Dynamic Space Converts Relativity
Into Absolute Time And Distance

(Tuomo Suntola)

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.

* * * * *

1 - Space as the surface of a 4-sphere

Many physicists have noticed the striking equivalence between the total rest energy of all mass in space and the gravitational energy of space estimated from Newton's gravitational energy as $E \approx GM_\Sigma^2/R$ where $R = c/H$ is the Hubble radius. For further analysis of the total gravitational energy we need to assume certain geometry of space. A natural solution is a three-dimensional surface of a four-dimensional sphere. Following the ideas of Ludwig Schläfli, Georg Riemann and Ernst Mach, Einstein, Ref. [1] proposed such geometry in 1917. Einstein was looking for static space, which lead to the need of the cosmology constant to prevent shrinkage of the structure. Further, the fourth dimension was already reserved for time in the theory of relativity just completed. As the result, the spherical space was rejected.

Combining the idea of space as the surface of a 4-sphere to the mystery of the equality between the gravitational energy and the rest energy of mass in space suggests that space as the surface of a 4-sphere is in motion at velocity c in the direction of the radius of the 4-sphere so that the energy of motion related to mass in space moving at velocity c along the 4-radius is written like the energy of light as $E = cp = c \cdot M_\Sigma c = M_\Sigma c^2$ (see Figure 1).
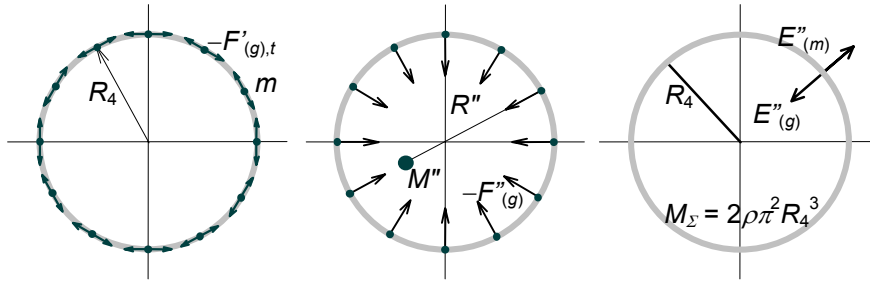

Figure 1. The tangential shrinking force, $F'_{(g),t}$, due to the gravitation of uniformly distributed mass in spherical space is equivalent to the gravitational effect, $F''_{(g)}$, of mass equivalence M'' at distance R'' from mass m along the 4-radius of the structure. The sum of the total energies of motion and gravitation in space is zero.

A detailed mathematical analysis taking into account the four-dimensional geometry in the expression for the gravitational energy allows the zero-energy balance between motion and gravitation to written in form

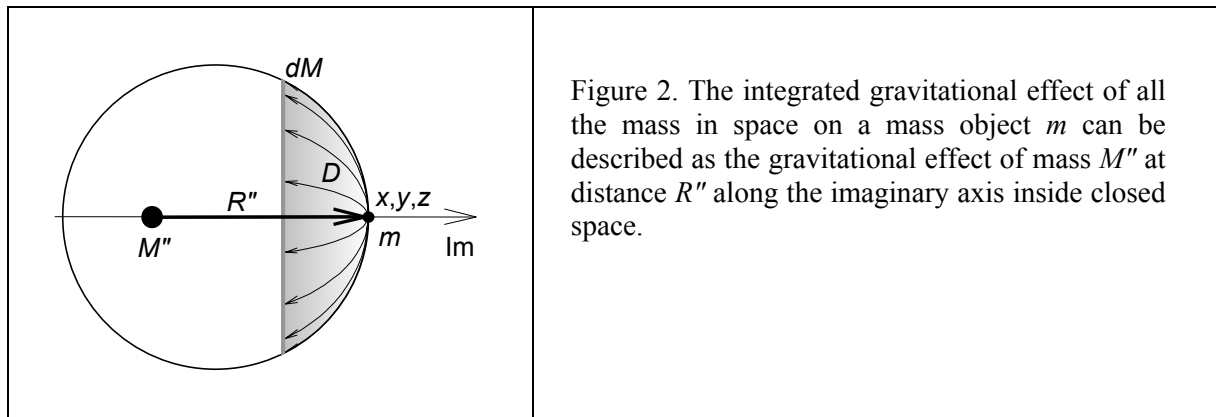$$M_\Sigma c_0^2 - \frac{GG_E M_\Sigma^2}{R_4} = 0 \tag{1}$$

