the elements of family (3) naturally play a role in his analysis.

of x and sensation $s2$ of y, where A experiences $s1$ and $s2$ as similar in colour. What explains the experience of similarity? In the unified theory, x and y are such objects that they reflect (or emit or transmit) such wavelength-intensity combinations of light in environment e, that when these combinations of light interact with the cognitive machinery of A, this results in sensations $s1$ and $s2$, which are such that A experiences them as similar. But this does not imply that x and y are identical objects nor that they resemble closely; this does not exclude that x and y resemble closely either. Both cases and everything in between is compatible with the unified theory.

EXPERIENCED SIMILARITY OF SIMILAR OBJECTS. Why does a vast majority of people call the leaves of ground plants with the colour predicate 'green'? The general explanation is that the leaves are such objects that they reflect such wavelength-intensity combinations of light in typical daylight environments, that when these combinations of light interact with the cognitive machineries of the vast majority of people, this results in certain stable colour sensations in the people. Because of the colour constancy, it has become practical to denote leaves with some fixed colour predicate which happens to be 'green' in English.

The reason why people typically experience leaves as green is found from the light they reflect and the structure of human cognitive machinery. The reason why they reflect such light is found from their structures which happen to resemble clearly. The spectrum of light that is visible to average humans is the range between about 390-700 manometers, and daylight is a combination of lights of different wavelengths in that range, plus other wavelengths. Leaves of ground plants *absorb* light very efficiently in the ranges [390 500] and [600 700], but absorb very little light in the range [500 600]. The leaves reflect most of the light in the range [500 600] (Misra et al. [274]). When light in the range [500 600] interacts with the cognitive machinery of an average human agent, the agent gets a sensation of green.

Why is the effective white light *excitation/absorption* spectrum of the leaves of ground plants the union of [390 500] and [600 700]? The reason is found from *chlorophyll a* and *b* molecules in the leaves. A chlorophyll (a or b) molecule absorbs light very efficiently in the ranges [390 500] and [600 700], but absorbs very little light in the range [500 600]. The molecule uses the absorbed light for three purposes: to provide energy for photosynthesis, to produce heat and to emit light. The emitted light is red but chlorophyll emits so little red light that it is not typically seen, except in a special setting. The molecule reflects most of the light in the range [500 600]. Chlorophyll thus explains the absorption spectrum of the leaves of ground plants.

Why is the effective white light absorption spectrum of a chlorophyll molecule the union of [390 500] and [600 700], i.e., what is it in the structure of the molecule that determines the effective spectrum? It suffices to say that when it is known that an object absorbs light very efficiently in a certain range and reflects most of the light in another range, then it is know that *chemical bonds* in a certain range are present in the object; the account of just which bonds reflect which wavelength-intensity combinations is the concern of chemistry.

METAMERS: EXPERIENCED SIMILARITY OF HETEROGENEOUS OBJECTS. Any two different wavelength-intensity combinations w and v which yield colour sensations in agent A that A experiences as identical, are *metamers* with respect to A. The concept 'metamer' has thus been defined in terms of the unified theory: in terms of the family of colour sensations of the perceiving agents, and the family of lights with which the agents in-

teract.[119] Ideally, metamers-to-A can be deduced from the complete knowledge of the structure of A, for based on this knowledge it can be deduced what kinds of stimuli cause what kinds of sensations in A. Suppose that all those metamers are known which result in certain sensations of red in A, which A experiences as identical sensations of red. When A gets such a sensation in environment e by perceiving the mind-independent object o, it is known that the sensation was due to some of these metamers. Therefore, it is known that o reflects one of these metamers in e. Therefore, the structure of o can be deduced to be in the range of all epistemically possible objects which reflect one of these metamers in e. The chain from behaviour to structure is discussed further in §8.3.

ONE-OVER-MANY PROPERTIES? It has been concluded that a human agent can experience homogeneous as well as heterogeneous objects as similar in colour. Therefore, it can be supposed that objects which seem to be similar in colour resemble closely sometimes but not always. Accordingly, the translation of 'not always' into 'never' would be over-propagation; the translation of 'sometimes' into 'always' would be over-propagation in the opposite direction. Hendel [167, p. 123, 125] seems to over-propagate 'not always' into 'never' by saying "What underlies the finding of such resemblance is the assimilative tendency of the mind itself, and nothing in the perceived things." Likewise, according to Campbell [74, p. 256], "It seems that we shall not be able to escape the conclusion that the unity of specific colours... must lie in the observer's response to the physical facts, rather than in those facts themselves." When the experienced unity lies in observer's response to physical facts and not in the facts themselves, we are dealing with objects whose colour properties do not resemble in a relevant sense, but the objects are still experienced to have a similar colour. It would be over-propagation to suppose that the colour properties *never* resemble closely.

