Dynamic space converts relativity into absolute time and distance

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Abstract

A confusing feature in the theory of relativity is the use of time and distance as parameters in explaining the constancy of the velocity of light and the reduced frequencies of atomic clocks in fast motion and in high gravitational field. It is well known that a radio signal passing a mass center is delayed compared to a signal from same distance through free space. Instead of stating that the velocity of the signal were reduced the theory of relativity explains that time close to mass centers flows slower thus saving the basic assumption of the theory, the constancy of the velocity of light. Same is true for atomic oscillators and the characteristic absorption and emission frequencies of atoms, an atomic clock loosing time when in fast motion is not considered as running slower but as experienced slower flow of time.

A key demand of a physical theory is its capability to create an understandable picture of the reality we observe. Instead of just introducing mathematical expressions for observations, a physical theory should explain the logic behind the phenomena observed. The old Ptolemy astronomy worked well for calendar and eclipses but failed in serving as a basis for a physical view of celestial motions. A key in Copernicus' findings was the realization of the observer's state in the system - instead of defining the observer's state as the origin at rest Copernicus identified the Sun as the origin of the planetary system with Earth orbiting and rotating like any other planet. Such a structure gave basis for a physical approach of motions in the system thus opening a new era for the understanding of celestial mechanics and the laws of nature.

The Dynamic Universe approach takes a further step in reorienting the observer. The observable three-dimensional space as whole is considered as a closed spherical structure with its dynamics determined by a zero energy balance between gravitation and motion in the structure. Such approach links local phenomena to the state and motion of whole space and gives physical explanations to several postulates like the velocity of light, the rest energy of matter and the Mach's principle. It also explains the dependence of the velocity of light on the gravitational environment and the dependence of the ticking frequencies of atomic clocks on the state of local motion and gravitation - not by distorting time and distance coordinates but in absolute time and distance.

Introduction

The idea of describing space as a closed surface of a four-dimensional sphere is not a new approach. In 1917, following the ideas of Ludwig Schläfli, Georg Riemann and Ernst Mach, Einstein proposed the concept of spherically closed space as the surface of a hypersphere in Euclidean four-dimensional universe [1]. Space as the surface of a 4-sphere with uniform distribution of mass fulfilled the cosmological principle, but Einstein could not show a mathematical connection between the concept of the 4-sphere and the theory of relativity. Furthermore, following the general view at that time Einstein assumed a static model; in order to remain in static state the 4-sphere required a cosmological constant to offset the gravitation of the structure. In early 1920s Alexander Friedmann generalized the cosmological view of general relativity by describing options for closed, flat and open space depending on the overall mass density. Conservation of energy in Friedmann's model was achieved by allowing expansion of space, a step that turned out to be revolutionary. The idea of uniformly expanding space got strong support in late 1920's when Edwin Hubble, by interpreting the observed redshifts of distant objects as Doppler effect, proposed that the recession velocity of a celestial object is directly proportional to its distance from the observer.

In his lectures on gravitation in early 60's Richard Feynman stated:

> "If now we compare this number [total gravitational energy $M_\Sigma^2 G/R$] to the total rest energy of the universe, $M_\Sigma c^2$, lo and behold, we get the amazing result that $GM_\Sigma^2/R = M_\Sigma c^2$, so that the total energy of the universe is zero. — It is exciting to think that it costs nothing to create a new particle, since we can create it at the center of the universe where it will have a negative gravitational energy equal to $M_\Sigma c^2$. — Why this should be so is one of the great mysteries—and therefore one of the important questions of physics. After all, what would be the use of studying physics if the mysteries were not the most important things to investigate". [2]

and further

> "...One intriguing suggestion is that the universe has a structure analogous to that of a spherical surface. If we move in any direction on such a surface, we never meet a boundary or end, yet the surface is bounded and finite. It might be that our three-dimensional space is such a thing, a tridimensional surface of a four sphere. The arrangement and distribution of galaxies in the world that we see would then be something analogous to a distribution of spots on a spherical ball." [3]

A closer study of Feynman's "intriguing suggestion of spherically closed space" leads to dynamic space described as a spherically closed structure expanding in the direction of the radius in the fourth dimension. Such solution shows the rest energy of matter as the energy of motion mass has due to the expansion of space in the fourth dimension. The dynamics of space is determined by the balance of motion and gravitation in the structure which explains the "the great mystery" of the zero-energy condition between gravitational energy and the rest energy of matter in space. Following the zero energy principle, any motion or gravitational state in space becomes related to the motion and gravitational state of whole space. Clocks in motion and clocks near mass centers run slower due to the linkage between the local energetic environment and the contribution of whole space. Contrary to the theory of relativity, in dynamic space time and distance can be handled as absolute coordinate quantities.

Spherically closed dynamic space is studied in detail in the Dynamic Universe theory [4]; predictions derived are supported by experiments equally or better than the corresponding predictions derived from the theory of relativity and standard cosmology model. The Dynamic Universe gives a holistic, highly ordered picture of space and universe. The multitude forms of local expressions of energy originate from and are related to the energy built up in the contraction − expansion process of spherically closed space. Mass appears as the substance for the expression of energy — mass as such is not observable, it becomes observable through momentum when in motion and through gravitation when at finite distance to other mass.

Dynamic space has generated the rest energy of matter against a release of gravitational energy in a contraction phase from infinity in the past to singularity turning the contraction to expansion. In the expansion phase the rest energy of matter is released back until zero at infinity. At infinity in the future, all motion gained from gravity in the contraction will have been returned back. Mass is conserved but it will no longer be observable because the rest energy of matter will have vanished along with the cessation of motion. The energy of gravitation will also become zero owing to the infinite distances. The cycle of observable physical existence begins at cessation in emptiness and ends at cessation in emptiness.

Basic assumptions of the Dynamic Universe

The basic assumptions needed in a full analysis of spherically closed space are the following:

1. Space inhabiting mass as the substance for the expression of the energies of motion and gravitation is the three-dimensional surface of a four-dimensional sphere

2. The inherent energy of gravitation of mass M on mass m at distance r is defined in hypothetical infinite "exclusive" space where only masses M and m are present

$$E_{g(i)} = -\frac{GmM}{r} \tag{1}$$

3. The inherent momentum and the energy of motion is defined in hypothetical environment at rest

$$E_{m(i)} = v\left|\mathbf{p}_{(i)}\right| = v \cdot m\mathbf{v} \tag{2}$$

The inherent energy of motion is formally identical to the energy of electromagnetic radiation ($E = c \cdot \mathbf{p}$). For motion of mass objects in moving environment like in three-dimensional space the expression of momentum and the energy of motion are modified due to the motion of the space.