where $G_E = 0.776$ is a geometrical factor resulting from the integration of the gravitational energy throughout the three-dimensional surface of the 4-sphere, Ref. [2].

When solved for the velocity of space, c_0, in the direction of the radius of the structure we get

$$c_0 = \pm\sqrt{\frac{GG_E M_\Sigma}{R_4}} = \pm\sqrt{\frac{GM''}{R''}} \tag{2}$$

which means that for maintaining the zero energy balance in space the velocity of expansion or contraction along the 4-radius is linked to the gravitational constant, total mass in space and the actual length of the 4-radius. For a mass density $5 \cdot 10^{-27}$ [kg/m^3], which is 0.55 times the Friedmann critical mass, and the 4-radius of space $R_4 = 14 \cdot 10^9$ light years, the numerical value of c_0 in equation (2) is equal to $c_0 = c = 300\ 000$ km/s. The latter form of equation (2) applies the mass equivalence M'' of space at distance R'' in the fourth dimension, in the direction of the 4-radius of three-dimensional space (see Figure 2). When applied to mass object m equation (1) means that the rest energy of matter can be explained as the energy of motion due to the expansion of space along the 4-radius.

The buildup and release of the energy of matter in space can be described as a zero-energy process from infinity in the past through singularity to infinity in the future. In the contraction phase mass obtains its velocity against the release of gravitational energy like in free fall and in the expansion phase the energy of motion obtained in the contraction is converted back to the gravitational energy.

Figure 2. The integrated gravitational effect of all the mass in space on a mass object m can be described as the gravitational effect of mass M'' at distance R'' along the imaginary axis inside closed space.

In the expansion phase, the radial motion of space works against the gravitation of the structure, which means that the radial expansion velocity is gradually diminishing. The relative reduction of the expansion velocity in the present state of the Universe is about $\Delta c_0/c_0 = 4 \cdot 10^{-11}$ /year. It turns out that the frequencies of atomic clocks and the characteristic wave numbers of the spectral lines of atoms are directly proportional to the internal momentum due to the motion of space at velocity c_0. Accordingly, the reduction of the velocity of light is not detectable in measurements based on the readings of atomic clocks.
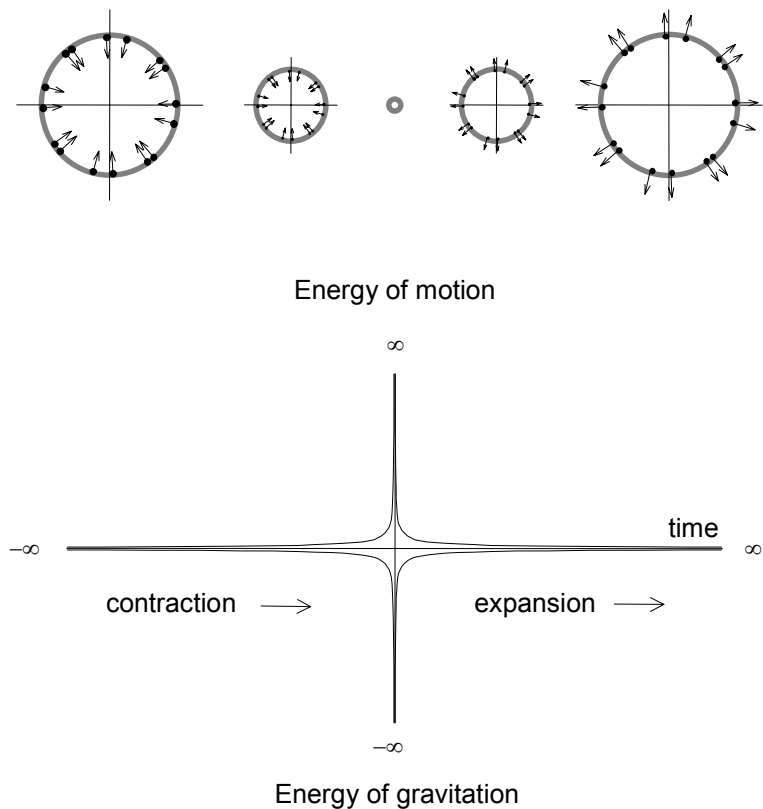