Consider two arbitrary objects which are experienced to have the identical shade of red. There are various alternatives: the objects instantiate the identical colour property; they instantiate a very similar colour property; they instantiate a somewhat similar colour property; they instantiate a very different colour property. Therefore, red is certainly not a one-over-many *property*, but a one-over-many *range* of properties. The following remarks are compatible with this notion and thus compatible with the unified theory: "there need be no one property that all red things share. ... Nothing, therefore, in our learning of the use of the predicate 'red' requires it to correspond to any one property of the things we apply it to" (Mellor [265, pp. 110-2]); "there need not be anything that distinct red things "really" have in common" (Maurin [253, p. 46]). The notion that red is not a single property but a range of properties is thus fully compatible with the unified theory.

8.3 From Behaviour to Structure

The strength of the chain from the knowledge of the colour behaviour of an object to the knowledge of the structure of the object is as strong as the contemporary scientific knowledge. The colour behaviour of an object is handled in terms of its *colour profile*, and the chain from a partial detection of a colour profile into the knowledge of a range of objects is discussed.

[119] For comparison, Byrne and Hilbert [71, p. 10] define metamers without a direct reference to the perceiving agent: "objects with quite different reflectances can match in color under a given illuminant. Two such objects are a *metameric pair* with respect to that illuminant."

COLOUR PROFILES.[120] Talking about the colour profile C_o of the colour object o is a way of talking about the colour behaviour of o. The ideally complete definition of C_o can be thought to be syntactically a list of all (environment, reflection-emission-transmission) pairs of o. Given an arbitrary environment e, the ideal definition of C_o is thought to contain the information of what kind of light o would reflect-emit-transmit in e. Object o determines C_o, i.e., the structure of an object together with its environment determines its behaviour. While o is literally a certain kind of an object with a certain kind of a structure, o does not literally *have* a colour profile. Therefore, the unified theory should not be confused with a relational nor a dispositional theory (§8.5).

FROM BEHAVIOUR TO STRUCTURE. Reflection-emission-transmission measurements are committed to o in different environments. This yields partial knowledge of the colour profile C_o of o. The partial knowledge of C_o in turn gives knowledge of the range of all those epistemically possible particulars $[O]$ which match the measured portion of C_o. Typically, the better C_o is known the narrower is $[O]$. As the partial knowledge of C_o gives merely a range of epistemically possible objects $[O]$, the knowledge of $[O]$ is partially or totally *disjunctive*: it is known that o is either the structure a_1 or a_2 or ... or a_n. If it can be deduced that all these epistemic possibilities share a common part, then the knowledge is partially disjunctive; if even this cannot be deduced, the knowledge is totally disjunctive.

Even human perception with bare eye manages to detect colour profiles partially; although the resulting knowledge of the structure of the perceived object is highly disjunctive, it is still better than nothing. According to Hall [162, p. 126] "merely from perceiving something to be red, you cannot say anything about its physical constitution." Hall is correct in the sense that colour detection with bare eye only manages to yield a highly heterogeneous range of epistemically possible objects. But the range of all objects which an average human being experiences as red in typical daylight conditions is much narrower than the range of all objects, i.e., based on the perception of red in typical daylight conditions you can say at least something disjunctive about the constitution of the perceived object.

Consider a strategy of trying to break the chain from perception to structure: (i) suppose that nature is *qualitatively infinite*; (ii) therefore perception only manages to identify an infinite range of different objects; (iii) as the identification of an infinitely heterogeneous range amounts to nothing, perceptions give no information about the perceived objects. The argument builds on an unnecessarily heavy axiom (qualitative infinity), and therefore has no force: in economical unification an empirically sufficient metaphysical view cannot be replaced by a more complex metaphysical view that is in no ways better. Moreover, the unified theory is compatible with nature being qualitatively infinite, and even if nature were qualitatively infinite, scientists have provably managed to successfully connect partial colour profiles to ranges of structures in a way that these connections are applicable. All that scientists can do in any case is to establish firmer and firmer links between colour profiles and ranges of structures, and contemplations about qualitative infinity have no effect on this process.

[120]The colour profile of an object is very close to what Rosenthal [339, p. 86] calls *reflectance profile* of an object; the only difference is that a colour profile includes emission and transmission in addition to reflection.

8.4 Impossible Colours

Certain objects which consist of combinations of mind-independent red and green parts cannot yield certain red-green colour sensations in human agents in typical daylight conditions; certain objects which consist of combinations of mind-independent yellow and blue parts cannot yield certain yellow-blue colour sensations. In human cognitive machinery, red light cancels the effects of green light, and yellow light cancels the effects of blue light: therefore we cannot experience certain red and green lights coming from the same source as red-green in typical conditions, and we cannot experience certain yellow and blue lights coming from the same source as yellow-blue in typical conditions. The yellow-blue and red-green colours of such objects are called *impossible colours*.