4. As the initial condition mass is at rest and uniformly distributed in spherically closed space with infinite 4-radius. The dynamics **of** space is driven by a zero-energy condition of the energies of motion and gravitation. Dynamics **in** space conserve the total energies of motion and gravitation built up through the dynamics **of** space.

Gravitation and dynamics in spherically closed space

The concept of space as a 4-sphere was first time suggested by Ludwig Schläfli and Georg Riemann in the mid-nineteenth century. In a writing on cosmology in 1917 Albert Einstein proposed spherical space as a part of relativistic cosmology. By that time, however, the general theory of relativity had just linked time to space as the fourth dimension, ruling out the possibility of the fourth dimension as the purely geometrical dimension required by an orthodox 4-sphere. Also, Einstein was looking for a static solution for space. Gravitation of mass within a 4-sphere would cause a shrinkage force, which would immediately throw the whole structure into a contracting motion along the radius in the fourth dimension. The reason for Einstein to suggest a cosmological constant was just to prevent such a collapse. At that time understanding of distant space was vague, galactic structures were unknown; the recession of galaxies and expansion of space were discovered by Edvin Hubble in late 20's, about ten years after Einstein's concept of closed static space.

In spherically closed space a natural solution is not static space but space subject to contraction and expansion. Dynamics based on a zero-energy principle shows the rest energy of matter as the energy of motion mass has due to the contraction or expansion of space in the fourth dimension, in the direction of the 4-radius which also means that the velocity light is determined by and equal to the velocity of space. Such a solution explains the character of the velocity of light as the maximum velocity in space and gives a straightforward answer to the mystery regarding the equality of the rest energy and the gravitational energy of all mass in space.

In contraction started from the state of rest at infinity in the past motion is gained against release of gravitational energy, in expansion motion works against gravitation resulting in gradual deceleration of expansion until rest at infinity.

By applying the mass equivalence of spherical space introduced in Figure 1, zero energy balance between motion and gravitation can be expressed as

$$mc^2 - \frac{GmM\,''}{R_4} = 0 \qquad \text{or} \qquad M_\Sigma c^2 - \frac{GM_\Sigma M\,''}{R_4} = 0 \tag{3}$$

where $M_\Sigma = \Sigma m$ is the total mass in space.
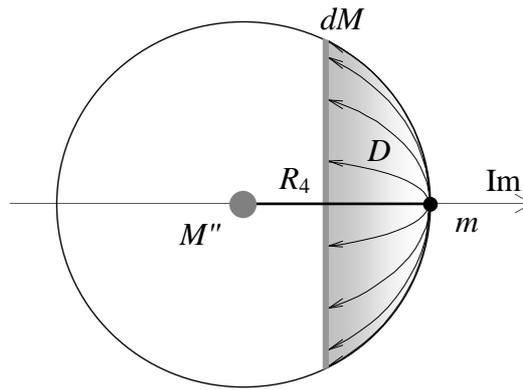
Figure 1. The gravitational energy resulted on mass m by mass M_Σ distributed uniformly in the three dimensional "surface" of a 4-sphere can be calculated by integrating the gravitational energy all around the "surface". The resulting gravitational energy is equal to the gravitational energy resulted by mass equivalence $M"$ at distance $R"$ in the direction of the local imaginary axis. As a consequence of geometrical factors in the 4-sphere, mass equivalence $M" = 0.776 \cdot M_\Sigma$. For mass m in hypothetical homogeneous space distance $R"$ is equal to the 4-radius of space, R_4.

Equation (3) links the velocity of light to the gravitational constant, the total mass in space, and the 4-radius as

$$c = \pm\sqrt{\frac{GM"}{R_4}} \tag{4}$$

where the minus sign describes a contraction phase before singularity. Applying a mass density $\rho \approx 0.55 \cdot \rho_c$, where ρ_c is the Friedmann critical mass density, 4-radius $R" = 14 \cdot 10^9$ light years (present estimate of the Hubble radius), and the gravitational constant $G = 6.7 \cdot 10^{-11}$ [Nm^2/kg^2] equation (4) gives c the measured value of the velocity of light, $c = 300\ 000$ km/s. When solved for time t since singularity, the expansion velocity obtains the form

$$c = \frac{dR_4}{dt} = \left(\frac{2}{3}\frac{GM"}{t}\right)^{1/3} \tag{5}$$

which shows the development of the velocity of light with the expansion of space. Time t from singularity can be expressed as

$$t = \frac{2}{3}\frac{R_4}{c} \tag{6}$$

which means that the age of the expanding universe corresponding to Hubble radius 14 billion light years [equal to Hubble constant $H_0 = 70$ [(km/s)/Mpc] is 9.3 billion years. In dynamic space the rest energy of matter goes down with expansion

$$E"_m = -E"_g = \left(\frac{2}{3}\frac{GM"^2}{t}\right)^{2/3} \tag{7}$$

as a consequence, like the frequency of atomic oscillators, also the rate of radioactive decay goes down which means that presently applied linear interpretation of radioactive dating data from time close to singularity gives too high age estimates.

Declining of the velocity of light with the expansion of space, in meters/second, is not observable since the definition of a second is based on the length of an oscillation cycle of atomic oscil-

lators, which change in direct proportion to the change in the velocity of light. The relative declining of the velocity of light in the present state of the universe is about $\Delta c/c \approx 4 \cdot 10^{-11}$/year.

In the dynamic zero-energy process, space is first accelerated inward by its own gravitation, starting from infinite 4-radius, $R_4 = \infty$. The acceleration culminates in singularity with infinite energy of motion at the center of the sphere. The energy of motion is gained against loss of gravitational energy: as the energy of motion increases to infinity, the energy of gravitation decreases to minus infinity. The development of the energies of motion (rest energy of matter in space) and gravitation from infinity in the past to infinity in the future is illustrated in Figure 2 based on equation (5). At infinity in the past like at infinity in the future, the 4-radius of space is infinite and motion is ceased. Mass exists, but as it is not energized it is not detectable. Mass can be understood as the substance for the expression energy. Mass is not detectable as such but through motion or interaction with other mass.
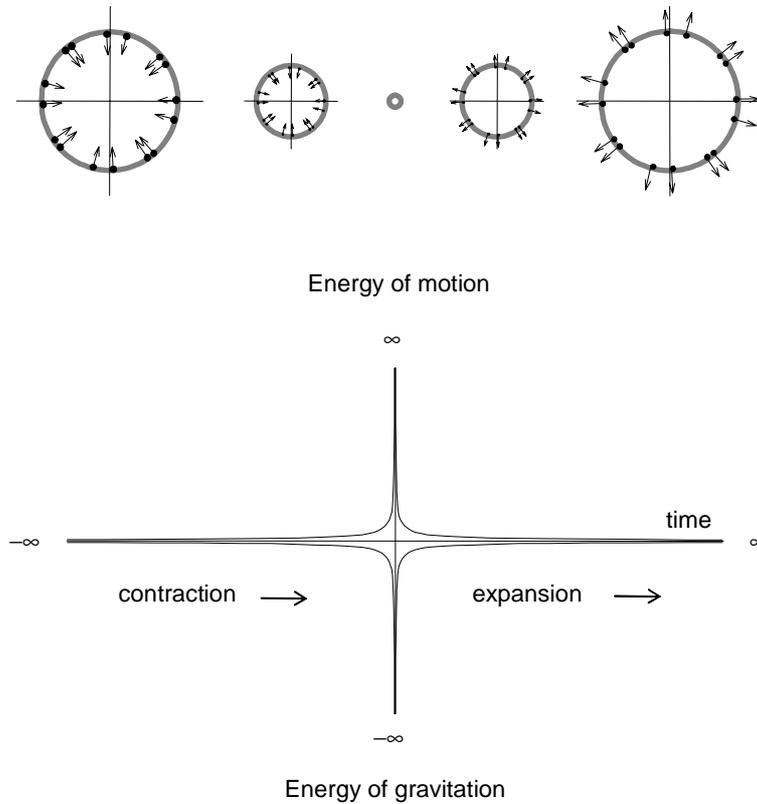