Figure 3. Contraction and expansion of space and the corresponding evolution of the energies of motion and gravitation. In the contraction phase, the 4-radius of space goes from infinity to zero. In the expansion phase, after singularity, the radius increases from zero back to infinity. Zero total energy is preserved through the entire process.

2 - The fourth dimension

The shocking message of equations (1) and (2) is that the velocity light appears as the velocity of all mass in the fourth dimension. Same message is hidden in the line element in Lorentz coordinates or Minkowski metrics which in local homogeneous space can be expressed as

$$(ds)^2 = -(cdt)^2 + (dx)^2 + (dy)^2 + (dz)^2 \tag{3}$$

or in vector form as

$$d\mathbf{s} = \mathrm{i}\,\mathbf{c}dt + d\mathbf{x} + d\mathbf{y} + d\mathbf{z} \tag{4}$$

where $\mathbf{c}$ instead of dt is expressed as a vector in the fourth dimension, mathematically shown as the imaginary direction. Following the concept of space as the three dimensional surface of a 4-sphere, $\mathbf{c}$ in equation (4) does not mean motion *in* space but motion *of* space, i.e. motion that all matter at rest in space is subject to according to equation (2). Accordingly, the rest momentum of a mass object in space is

$$\mathbf{p}_4 = \mathrm{i}\,m\mathbf{c}_4 \tag{5}$$

i.e. momentum in the fourth dimension which, when summarized to a momentum $\mathbf{p}$ in a space direction gives the total momentum $\mathbf{p}_{tot}$ relevant with the total energy of an object moving in space

$$E_{tot} = c_4 p_{tot} = c_4 \sqrt{p_r^2 + (mc_4)^2} \tag{6}$$

Equation (6) shows the total energy of an object in the same format as given by the theory of special relativity, however, without the use of the Lorentz transformation as a correction of the coordinates. Equation (6) describes the total energy as the result of the orthogonal sum of momenta due to the motion *of* space and the motion *in* space.

In fact, motion of space at the velocity of light along the radius of curvature is implicitly given in the Hubble law and the uniform expansion of space, which were not known at the time the theory of relativity was formulated.