Crane and Piantanida [94] showed that in certain laboratory settings, the test agents after all did experience certain combinations of red and green when they were perceiving a certain combination of red and green bars for several seconds. Altogether three different groups of red-green sensations were reported as a result of perceiving one combination of red and green bars. What does this show? It shows that a human agent in a certain laboratory setting gets one or another (typically in one of three groups) colour sensation when being stimulated in a certain way for a certain period of time. Because of this discovery, we can now predict that when a human agent gets a colour sensation which is very similar to the sensations that the test agents got in Crane and Piantanida's test setting, the agent is probably plugged into a similar laboratory setting. Arstila maintains that the test undermines colour realism:

> [I]f we are able to experience them, then they have to be consequences of those processes that take place after retinocortical processes; in other words, they are consequences of corticocortinal processes, as claimed by Crane and Piantanida and do not represent the properties of extramental objects. Thus it has been argued that these new colors cannot be reduced to the properties of physical objects; they do not have physical counterparts. Due to this problem, color realism cannot differentiate impossible colors from other colors; and without such an account it cannot explain our colour experiences. However, as opponent processes prevent it, color realism cannot provide the required account. Accordingly, all versions of color realism are false. Arstila [30, p. 102-3]

Why should the red-green sensations not represent extramental (mind-independent) objects? When a human agent is stimulated by certain kind of light in the test setting for several seconds, the perception yields —by both retinocortical and corticocortinal processes— some red-green sensation. The sensation corresponds to the light source, i.e., it is true that the light source sends light that yields the red-green sensation. The light source is a mind-independent physical object, and impossible colours can be differentiated from other colours in terms of the unified theory. In typical environments certain mind-independent x-y combinations cannot yield x-y sensations; an x-y sensation is called an impossible colour because of this reason. In special settings, certain mind-independent x-y combinations can after all yield certain x-y sensations, i.e., an x-y sensation is not an impossible colour after all within the special settings; accordingly, the x-y sensation corresponds to some mind-independent x-y combination. Why should this be a threat to colour realism?

8.5 The Unified Theory vs. Relationalism and Dispositionalism

Averill [35] and Cohen [89] arrive at relationalism about colour mainly because it resolves conflicts which follow from interpersonal differences and heterogeneous lightning conditions. Different agents in different environments get different sensations about identical

or close to identical objects, and therefore the question raises about what is the colour of such objects: "It is quite common, for example, when one person perceives something as bluish-green, for the other to perceive it clearly as yellowish-green. How can one decide which one of them perceives colors truthfully?" (Arstila [30, p. 74]). Cohen [90, §2.2] comes up with a solution: "There is no independent and well-motivated reason for thinking that just one of the variants ... is veridical (at the expense of the others)." Relationalism is formulated accordingly.

According to Cohen (*ibid*, §1.3) "The heart of color relationalism is the claim that colors are relational; in particular, the relationalist claims that they are constituted in terms of a relation between (inter alia) objects and subjects." While the unified theory distinguishes the colour families (1-3) and assigns colour predicates for the elements of all three families, Cohen's version of relationalism bunches up all three families and assigns colour predicates to certain combinations of elements of the families. In relationalism the sensation $s1$ of agent $a1$ in environment $e1$ about object o *is* the colour of o for $a1$ in $e1$. Likewise, the sensation $s2$ of agent $a2$ in environment $e2$ about object p which is identical to o *is* the colour of p for $a2$ in $e2$. There are thus no conflicts in relationalism, but only different agent-environment-sensation pairs. For instance, when one person perceives an object as bluish-green, the object is bluish-green for that person in that environment; when another person perceives an identical object as yellowish-green, the object is yellowish-green for that person in that environment.

The unified theory resolves the conflicts in essentially the same way as relationalism. In both theories, colour sensations which result from perceiving mind-independent objects in environments always correspond to the objects: when a human agent experiences a leave of a tree to be green in daylight conditions, the sensation corresponds to the leave; when the agent experiences an identical leave to be black in a low light environment, the sensation corresponds to the leave. How can a green and a black sensation both correspond to an identical object? The sensation of green corresponds to the leave, as it is true that there is some object in some location which is such that it causes the sensation of green in daylight conditions. The sensation of black corresponds to the leave, as it is true that there is some object in some location which is such that it causes the sensation of black in dark conditions.