Figure 2. Contraction and expansion of space and the corresponding evolution of the energies of motion and gravitation. In the contraction phase, the 4-radius of space goes from infinity to zero. In the expansion phase, after singularity, the radius increases from zero back to infinity. Zero total energy is preserved through the entire process.

The rest energy of matter

Any mass object in space has obtained its rest energy against release of gravitational energy in the contraction phase of space. The rest energy is balanced by the gravitational energy of all mass in space, i.e. the energetic state of a mass object is characterized as an excited state of the energies of motion and gravitation. For mass object m at rest in homogeneous space the energy balance between the energy of motion E''_m and the energy of gravitation E''_g can be expressed as

$$E''_m + E''_g = 0 \qquad \text{or} \qquad mc^2 = m\frac{GM''}{R_4} \qquad (8)$$

Energetically, there is no need to antimatter with negative energy, gravitational energy related a mass object serves as the negative counterpart to the positive rest energy, Figure 3.
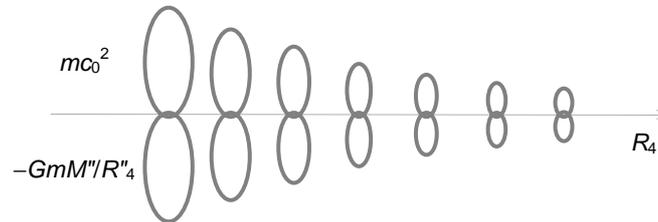

Figure 3. The two-fold nature of matter at rest in space is manifested by the energies of motion and gravitation. The intensity of the energies of motion and gravitation declines as space expands along the 4-radius.

Fourth dimension in spherically closed space

When the fourth dimension is interpreted as a geometrical dimension, as it should in a spherically closed dynamic space, a line element in the fourth dimension $|ds_4| = c \cdot dt$ means the distance traveled by space due to expansion in time interval dt. As a consequence, the momentum of mass m due to expansion is $\mathbf{p}_4 = m\mathbf{c}_4$ and the energy of motion, when expressed as inherent energy of motion, formally like the energy of electromagnetic radiation propagating at velocity c, obtains the form $E_{m4} = c \cdot |\mathbf{p}_4| = c \cdot |m\mathbf{c}_4|$ or $E_{m4} = mc^2$, which shows the rest energy of matter as the "energy equivalence" of momentum in the fourth dimension. The total momentum of an object can now be expressed as the orthogonal sum of the momentum in space, in one of the three space directions, and momentum in the fourth dimension due to the motion of space as

$$\mathbf{p}_{tot} = \mathbf{p} + \mathbf{p}_4 \qquad (9)$$

and the corresponding energy as

$$E_{tot} = c \mid \mathbf{p}_{tot} \mid = c\sqrt{\left|m\mathbf{c}_4\right|^2 + \left|\mathbf{p}\right|^2} \qquad (10)$$

which is the well known expression of the total energy introduced by the theory of special relativity through a completely different reasoning.

It is useful to describe the four-dimensional system in complex coordinates where space directions (x,y,z) are described as real axes and the fourth dimension as the imaginary axis perpendicular to all real axes. By choosing a space direction (generally denoted as r) the effect of fourth dimension can be expressed in two-dimensional complex coordinates where the real axis is the selected space direction $\{r\}$ and the imaginary direction the fourth dimension along the radius R'' pointing from the mass equivalence of the spherical space.

For a mass object at rest in space the "rest momentum" $\mathbf{p}_{\text{rest}} = \mathrm{i}\,mc$ appears in the imaginary direction, perpendicular to any space direction. When the object is given velocity $\mathbf{v}$ in space direction $\{r\}$, the total velocity has a direction combining the real and imaginary components, velocity $\mathbf{v}$ in along the real axis $\{r\}$ and velocity $\mathbf{c}$ along the imaginary axis $\{R''\}$. The total energy of the moving object is the sum of the rest energy and the kinetic energy needed to obtain velocity $\mathbf{v}$ in space.

For conserving the rest energy $E_{\text{rest}} = c|m\mathbf{c}|$ of an object in motion, the scalar value of the rest momentum $|m\mathbf{c}|$ must be conserved. If the rest momentum has component $m\mathbf{v}$ in space direction

{r}, the component in the imaginary direction is reduced by factor $\sqrt{1-\beta^2}$ where $\beta = v/c$ and the rest momentum of the moving object obtains the form

$$\mathbf{p}_{\text{rest}} = m\mathbf{v} + \mathrm{i}\, m\sqrt{1-\beta^2}\, \mathbf{c} \quad ; \quad |\mathbf{p}_{\text{rest}}| = mc \qquad (11)$$

Equation (11) means that the direction of the rest momentum of an object moving in space is turned by angle $\psi = \arcsin(v/c)$ from direction of the imaginary axis, Figure 4.