3 - Motion in spherical space

Observing that any motion in spherically closed space is central motion relative to the mass equivalence of space in the fourth dimension, the gravitational acceleration in the fourth dimension is reduced due to central acceleration (Figure 4). The effect can be expressed as a reduction of work done by the object against the gravitation of the mass equivalence of space in the fourth dimension. The effect can be expressed in terms of a reduction of the internal mass m_I responding to the gravitational interaction with the total mass in space
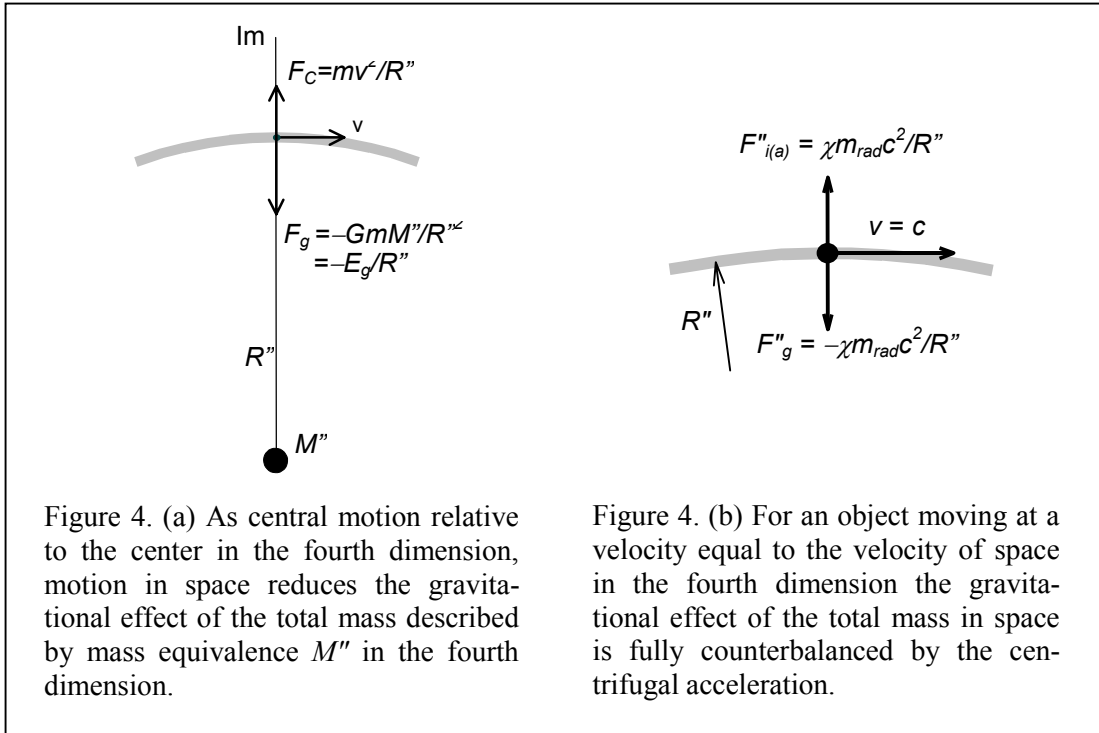
$$m_I = m_{eff}\left(1 - \beta^2\right) = m\sqrt{1 - \beta^2} \tag{7}$$

The reduction of the internal mass reduces the momentum of the object in the fourth dimension and, accordingly the "excitation" of the energies of motion and gravitation. It can be shown that such situation results in a reduction of the characteristic frequencies of atomic oscillators, i.e. the frequency of atomic oscillators moving at velocity $\beta = v/c$ is reduced by factor $\sqrt{1 - \beta^2}$ as

$$f_I = f_0\sqrt{1 - \beta^2} \tag{8}$$

where f_0 is the frequency of the oscillator at rest in the local energy frame. Equations (7) and (8) give direct physical meanings to the Lorentz factor - not as a correction of time coordinate but a factor reducing the internal energetic response of a moving object to the gravitation of

4

the total mass in space on the object. In terms of inertia this means that the buildup of kinetic energy when accelerating an object to a velocity in space involves the work done in reducing the gravitational energy due to all mass in space.

Figure 4. (a) As central motion relative to the center in the fourth dimension, motion in space reduces the gravitational effect of the total mass described by mass equivalence M'' in the fourth dimension.