The crucial difference between the unified theory and relationalism is that in the unified theory the colour families are strictly separated: the sensation $s1$ of agent $a1$ in environment $e1$ about object o is simply the sensation that agent $a1$ in environment $e1$ gets about object o. The colour property of o is completely independent of how any agent experiences it, whereas the colour property of o naturally affects the sensation that an agent gets from perceiving o in sufficiently illuminated environments. In sum, both the unified theory and relationalism resolve conflicts that result from interpersonal differences, but the unified theory sustains the three colour families whereas relationalism mixes these. The mixing makes things difficult, because in the context of relationalism we cannot talk about colour properties of objects without the link to one or another agent.

RELATIONAL CLASSIFICATION OF COLOUR OBJECTS. The unified theory can be seen to incorporate the applicable ingredients of relationalism also by means of a relational classification of mind-independent colour objects. To illustrate, propositions such as 'blood is red' and 'leaves of trees are green in the summer' are generally considered to be true because most people in most environments where colour vision works properly experience the leaves as green and blood as red, and name them with predicates 'green' and 'red,' respectively. Such common mappings can be used as arbiters: if most people in

most environments where colour vision works properly would name object o green, then the proposition that o is green is true; if not, the proposition is false. In this sense, the proposition that 'o is green' is equivalent with the proposition that 'most of the people in most of the environments where colour vision works properly would name o green.'

DISPOSITIONALISM. "Color-Dispositionalism is the view that colors are dispositional properties: powers to appear in distinctive ways to perceivers (of the right kind), in the right kind of circumstances; i.e., to cause experiences of an appropriate kind in those circumstances" (Maund [252]). This definition of dispositionalism which interconnects the perceiver, the perceived object and the environment, is very close to relationalism. The unified theory incorporates the fruitful ingredients of relationalism and thus also of the version of dispositionalism which is very close to relationalism, while sustaining intrinsic colour properties. Therefore this version of dispositionalism is not investigated further. Dispositionalism can be formulated also independently of the perceiving agent: colour properties are powers to reflect certain kind of light in certain environments. In the unified theory colour objects (with their properties) cause the dispositions (the colour profiles), but colour properties are not mixed with the dispositions. The explanation of *why* an object has a certain colour profile starts from the object, not from the disposition: "We can explain dispositions by means of their categorical bases [objects and their intrinsic properties] but we cannot explain a categorical basis by means of the dispositions it constitutes" (Vanderbeeken [406, p. 137]).

8.6 Summary

The unified colour theory was built by defining various concepts in terms of EUO, starting from perception and proceeding into colour perception and the three colour families. Colours were handled because these are typically discussed in the philosophical literature; the process of perception could have been complemented as well with the families of odors, tastes and sounds, i.e., plain perception in the context of EUO unites all these. The unified theory unifies the central applicable ingredients of colour subjectivism, colour physicalism, colour relationalism and colour dispositionalism into a coherent whole. The unified theory captures the primary meanings of colour that are at work in natural science and human social behaviour. The unified theory has no difficulties in defining the goal of colour science and the concepts metamers and impossible colours, in classifying colour objects, in explaining different cases of the experience of similarity and the chain from behaviour to structure, and in answering the question of whether colour properties are one-over-many properties. The unified colour theory has all virtues that an economically unified colour theory should have: it is defined in terms of an economically unified ontology; it is comprehensive and understandable; it is in line with science about colours and with increasing knowledge about colours; it handles special cases as well as general cases; it incorporates fruitful ingredients of competing theories and manages to resolve arguments targeted against colour realism.

9 Concluding Remarks

The central argument by which this doctoral dissertation is defended is that economical unification is a more progressive method of philosophical analysis than plain conceptual analysis of individual pieces in isolation from one another, in the absence of a unified ontology, and without having economy or virtuousness as the criterion. Virtuousness as the criterion yields a virtuous ontology which enables everything built on it to be virtuous. Applying the method is the process of building an economically unified ontology by having the principle of economy as the criterion, and defining concepts in terms of the ontology. In this process, the meanings of concepts are disambiguated and genuinely understood, and interrelations between ontological commitments, between defined concepts, and naturally between ontological commitments and concepts defined in terms of them, are explicated and understood. Problems are efficiently resolved, stability is gained, and ontological, terminological and all conceptual redundancy is reduced. The progressiveness of the method has been testified by showing that it does what is expected from it, and this was done by actually *doing* the unification, i.e., by actually applying the method in practice. Consider the central partially overlapping contributions of this thesis to the existing body of knowledge.

1. Advancing unification substantially. Methodology, ontology and applications have been interrelated. Several methodological concepts have been interrelated, several ontological commitments have been interrelated, and several applications have been interrelated externally and unified internally in terms of the ontology. Explication of external interrelations of applications means showing how the theories of truth, possibility and colour as well as all other concepts defined in terms of EUO work together seamlessly.