Momentum $\mathbf{p}$ needed to be applied to mass object m at rest in order turn the direction of momentum $\mathrm{i}\, mc_4$ by angle ψ an be expressed as

$$p = |\mathbf{p}| = mc \tan\psi = mc \frac{\sin\psi}{\cos\psi} = mc \frac{\beta}{\sqrt{1-\beta^2}} = \frac{mv}{\sqrt{1-\beta^2}} = m_{\text{eff}}\, v \qquad (12)$$

as illustrated in Figure 5(a).
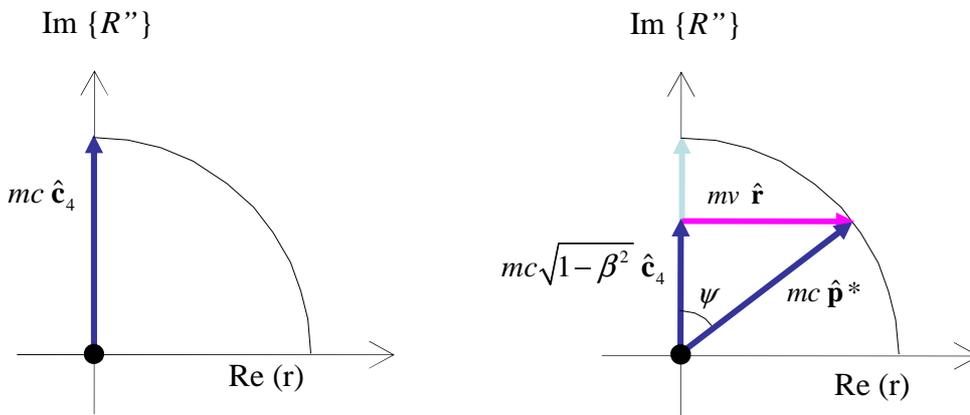
Figure 4. The rest momentum of an object (a) at rest in space and (b) moving at velocity $\mathbf{v}$ in space direction {r}.
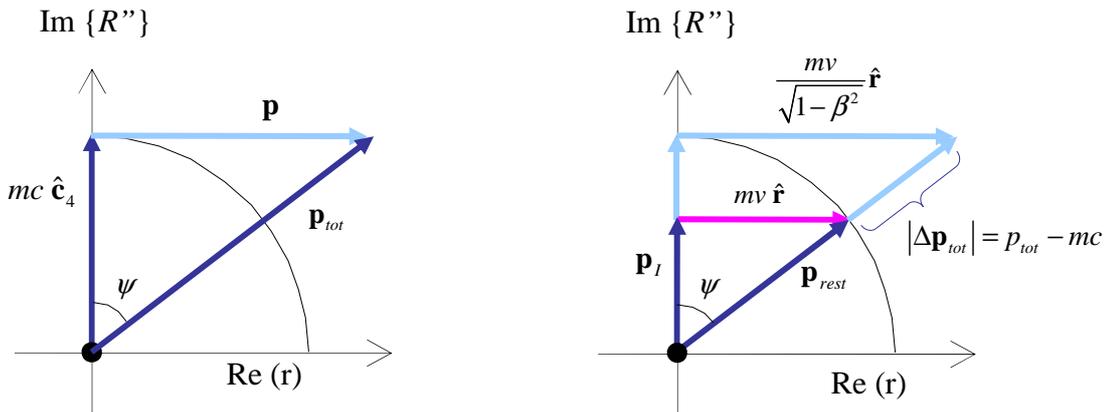
Figure 5. (a) Total momentum $\mathbf{p}_{\text{tot}}$ as the sum the momentum at rest mc_4 and momentum $\mathbf{p}$ applied in a space direction. The scalar value of momentum $\mathbf{p}_{\text{tot}}$ is increased by $\Delta\mathbf{p}_{\text{tot}}$ with energy equivalence $\Delta E = c|\Delta\mathbf{p}_{\text{tot}}|$ which is the kinetic energy related to the motion in the local energy frame. The internal momentum $\mathbf{p}_I$ is the imaginary component of the rest momentum $\mathbf{p}_{\text{rest}}$.

Figure 5(b) shows the increase in the scalar value of total momentum $|\Delta\mathbf{p}_{\text{tot}}|$ which, with reference to equations (11) and (12) has the value

$$|\Delta\mathbf{p}| = \frac{mc}{\sqrt{1-\beta^2}} - mc = mc\left(\frac{1}{\sqrt{1-\beta^2}} - 1\right) \tag{13}$$

with energy equivalence

$$\Delta E = c|\Delta\mathbf{p}| = mc^2\left(\frac{1}{\sqrt{1-\beta^2}} - 1\right) = E_{kin} \tag{14}$$

which means the work needed to put mass object m into motion at velocity v in space. Equation is equal to the expression of kinetic energy derived in the theory of special relativity, again, through a completely different reasoning. Equations (11–14) also mean that the imaginary velocity, the velocity of space in the direction of the 4-radius, is the maximum velocity obtainable in space.

The kinetic energy of an object is reversible, it is released when the object is returned to *the state of rest in the energy frame the motion has been obtained*. The rest energy of the object can be characterized as the intrinsic energy of the object, it is released only in billions and billions of years through the work the expansion of space does against the gravitation in the direction of the 4-radius of space. As illustrated in Figures 4 and 5 an effect of motion in space is the turn of the rest momentum by angle ψ towards the direction of velocity $\mathbf{v}$. As a result the component of the rest momentum in the direction of the 4-radius is reduced by factor $\sqrt{1-\beta^2}$ i.e. *the momentum working against the gravitation of the total mass in space is reduced*. Because the velocity of space, i $\mathbf{c}$, is independent of the motion of an object in space the reduction of the momentum is described as a reduction of the *internal mass m_I* of the object

$$m_{I(\beta)} = m\sqrt{1-\beta^2} \quad ; \quad \mathbf{p}_{I(\beta)} = m_{I(\beta)}\mathbf{c}_4 \tag{15}$$

Internal mass related *internal momentum* in the fourth dimension is the counterpart of *external mass* (the effective mass) related to velocity and momentum in space directions [compare equations (12) and (15)].

The reduced work done against gravitation in the direction of the 4-radius can be expressed as

$$E_{I(m)} = c|\mathbf{p}_I| = cm_I c = mc^2\sqrt{1-\beta^2} \tag{16}$$

where E_I is referred to as the *internal energy* of the object. The reduction of the internal energy is the work done in reducing the effective gravitational energy of the total mass in space on the moving object. This is a quantitative interpretation of Mach's principle, the linkage of the total mass in space to the buildup of kinetic energy of an object accelerated in space.