Figure 4. (b) For an object moving at a velocity equal to the velocity of space in the fourth dimension the gravitational effect of the total mass in space is fully counterbalanced by the centrifugal acceleration.
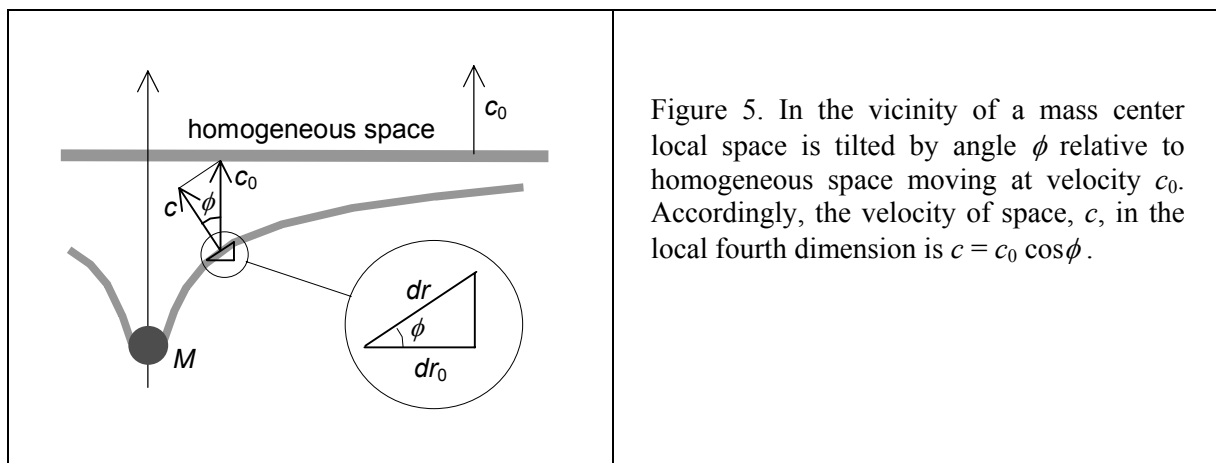
4 - The effect of mass centers on the local velocity of light

The idealized picture of completely symmetric spherical space assumes that mass is uniformly distributed all over the space. When mass is cumulated into mass centers in space the conservation of total gravitational energy demands that the "smooth" surface of an ideal four-dimensional sphere is tilted to form dents in the fourth dimension around mass centers in space. In tilted space also the direction of the fourth dimension is turned relative to the direction of the expansion, accordingly, locally the velocity of space in the fourth dimension is reduced in proportion to the tilting (see Figure 5).
In a local gravitational frame the famous equation $E = mc^2$ shall written in form

$$E_\delta = c_{0\delta} mc \qquad (9)$$

Figure 5. In the vicinity of a mass center local space is tilted by angle ϕ relative to homogeneous space moving at velocity c_0. Accordingly, the velocity of space, c, in the local fourth dimension is $c = c_0 \cos\phi$.

where c is the local velocity of light in the gravitational state denoted by the gravitational factor δ and $c_{0\delta}$ is the velocity of light outside the local gravitational frame, in the apparent homogeneous space of the local frame. The local velocity of light can be expressed in terms of the local gravitational state as

$$c = c_{0\delta}\cos\phi = c_{0\delta}\left(1-\delta\right) = c_{0\delta}\left(1-\frac{GM}{rc_0 c_{0\delta}}\right) \approx c_{0\delta}\left(1-\frac{GM}{rc^2}\right) \tag{10}$$

where ϕ is the tilting angle of local space and δ the gravitational factor as expressed in terms of the gravitational constant G, M the mass of the central mass of the gravitational frame at distance r from the location of the object studied.

Factor mc in equation (9) has the meaning of momentum in the local fourth dimension. The kinetic energy of free fall in a local gravitational frame is gained against a release of the rest energy of the falling object through the reduction of the local velocity of light.

As a consequence of the reduction of the momentum in the fourth dimension the locally obtainable maximum velocity in space, the local velocity of light, and the frequencies of internal atomic processes are reduced. *Motion in space* reduces the frequencies of internal atomic processes through the reduction of internal mass, *mass centers in space* reduce the frequencies through a reduced velocity of light in tilted space. Combining effects of motion on the internal mass of an object and the effect of reduction of local velocity of light, the characteristic frequencies of an atomic oscillator moving at velocity β in gravitational state δ in a local gravitational frame can be expressed as

$$f_{\delta,\beta} = f_{0\delta,0}\left(1-\delta\right)\sqrt{1-\beta^2} \tag{11}$$

where frequency $f_{0\delta,\beta}$ is the frequency of the oscillator at rest in the apparent homogeneous space of the local gravitational frame.

Local tilting of space and the reduction of the velocity of light near mass centers have several interesting consequences. Light or radio signal passing a mass center is delayed due to the lengthened path and reduced velocity. Also, the path is bent due to the local deformation of space. A further consequence of the local deformation of space is that the main axis of elliptical planetary orbits is subject to a rotation observed as a shift in the perihelion of the orbit.