2. Systematisation of the method of economical unification and showing how it can be successfully applied, thus providing a clearly more progressive alternative to plain conceptual analysis. Economical unification merely combines the Aristotelio-Machian goal of seeking out the simplest first principles and the axiomatic method from mathematics, thus applying results of philosophy of science in philosophical analysis itself. The method provides interesting prospects for follow-up research as various concepts are in the need of disambiguation by unification, and the method is applicable in every field whose goals and premisses can be explicated.

3. Pointing out the indispensability of the principle of economy in science and in philosophy of science. It was shown how economy can be applied as an evaluation criterion of theories, and that there are no good alternatives for applying it if the goal is to bring the progress rate of science into the state of optimal acceleration. It was shown that economy genuinely unifies the philosophy of science, as it functions as an efficient point of departure to the challenges of underdetermination, defining of approximate truth, incorporating the falsifiability criterion in theory evaluation, preventing unconditional stagnation to paradigms, determining what is the reasonable degree of theory proliferation, in making paradigm shifts rational, and in determining the meaning of a good scientific explanation.

4. Applying economy in deriving the axioms of EUO, which was a prerequisite for showing that the method does what it is supposed to. Showing how everything else can be built on presentism. Partially popularising the Dynamic Universe model and showing that the axioms of EUO are compatible with it, thus coming up with a proof that a somewhat economically unified theory is not just a possibility, but actuality. It is quite different to *say* that philosophy and physics are one, than to *show* what this means by a comprehensive example. This example also provides an easily accessible introduction

to some of the top-level interrelations of physics and philosophy, especially temporal existence and causality. It is not claimed that the fusion of EUO and the Dynamic Universe model is the only alternative, but the method requires some alternative, and a fusion with relativistic physics could not be applied because it especially keeps science disunified, as its conception of time is not understandable and as it does not build on the conservation law.

6. Complementing previous efforts of internally unifying applications, by formulating mutually compatible definitions which together do the jobs of e.g. previously competing theories of truth and previously competing theories of possibility. Complementing Ingthorsson's work on the unified theory of truth and defending the resulting theory extensively. Defending the unified colour theory which was formulated by Rosenthal. Complementing the work of Belnap, McCall and Briggs and Forbes on the unified theory of possibility, simplifying their foundations by presentism and defending presentism substantially, also by relying on the Dynamic Universe model. Complementing Margolis and Laurence' defence of concepts as mental representations by showing that the naturalist definition of 'abstract' reconciles nominalism and Platonism.

The method does what is expected from it, and it should be considered as a valuable contribution for the sake the progress that comes along with it. Its progressiveness can be denied only by closing one's eyes. Hume's guillotine works: it is certainly not wisdom to look at the currently disunified science and philosophy and to conclude that this is how things should be, because this is how things currently are. One should not try to bury the goal towards ideal science because science is currently not ideal, and one should not deny that steps towards the ideal state are progressive.

I am willing to complement future versions of this thesis by important aspects of the investigated topics that were not taken in account, and all suggestions are welcome.

Appendix A: Mereology

Mereology is a simple formal foundation for transitive part-whole relations. Lesniewski [220] gave his first axiomatization of mereology in 1916, and coined in the term 'mereology' in 1927, which derives from the Greek word for *part*: *méros*. There are several versions of mereology and several ways to axiomatize these. See e.g. Sowa [370, pp. 105-8] and Simons [361, pp. 42-3] for comparison. These axioms were formulated by Aapo Halko. The axioms of mereology define the model $\{\mathcal{D}, \preceq\}$, where the elements of $\mathcal{D}$ will be called *aggregates*. An aggregate is composed of other aggregates, or if an aggregate is indivisible, it is an *ur*-element, where *ur* is *basic* in German.

AXIOM OF EXTENSIONALITY: $x = y \leftrightarrow \forall w(w \preceq x \leftrightarrow w \preceq y)$. $x = y$ iff (if and only if) every part of x is a part of y, and every part of y is a part of x. Examples: $a_1 = a_1$; $a_1a_2 = a_1a_2$.

AXIOM OF REFLEXIVITY: $\forall x(x \preceq x)$. Every aggregate is a part of itself.

AXIOM OF TRANSITIVITY: $\forall x, y, z((x \preceq y \wedge y \preceq z) \rightarrow x \preceq z)$. If x is part of y and y is part of z, then x is a part of z.

AXIOM OF SYMMETRICITY: $\forall x, y((x \preceq y \wedge y \preceq x) \leftrightarrow x = y)$. x is identical with y iff x is a part of y and y is a part of x.