Effect of gravitation on the local velocity of light

The picture of regular spherical space was based on homogeneous distribution of mass as we can assume at cosmology level. Locally, mass has accumulated into mass centers. Following the zero-energy principle and the conservation the total momentum due to the expansion of space along the 4-radius, it can be shown that accumulation of mass into mass centers in space result in bending of the 4-surface in the fourth dimension, Figure 7. In bended space the direction of local fourth dimension (local imaginary direction) deviates from the direction of the 4-radius. Accordingly, also the local imaginary velocity of space is reduced by factor $\cos\phi$ from the velocity of the expansion in the direction of R_4, the direction of imaginary axis in homogeneous space, Figure 7.
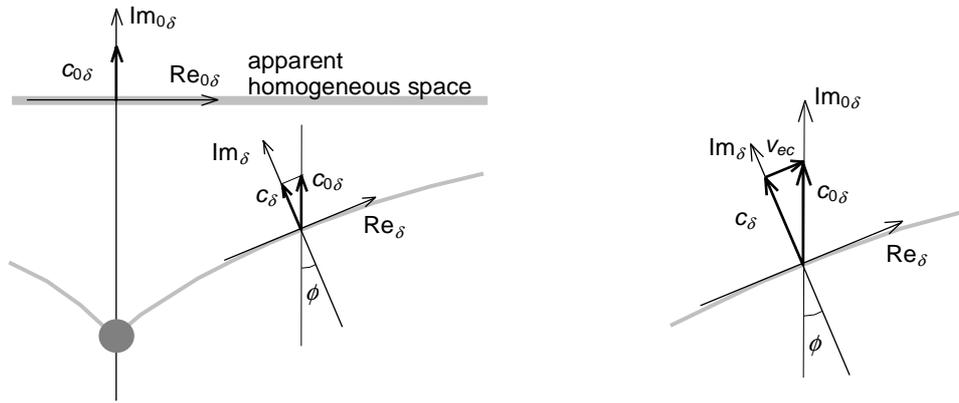
Figure 7. Space is tilted in the fourth dimension close to mass centers in space. Local complex coordinates follow the shape of space, causing the local imaginary axis, Im_δ, to deviate from the direction of the imaginary axis in apparent homogeneous space, $Im_{0\delta}$. The imaginary velocity of space in the δ-state, c_δ, is reduced according to the formula $c_\delta = c_{0\delta} \cos\phi$, where ϕ is the tilting angle of space in the δ-state. The orthogonal sum of the local imaginary velocity and the escape velocity, v_{ec}, to apparent homogeneous space is equal to the imaginary velocity of the apparent homogeneous space as illustrated in the picture on the right.

In a detailed analysis factor $\cos\phi$ can be related to distance $r_{0\delta}$ measured in the direction of non-tilted space and mass M of the local gravitational center as

$$\cos\phi = 1 - \delta = 1 - \frac{GM}{r_{0\delta}c^2} \tag{20}$$

which means that the local velocity of light shall be expressed as

$$c_\delta = c = c_{0\delta}(1-\delta) = c_{0\delta}\left(1 - \frac{GM}{r_{0\delta}c_0 c_{0\delta}}\right) \approx c_{0\delta}\left(1 - \frac{GM}{r_{0\delta}c^2}\right) \tag{21}$$

where $c_{0\delta}$ means the velocity of light in apparent homogeneous space related to the local gravitational frame (the local dent in space). In tiled space the reduced gravitational energy related to the mass equivalence is equal to

$$E''_{g(0\delta)} = E^*_{g(0\delta)}(1-\delta) = \frac{GM''}{R''_{0\delta}}\left(1 - \frac{GM}{r_{0\delta}c^2}\right) = E^*_{g(0\delta)} - E_G \tag{22}$$

where E_G is local gravitational potential, the work released when mass m in taken far from mass center M to distance r from M

$$E_G = -\frac{GM}{r_{0\delta}} \tag{23}$$

In a precise analysis gravitational energy E_G is a complex function

$$E_G = -\frac{GmM}{r_{0\delta}}\left[\sin\phi + i_\delta \cos\phi\right] = -\frac{GmM}{r_{0\delta}}\sqrt{1-(1-\delta)^2} - i_\delta \frac{GmM}{r_\delta} \tag{24}$$

with the imaginary part equal to Newtonian gravitational energy, where distance r_δ means the distance along the tangent of space at the location on mass m, Figure 8.
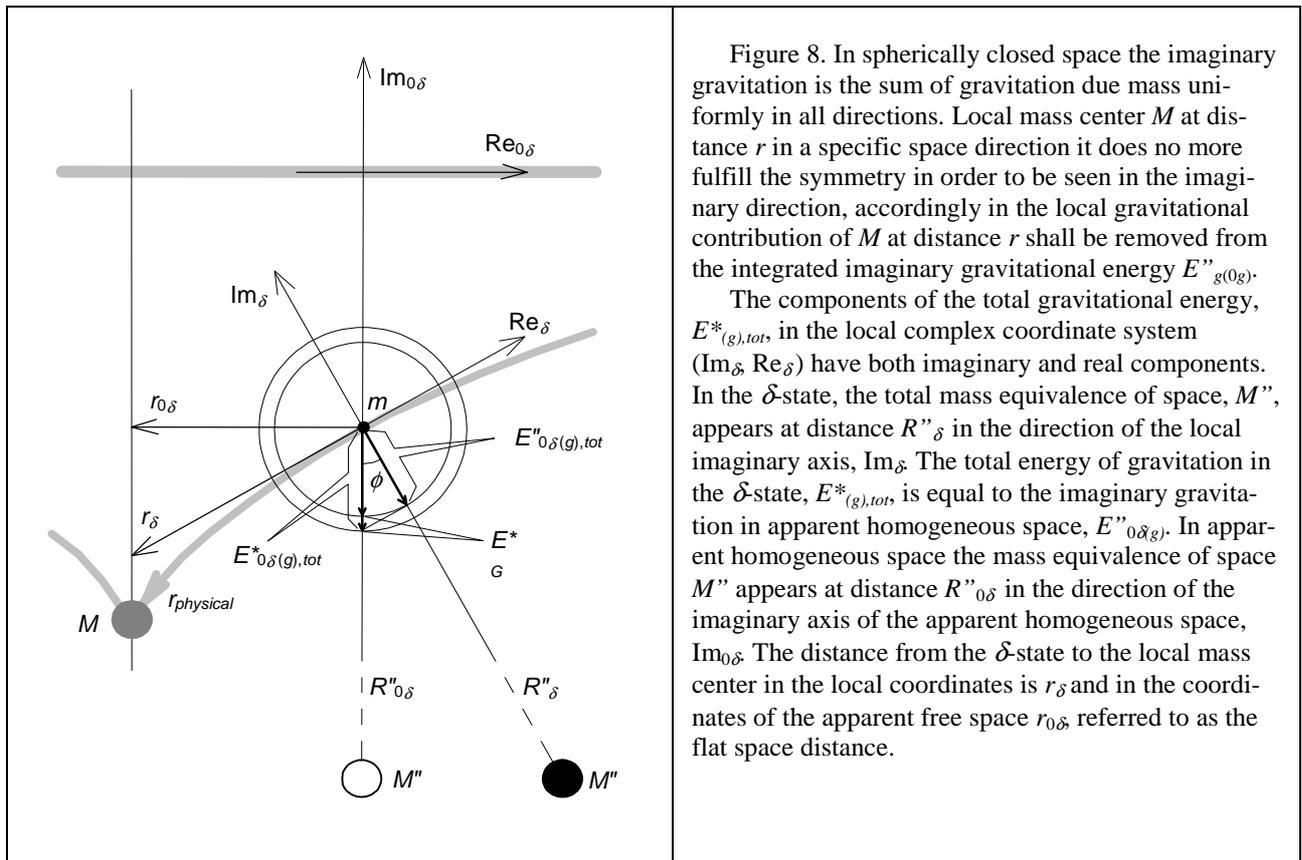
Figure 8. In spherically closed space the imaginary gravitation is the sum of gravitation due mass uniformly in all directions. Local mass center M at distance r in a specific space direction it does no more fulfill the symmetry in order to be seen in the imaginary direction, accordingly in the local gravitational contribution of M at distance r shall be removed from the integrated imaginary gravitational energy $E''_{g(0g)}$.