5 - The system of cascaded gravitational frames

Real space consists of cascaded gravitational systems such as our planetary system in the solar system, the solar system in the Galaxy, and the Galaxy in the local galaxy group. Following the zero energy principle, in cascaded gravitational systems the local velocity of light can be related to the velocity of light in apparent homogeneous space around the local dent and, finally, to the expansion velocity of hypothetical homogeneous space in the fourth dimension (see Figure 6). This also means that in a gravitational frame like the Earth gravitational frame the zero reference for the local velocity of light is locked to the shape of the local dent, the zero reference follows the orbital motion of the Earth around the Sun, i.e. the reference at rest "the local ether" for the propagation of light in the Earth gravitational frame is the Earth centered non-rotating frame (or Earth Centered Inertial frame in the language of the general theory of relativity). Based on the present knowledge of the gravitational systems Earth is bound to (the Solar system, Milky way and the local galaxy group), the local velocity of light on the Earth is about $1/10^6$ (one per million) lower than the velocity of light in hypothetical homogeneous space where all mass were uniformly distributed.
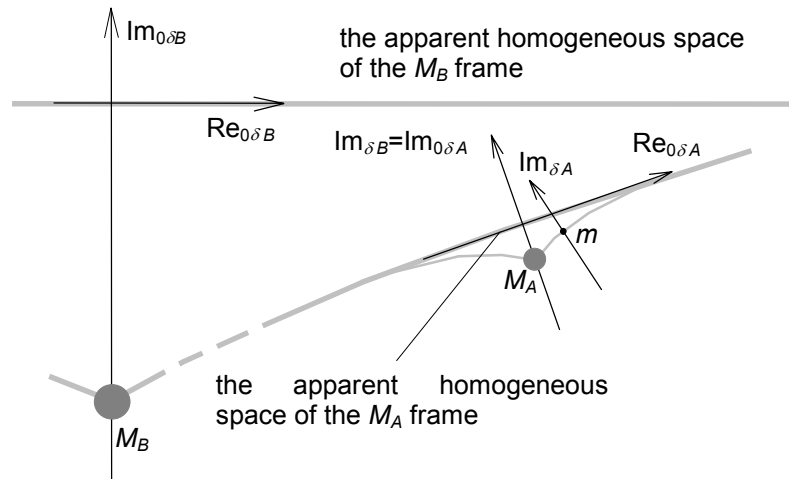
Figure 6. Apparent homogeneous space of the M_A frame around
mass center M_A follows the direction of space in the M_B frame as
it were without the M_A center.

The assumption we made of space as a closed surface of a four dimensional sphere contracting and expanding by maintaining zero total energy leads to a number of phenomena we are used to know as relativistic effects. As a major difference to the theory of relativity we do not need to use the coordinate quantities, distance and time as parameters to explain the phenomena.

In dynamic space, the effects of motion and local gravitation on internal atomic processes like the ticking frequencies of atomic clocks can be understood as consequences of the motion and local gravitation on the energetic state of the objects. More than that, we can understand why the velocity of light is the maximum velocity obtainable in space and how the inertia of mass linked to the total mass in space.

We do not need to assume that time were different due to gravitational field to understand the delay and bending of light near mass centers or the gravitational red- and blueshift of atomic clocks and electromagnetic radiation. We can honor the coordinate quantities as constant measures in all observations. The velocity of light is not a constant but a function of the local gravitational state.