DEFINITION OF UR-ELEMENT: $\nexists x(x \prec y)$, denoted as $ur(y)$. Ur-element is indivisible and has no proper parts.

(OPTIONAL) AXIOM FOR DISCRETE MEREOLOGY: $\forall x \exists y(ur(y) \wedge y \preceq x)$. Every aggregate is composed of ur-elements only, and can be subdivided down to the point where nothing is left but a single ur-element. Discrete mereology is a sufficient logical foundation for part-whole relations in EUO.

DEFINITION OF PROPER PART: $x \preceq y \wedge \neg(y \preceq x)$, denoted as $x \prec y$. Aggregate x is a proper part of aggregate y iff x is a part of y but y is not a part of x. Examples: $a_1 \prec a_1a_2$; $a_2 \prec a_1a_2$; $a_1a_2 \prec a_1a_2a_3$; $a_2a_3 \prec a_1a_2a_3$; $a_1a_3 \prec a_1a_2a_3$. No aggregate is a proper part of itself. The negation "A is not a proper part of B" is denoted as $A \not\prec B$, or as $\neg(A \prec B)$. Examples: $a_1 \not\prec a_1$; $a_1 \not\prec a_2$; $a_1a_2 \not\prec a_1a_2$.

DEFINITION OF OVERLAP: $\exists z(z \preceq x \wedge z \preceq y)$, denoted as $\circ(x, y)$. Aggregate x overlaps with aggregate y iff x and y have a common part z. For example, $\circ(a_1a_2, a_2a_3)$ and $\circ(a_1, a_1)$ are true; $\circ(a_1, a_2)$ and $\circ(a_1a_2, a_3a_4)$ are false. Overlap is the contrary of disjointness: $\neg \circ (A, B) \leftrightarrow A \wr B$; $\circ(A, B) \leftrightarrow \neg(A \wr B)$. That A and B overlap can be written also as $A \circ B$.

DEFINITION OF DISJOINTNESS: $\nexists z(z \preceq x \wedge z \preceq y)$, denoted as $x \wr y$. Two aggregates are disjoint iff they have no common parts. Examples: $a_1 \wr a_2$; $a_1a_2 \wr a_3a_4$.

DEFINITION OF INTERSECTION/MEET: $\forall w((w \preceq x \wedge w \preceq y) \leftrightarrow w \preceq z)$, denoted as $z = x \otimes y$. Intersection of x and y contains all those, and only those parts of x that are also parts of y. Examples: $a_1 \otimes a_1 = a_1$; $a_1a_2 \otimes a_1 = a_1$; $a_1a_2 \otimes a_2a_3 = a_2$; $a_1a_2a_3 \otimes a_2a_3a_4 = a_2a_3$.

DEFINITION OF UNION/JOIN: $y \preceq z \wedge x \preceq z \wedge \forall w((y \preceq w \wedge x \preceq w) \rightarrow z \preceq w)$, denoted as $z = x \oplus y$. The union z of aggregates x and y is an aggregate that contains all parts of x and all parts of y. Examples: $a_1 \oplus a_2 = a_1a_2$; $a_1 \oplus a_1 = a_1$; $a_1a_2 \oplus a_2a_3 = a_1a_2a_3$.

DEFINITION OF DIFFERENCE: $\forall x(x \preceq z \leftrightarrow (x \preceq y \wedge x \not\preceq w))$, denoted as $z = y \ominus w$. The difference $y \ominus w$ contains every part of y that is not a part of w. Examples: $a_1a_2 \ominus a_2 = a_1$; $a_1 \ominus a_2 = a_1$; $a_1a_2a_3 \ominus a_1a_2 = a_3$.

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Appendix C: Glossary and Abbreviations

ABSOLUTE SIMULTANEITY: an axiom of EUO which states all parts of a TSU exist at the same time; presupposed by presentism. §§4.1, 5.6

ABSTRACT: everything that is abstract is a thought realized in the mind of a human being. E.g. consciously experienced ideas such as mathematical objects can be classified as abstract. §4.14

AXIOM OF EUO: an unfalsifiable and unverifiable metaphysical commitment which is derived by the principle economy. §4

CAUSALITY: an axiom of EUO which states that all parts of the present TSU are causally connected and realize energy in an absolutely determinate location in an absolutely determinate way, and that the present TSU is the consequence of the preceding TSU and the cause of the succeeding TSU. §4.7

CLE: see the entry *conservation law of energy.*

CONSERVATION LAW OF ENERGY: an axiom of the Dynamic Universe model which states that the total energy of every TSU is identical. §5.1

DEFINITION: states something about something. A definition which is not an axiom nor a theorem defines the meaning of a concept in terms of an ontology, but does not state what exists.