The components of the total gravitational energy, $E^*_{(g),tot}$, in the local complex coordinate system (Im_δ, Re_δ) have both imaginary and real components. In the δ-state, the total mass equivalence of space, M'', appears at distance R''_δ in the direction of the local imaginary axis, Im_δ. The total energy of gravitation in the δ-state, $E^*_{(g),tot}$, is equal to the imaginary gravitation in apparent homogeneous space, $E''_{0\delta(g)}$. In apparent homogeneous space the mass equivalence of space M'' appears at distance $R''_{0\delta}$ in the direction of the imaginary axis of the apparent homogeneous space, $Im_{0\delta}$. The distance from the δ-state to the local mass center in the local coordinates is r_δ and in the coordinates of the apparent free space $r_{0\delta}$, referred to as the flat space distance.

In tilted space the momentum of a mass object in the fourth dimension is reduced due to the reduced velocity c_δ in the fourth dimension

$$\mathbf{p}_{I(\delta)} = m_I \mathbf{c}_{4(\delta)} = m_I c_{0\delta} (1-\delta) \hat{\mathbf{c}}_{4(\delta)} = m c_{0\delta} (1-\delta) \sqrt{1-\beta^2} \; \hat{\mathbf{c}}_{4(\delta)} \tag{25}$$

The momentum in the fourth dimension is reduced by the velocity of the object in space through the reduction of the internal mass and due to closeness of a mass center through the reduction of the local velocity of light. It will be shown that the frequency of an atomic oscillator is directly proportional to the internal momentum of the oscillating object. Accordingly, equation (25) gives the effects of local gravitation and motion on the frequency of atomic oscillators.

Homogeneous space and the state of rest

The zero-energy principle allows precise definition of a state of rest — both locally and in absolute sense. In space absolute state of rest means the state of rest in hypothetical homogeneous space where no gravitational energy has been conversed into motion in space. Fourth dimension in homogeneous space has the direction of the 4-radius of space. Accumulation of mass into mass centers in space results in formation of dents around the centers. In a second step accumulation of smaller centers within the first dent result in "sub-dents", local gravitational frames within the parent frame, Figure 8. Following the zero energy principle, in each sub-frame the velocity of light is related to the velocity of light in the parent frame, seen as apparent homogeneous space to the sub-frame.
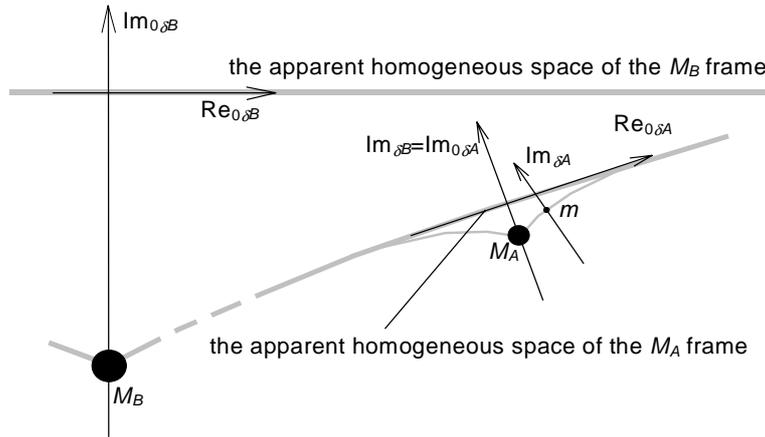
Figure 8. The profile of space in the neighborhood of local mass centers. Each mass center causes local tilting of space relative to the apparent homogeneous space and, finally, hypothetical homogeneous space.

Finally, the local velocity of light can be linked through the chain of cascaded parent frames to the velocity of light c_0 in hypothetical homogeneous space

$$c_{(\delta_n)} = c_0 \prod_{i=1}^{n} \left(1 - \frac{GM_i}{r_i c_i c_0}\right) = c_0 \prod_{i=1}^{n} \left(1 - \delta_i\right) \tag{26}$$

where gravitational factors δ_i combine the effects of the gravitational potential in each gravitational frame (like the gravitational potential determined by altitude in the Earth gravitational frame, gravitational potential of the Earth in the Sun gravitational frame, gravitational potential of the solar system in the Milky Way, ect.).

Corresponding conclusions can be made regarding frames combining motion and gravitation or more generally, motion and potential energy. A sub-frame can be considered as an energy object in the parent frame, the rest mass available for an object in a sub-frame is the internal mass of the energy characteristic to the sub-frame in its parent frame. In each frame the energy of motion shall be paid back to the potential energy it has been gained from. As the result the internal mass of an object can be linked to the rest mass m_0 of the object at rest in hypothetical homogeneous space as

$$m_{I(\beta_n)} = m_0 \prod_{i=1}^{n} \sqrt{1 - \beta_i^2} \tag{27}$$

where velocities β_i combine the effects of motions the object in each of the cascaded energy frames (like motion in an accelerator, motion of the accelerator in the Earth gravitational frame, motion of the Earth in the Sun frame, motion of the solar system in the Milky Way, ect.).

Tilting of space near mass centers together with the reduction of the local velocity light give precise predictions to the bending of light and the Shapiro delay in a complete agreement with observations.

The equation of motion based on local geometry of space and the conservation of the total energy in free fall (momentums in space and in the imaginary direction) appear in form

$$\mathbf{a}_{0\delta} = \ddot{\mathbf{r}}_{0\delta} = \frac{c_{0\delta}}{c_0} \frac{GM}{r_{0\delta}^2} \left(1 - \delta\right)^3 \hat{\mathbf{r}}_{0\delta} \tag{28}$$

which result in perihelion advance

$$\Delta \psi_{0\delta}(2\pi) = \frac{6\pi r_c}{a\left(1 - e^2\right)} \tag{29}$$

for elliptical planetary orbits with eccentricity e (equal to that derived from GR).