DU: see the entry *Dynamic Universe.* §5

DYNAMIC UNIVERSE: Suntola's unified theory whose central postulate is the conservation law of energy. §5

ECONOMY: see the entry *principle of economy.*

ECONOMICALLY UNIFIED ONTOLOGY: a system of interrelated ontological commitments that is favoured by the principle of economy and which has (in the ideal case) all theoretical virtues.

ECONOMICALLY UNIFIED CONCEPT/THEORY: a concept/theory that is defined unambiguously in terms of an economically unified ontology and which is applicable in the contexts of natural science and typical human social behaviour.

EUO: the given version of economically unified ontology. EUO incorporates axioms that are sufficient for concepts that are defined in terms of it in this thesis, such as truth, possibility and colour, so that the concepts function in the contexts of natural science and human social behaviour.

EXISTS: it follows from presentism that 'to exist' means primarily to be a part of the present TSU, whereas the past TSUs did exist and the future TSUs become into existence one at a time. However, the context eventually determines whether 'exists' refers to the present, past or future.

FACT: a true proposition. As an exception, see §6.8.1.

FINITENESS: an axiom of EUO which states that all TSUs are spatially finite and consist of finitely many indivisible and positive interrelated parts. §4.17

FLRW: see the entry *Friedmann-Lemaître-Robertson-Walker model.* §5

FRIEDMANN-LEMAÎTRE-ROBERTSON-WALKER MODEL. The contemporary standard model of cosmology which is based on the General Theory of Relativity. §5

GR: see the entry *General Theory of Relativity.* §5

GENERAL THEORY OF RELATIVITY: the General Theory of Relativity inherits all postulates of SR and adds the Equivalence principle.

GROUNDING: that a concept is grounded on an ontology means that the concept is defined in terms of the ontology. 'Grounding on' is equivalent with 'mapped to'.

HYPOTHETICAL ENTITY: an entity whose existence is predicted by a theory or which is supposed to exist for some other reason, but which has not been empirically verified to exist nor falsified to not exist. Hypothetical entities and regularities are commonly called parameters. §3.3

INFINITESIMAL: a number greater than zero and smaller than any real number.

INFINITE: see the entry *transfinite*.

LAW OF NON-CONTRADICTION: an axiom of EUO which states that one property cannot belong and not belong to the same particular at the same time in the same respect. §4.15

MAPPING: that a concept is mapped to an ontology means that the concept is defined in terms of the ontology. 'Grounding on' is equivalent with 'mapped to'.

MENTAL REALISM: an axiom of EUO according to which mental states of human beings exist. Implicit in ontological realism. §4.12

METAPHYSICS AND METAPHYSICAL COMMITMENT: a metaphysical commitment is an ontological commitment which is unfalsified and unverified by perception. The term 'metaphysics' is also used to denote the branch of philosophy that deals with ontological commitments: in this sense 'metaphysics' and 'ontology' both denote the same branch of philosophy. §1

MODEL: used in this thesis interchangeably with 'theory.' E.g. 'the Dynamic Universe model' could be translated as 'the Dynamic Universe theory,' and 'models of cosmology' could be translated as 'theories of cosmology.'

NATURALISM: a theorem of EUO according to which all parts of the Universe are directly or indirectly causally connected, and all that ever exists is a part of the Universe. §4.8.

NATURALISATION: naturalisation of a concept means that everything transcendent is shaved away from the concept while sustaining its functionality.

NON-POSITIVE NUMBER: an infinitesimal or a transfinite number or zero.

OBC: object-based correspondence theory of truth. §6

OBJECT: a part of the Universe; either a particular, a sequence of consecutive particulars or two or more particulars that are temporally scattered. §4.6

ONTOLOGICAL COMMITMENT: a belief of a human being about what exists, has existed or will exist or any combination of these. Ontological commitments of a theory are the entities which are required to exist in order for the theory to be true. §1

ONTOLOGICAL REALISM: an axiom of EUO which states that a proper part of the Universe is independent of human minds. §4.12

ONTOLOGY: a system which consists of interrelated ontological commitments. The term is also used to denote the branch of philosophy that deals with ontological commitments: in this sense 'metaphysics' and 'ontology' both denote the same branch of philosophy. §1

PARADIGM: a theory which is commonly accepted by a vast majority of the scientific community during some interval of time. §3.3

PARAMETER: any extra metaphysics which is coupled with the basic postulates of a theory in order to make the theory function as intended, such as to match perceptions; in models of cosmology parameters are typically called extra regularities and hypothetical entities. §§3.3,5.7

PARTIAL UNIFICATION: postulate C is found which is common to theories A and B, but A and B have non-overlapping postulates even after the partial unification. §3.3

PARTICULAR: an energy-endowed part of the Universe that exists exactly at one time in one location. §4.6

PHYSICALISM: a theorem of EUO according to which all that ever exists is physical, i.e., that all that ever exists realizes energy at some absolutely determinate time in some absolutely determinate location in some absolutely determinate way. §4.13

POSITIVE NUMBER: a real number greater than zero.