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Electromagnetic energy and the energy of a quantum

The motion of space at velocity c in the fourth dimension and the interpretation of the rest energy of matter as the energy of motion allow the interpretation of Coulomb force as the electromagnetic force due to the motion of charges at velocity c in the fourth dimension. By applying vacuum permeability μ_0, which can be shown to independent of the velocity of the expansion of space, instead of vacuum permittivity ε_0, the Coulomb energy can be expressed in form

$$E_{\mathrm{EM}} = \frac{q_1 q_2 \mu_0}{4\pi r} c_0 c \approx \frac{q_1 q_2 \mu_0}{4\pi r} c^2 \tag{30}$$

where factor

$$\frac{q_1 q_2 \mu_0}{4\pi r} = m_{EM} \tag{31}$$

has the dimension of mass [kg] and can be regarded as the mass equivalence, the substance of electromagnetic energy allowing the expression of electromagnetic energy in form equal to the form of rest energy as

$$E_{\mathrm{EM}} = m_{EM} \, c^2 \tag{32}$$

Solution given by Maxwell's equation to the energy flow of one cycle in a dipole of length z_0 can be developed into form (without any assumptions related to dynamic space)

$$E_{\lambda 0} = \frac{P}{f} = \frac{N^2 e^2 z_0^2 \chi \mu_0 16 \pi^4 f^4}{12\pi c f} = N^2 \left(\frac{z_0}{\lambda} \right)^2 \frac{2}{3} \left(2\pi^3 e^2 \mu_0 c \right) f \tag{33}$$

where N^2 is the number of unit charges oscillating in the dipole at frequency f. Factor 2/3 means the ratio of average power density of radiation to the power density emitted along the normal plane of the dipole. The constant in parenthesis, $2\pi^3 e^2 \mu_0 c$, has the dimensions of momentum–length, like Planck's constant h. Applying an effective dipole length slightly above a wavelength, $z_0/\lambda = 1.051$, also the numerical value of the constant is equal to Planck's constant, $(z_0/\lambda)^2 \cdot 2\pi^3 e^2 \mu_0 c = 6.6256 \cdot 10^{-34} = h$ [kgm²/s]. Accordingly, an ideal dipole with the power distribution factor equal to 1 and an effective length $z_0/\lambda = 1.051$ emits one quantum per cycle for each oscillating unit charge

$$E_{\lambda 0} = \left(1.051 \cdot 2\pi^3 e^2 \mu_0 c_0 \right) f = h \, f \tag{34}$$

In dynamic space a point emitter like atom moves at velocity c in the fourth dimension, i.e. the distance of one wavelength in a cycle. Accordingly, energy transition in an atomic emitter can be regarded as one oscillation cycle occurring while the source has traveled one wavelength in the fourth dimension. Because all space directions are perpendicular to the motion, all space directions appear in the direction of the normal plane of the dipole resulting in power distribution factor equal to 1. Such point source fulfils the criteria of a quantum emitter. The effective dipole length $z_0 = \lambda \cdot 1.05$ (instead of $z_0 = \lambda$) of a quantum emitter may be due to the 4-D geometry. As shown by equation (34) the factor giving the Planck's constant contains the velocity of light (or more correctly, the velocity of the expansion of space, c_0) as an internal factor. By separating the c from Planck's constant, the Planck's equation obtains the form

$$E_{\lambda 0} = h \, f = h_0 c_0 \, f = \frac{h_0}{\lambda} c c_0 = c_0 m_{\lambda 0} \, c \tag{35}$$

where constant $h_0 = h/c$ is called "the intrinsic Planck's constant" independent of the expansion of space. The intrinsic Planck's constant has the dimension of kilogram-meters [kg·m], which gives the quantity $h_0/\lambda = m_{0\lambda}$ [kg] the meaning of mass equivalence of electromagnetic radiation and

allows the expression of the energy of a radiation quantum in form formally equal to the expression of rest mass.

Equation (35) give a physical meaning to energy quantum:

Quantum of electromagnetic radiation is the energy of one cycle of radiation emitted by one oscillation cycle of a unit charge in a quantum emitter.

The Heisenberg uncertainty principle turns into a clear message:

In order to obtain full information about the substance available in an energy quantum for the expression of momentum, we need to observe the full wavelength of the wave.

Frequency of atomic oscillators

The characteristic absorption and emission frequencies related to energy transitions in the electron structure of hydrogen atom is given by Balmer's formula which can be expressed as

$$f_{1,2} = RcZ^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right) \tag{36}$$

By applying the intrinsic Planck's constant the Rydberg's constant, R, obtains the form

$$R \approx R_\infty = \frac{m_e e^4}{8\varepsilon_0^2 h^3 c} = \frac{m_e e^4 \mu_0^2 c^4}{8h_0^3 c^3 c} = \frac{m_e e^4 \mu_0^2}{8h_0^3} \tag{37}$$

showing that R is independent of the velocity of light, c. Balmer's formula can now be expressed in form

$$f_{1,2} = \frac{e^4 \mu_0^2}{8h_0^3} Z^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right) m_e c \tag{38}$$

which shows that the characteristic frequency is directly proportional to the velocity of light. By applying the effects of motion and gravitation on c and m_e given in equations (26) and (27), equation (38) obtains the form

$$f_{1,2} = f_{1,2(0)} \prod_{i=1...n} \left[(1-\delta_i)\sqrt{1-\beta_i^2} \right] \tag{39}$$

where $f_{1,2(0)}$ is the frequency of the oscillator at rest in hypothetical homogeneous space. As shown by equation (39) the dependence of the characteristic absorption and emission as well as oscillation frequencies of hydrogen atom on the velocity and gravitational state of the atom. The definition of the state of rest and the predictions given by equations (39) are in a complete agreement with all experiments made with atomic clocks or any other instrument used to detect the "relativistic time dilation" or the constancy of the velocity of light.

Observing that wavelength $\lambda = c/f$ means that, unlike the emission and oscillation frequency, the emission wavelength is not a function of c. This means that the emission wavelength is independent of the gravitational state of the emitter. It also means that the characteristic wavelength remains constant in the course of the expansion of space, which confirms the interpretation of the Hubble law as the effect of expansion on the wavelength during the transmission from the emitter to the observer.

Cosmological consequences

Spherically closed space gives a more ordered picture of the universe than that suggested by cosmology models based on the theory of relativity. The buildup and release of the rest energy of matter can be understood as a continuous process from infinity in the past through singularity to infinity in the future. The instantaneous singularity is not a "hot Big Bang" but an ultimate excitation of the rest energy of matter.