POSTULATE: a basic unverifiable assumption of a theory. E.g. the conservation law of energy is a postulate of the Dynamic Universe model. All postulates are thus metaphysical commitments but all metaphysical commitments are not called postulates. Postulates may be coupled with parameters.

POTENTIAL INFINITY: a potentially infinite process never ceases and is never completed, i.e., one can always take one more, but never infinitely many (Styrman [381]).

PRESENTISM: an axiom of EUO which states that only the present TSU exists. §4.1

PRINCIPLE OF ECONOMY: the evaluation criterion of theories and ontologies according to which the metaphysically simplest theory that explains perceptions is to be preferred. §1

PROPOSITION: a proposition is a truth-valued thought which is realized in the mind of a human being in a certain location at a certain time, which refers to something else than the thought itself, which especially states that the thing to which the proposition refers exists or more specifically has certain properties in a certain location at a certain time. §6.1

REDUCTION: theory A is derived from theory B, where A and B are compatible. §3.3

REGULARITY: a supposed uniformity of nature, deduced based on perceptions, i.e., a metaphysical commitment of a theory. E.g. the elliptical orbits of the planets around the Sun are regularities of the Sun-centered paradigm. §3.3

RP: see the entry *relativistic physics*.

RELATIVISTIC PHYSICS: SR, GR and FLRW and all physics based on them.

SR: see the entry *the Special Theory of Relativity*.

SPECIAL THEORY OF RELATIVITY: Einstein's 1905 theory whose central postulates are the Relativity principle, the static velocity of light and Lorentz transformations. §5

STANDARD MODEL OF COSMOLOGY: the Friedmann-Lemaître-Robertson-Walker model (FLRW), which is founded on the Theory of Relativity. §5

TEMPORAL STAGE OF THE UNIVERSE (TSU): everything that exists at time t is a part of TSU t. A TSU is everything that exists at one instant. A TSU can also be called a temporal part of the Universe.

TEMPORAL PART: temporally consecutive particulars which constitute an object are called temporal parts of the object. E.g. a person within a period of one second is an

object; the person at the first instant of the period is called a temporal part of the object.

THEOREM OF EUO: an implication of one or more axioms of EUO, and therefore an unverifiable and unfalsifiable metaphysical commitment.

THEORY: a fusion of some ontology and all concepts defined in terms of the ontology. §1

THEORY OF RELATIVITY: denotes the General Theory of Relativity in this thesis. §5

THEORY SHIFT: theory A is replaced by theory B, where A and B are incompatible. §3.3

THING: an object, a mental property of an object, a concrete property of an object or any combination of these.

TRANSCENDISM: any postulate which violates naturalism. §4.9

TRANSFINITE: a number greater than any real number. The terms 'transfinite' and 'infinite' are interrelated as follows. An endless sequence such as $1, 2, 3, \ldots$ or $-, -, -, \ldots$ is an infinite sequence. Any *totality* that consists of infinitely many parts is transfinite. For instance, when all elements of an infinite sequence are considered as members of a set, the set is transfinite. The sequence $1, 2, 3, \ldots$ is infinite; the set $\{1, 2, 3, \ldots\}$ is transfinite. The transfinite numbers are called *cardinal numbers*, where the cardinality of a set is the answer to the question of how many members does the set have. The length of the sequence 1,2,3 is 3 and the cardinality of the set $\{1, 2, 3\}$ is 3. The sequence $1, 2, 3, \ldots$ is infinite, the set $\{1, 2, 3, \ldots\}$ is transfinite, and the cardinality of $\{1, 2, 3, \ldots\}$ is denoted by the 'transfinite' number ∞ or $\aleph$.

TSU: see the entry *temporal stage of the Universe*.

UNIVERSE: the Universe is a single non-branching sequence of consecutive TSUs which are in a forward directed temporal and causal succession. Only the present TSU exists, the past TSUs did exist, and the future TSUs become into existence one at a time. The Universe is thus strictly speaking an idealization —an idea realized in the mind of a human being— which however is supposed to correspond to what existed, what exists and what will exist. As in presentism only the present exists, only the idea about the present corresponds to an existing particular. If a proposition corresponds to a past object, the object existed in the past. If a proposition corresponds to a future object, the object will be realized in the future. §6.6

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