The contraction and expansion of space is considered as the primary energy buildup and release. As the initial condition the total mass of the universe is considered as being uniformly distributed throughout space. Condensation of matter into clusters in space is considered as a process of secondary energy buildup. The secondary energy buildup creates conditions, local singularities, "black holes", where the formless matter energized in the primary energy buildup is converted into electromagnetic radiation, elementary particles, and atomic structures.

In the preset state of expansion the 4-radius of the universe can be estimated to be about 14 billion light years (corresponding to Hubble constant $H_0 = 70$ (km/s)/Mpc). Since the expansion velocity has been faster in the past the corresponding time from singularity is 9.3 billion years. The expansion of space slows down gradually, present decrease in the expansion velocity (and the velocity of light) is $\Delta c/c \approx -3.6 \cdot 10^{-11}$ /year.

The expansion of space occurs uniformly everywhere in space, not only between galaxies or galaxy groups as taught by the standard model. The dimensions of galaxies and the radii of orbiting stellar systems are subject to expansion. Atomic radii, however, are conserved. The precise geometry, dynamics and energetic development of space allow the derivation of precise mathematical expressions for redshifts, optical distances, angular sizes, and apparent magnitudes of cosmological objects throughout the development of the Universe. The background radiation obtains a precise expression as the radiation propagated 360 degrees around expanding spherical space. What we see in the background radiation is the light emitted by the location of our own galaxy about 750 000 years after the singularity. The redshift of background radiation is $z = e^{2\pi} - 1 \approx 534.5$.

Predictions derived from the spherical, dynamic space in absolute time pass key cosmology tests equally or better than the corresponding predictions derived from the theory of general relativity and standard cosmology model (magnitude/redshift, Euclidean appearance of the angular size of distant objects, perihelion advance of elliptic orbits, bending of light and delay of radio signals near mass centers).

When interpreted with the standard model, recent observations of the magnitudes of distant supernova explosions have re-evoked discussions on the cosmology constant and created speculation of unknown repulsive forces at cosmological distances. However, the prediction derived from dynamic space corresponds exactly to recent observations without any new assumptions or free parameters, Figure 9.

Conclusions

As a basic feature of scientific thinking the reality behind natural phenomena should be understood unchangeable and independent of the models we use to describe it. The best a scientific model can give is a description which makes the reality understandable, rely on sound basic assumptions and internally coherent logic, and, specifically in physics and cosmology, gives precise predictions to phenomena observed and to be observed.

Apparent magnitude / redshift observed in supernova explosions

Apparent magnitude

$\Omega_M = 0.25$, $\Omega_\Lambda = 0.75$ accelerating expansion, best fit with cosmology constant in standard model (Knop et.al. [1])

DU prediction:
$m = 24.06 + 5 \log z + 2.5 \log(z+1)$

$\Omega_M = 0.25$, $\Omega_\Lambda = 0$

$\Omega_M = 1$, $\Omega_\Lambda = 0$ "flat space", Einstein - deSitter model, zero cosmology constant (Knop et.al. [1])

Redshift (z)

	sn2002dd and sn1997ff
	Knop's data from column c in Table 3
	Knop's data from column c in Table 4
	Low-z data from column d in Table 5
	outliers skipped in chi-square calculation

DU-prediction:
=====================
N (data points)   = 54
DF   = 53
chi-square   = 57.2017
chi-square / DF   = 1.08

Data collection and chi-square calculation by Bob Day

Knop et.al., "New Constraints on Omega_M, Omega_Lambda, and w from an Independent Set of Eleven High-Redshift Supernovae Observed with HST", The Astrophysical Journal, 598:102–137, 2003 November 20.

Figure 9. For a satisfactory fit with observations, the interpretation of recent supernova observations [5] (magnitude/redshift) with standard model requires an assumption of "dark energy" with gravitational "push" at cosmological distances. Mathematically this can be demonstrated by re-introducing a cosmology constant rejected by Einstein after Hubble's findings of expanding space in late 1920's. Such solution means that the expansion of space is accelerating instead of decelerating as predicted by the "classical" Einstein - deSitter model.

The prediction derived from Dynamic Universe (DU) gives an excellent fit with observations without any free parameter or new assumption. The expansion of space continues forever with a decreasing velocity until zero at infinity.

We can identify three kinds of qualities or factors a physical model is based on

1. Basic laws of nature, fundamental quantities and natural constants
> The identification of the laws of nature is based on experience and reasoning of the general "rules" nature is found to express itself.

2. Phenomena to be described as consequences of the basic laws
> A successful description of a phenomenon generates predictions for observations made or to be made.

3. Coordinate quantities used as measures in describing phenomena
> Coordinate quantities, the basic measures, allow quantitative expressions of physical phenomena in form consistent with human perception.

We are not free to choose the laws of nature but we have considerable freedom in choosing the coordinate quantities. Time and distance are the most fundamental coordinate quantities. For human perception and logic time and distance shall be universal for all physical phenomena described. It's a basic rule in all measurements not to change measures for a phenomenon in differ-

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ent environments or circumstances; adjusting the measures is a shortcut, a false way out hiding the problem.

There is no need to sacrifice the constancy and universality of the basic coordinate quantities, distance and time, for right predictions of the frequencies of atomic oscillators and the seeming constancy of the velocity of light.

In space described as spherically closed entity with dynamics determined by zero-energy balance between motion and gravitation, absolute time and universal distance unit can be applied for all phenomena in space.

The choice is this:

If we fix the velocity of light and make it the maximum speed in space by applying Lorentz transformation as a law of nature, we have to use time and distance as parameters in describing the behavior of atomic oscillators and measurements of the phase velocity of light in moving frames. We have to postulate the rest energy of matter as a property of mass and accept a relative state of rest as our reference for motion. We are not able to conclude either the overall geometry of space or the development of the geometry with the expansion of space.

If we describe space as a dynamic zero-energy surface of a 4-dimensional sphere, time and distance can be used as absolute coordinate quantities and we understand the dependence of the velocity of light on the development of the universe and on local gravitational state. We can relate the value of the velocity of light to the total mass and dimensions of space, we understand why and when the velocity of light is observed as being constant, and also why the velocity of light is the maximum speed achievable in space. Further, we can define the state of rest in any local energy frame and relate that to the absolute state of rest in space. We can identify a quantitative expression to Mach's principle, to the nature of mass, and a quantum of energy.

The curious concept of time in theory of relativity was originally justified with and based on the relative velocity between the observer and the object. We know for sure, that the reading cumulated in the counter of a clock is unambiguously determined by the gravitational and motional state of the clock, it is not related to any particular observer. In energetic sense, the state of rest is always related to the local energy frame where motion is obtained.

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