In a complete form, taking into account the cascaded gravitational frames the equation for the rest energy of an object shall be written as

$$E_\delta = mc_0^2 (1-\delta) \prod_{i=0}^{n} \left[(1-\delta_i)\sqrt{1-\beta_i^2} \right] \tag{12}$$

where m is the mass of the object, c_0 is the expansion velocity of space. Gravitational factors δ_i describe the effects of the gravitational states of each gravitational frame in its parent frame and factors $\beta_i = v_i/c_i$ the motions of the local frame in the parent frames. On the Earth, the local velocity of light can be estimated to be $c \approx 0.999999\, c_0$. Taking into account the effects of the cascaded system of gravitational frames the frequency of atomic oscillators can be expressed as

$$f_{\delta,\beta} = f_0 \prod_{i=0}^{n} \left[(1-\delta_i)\sqrt{1-\beta_i^2} \right] \tag{13}$$

where f_0 is the frequency of the oscillator in hypothetical homogeneous [see equation (11) as reference].

7

6 - Expansion of space occurs everywhere

By linking the energies of motion and gravitation through the zero energy principle, the spherically expanding space allows (or demands) the expansion of space also to occur within local gravitational systems. In the Earth − Moon system this means that out of the 3.8 cm annual increase in the Earth to Moon distance 2.8 cm is due to the expansion of space and only 1 cm due to the tidal interaction.

In cosmological scale the propagation of light follows a spiral path, characterized by equal velocities in the fourth dimension with the expansion of space and the propagation observed in space (see Figure 6).
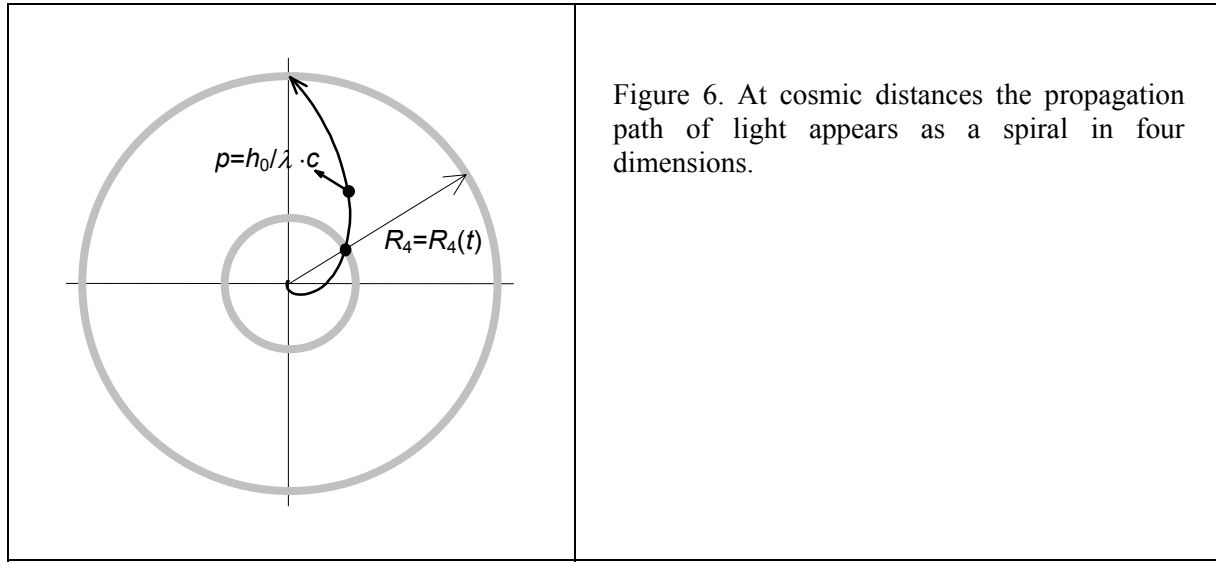

Figure 6. At cosmic distances the propagation path of light appears as a spiral in four dimensions.

The precise geometry of space and the defined propagation path of light in spherical space allows the derivation of the Hubble law and the redshift versus magnitude dependence without arbitrary parameters needed in the standard cosmology model. The Hubble law obtains the forms

$$z = \frac{D/R_4}{1 - D/R_4} \quad \text{and} \quad v = \frac{D}{R_4} c_0 \tag{14}$$

where the optical distance of the object, D, is the integrated tangential component of the light path from the object to the observer, which is the distance traveled by light in space. Inherently, equation (14) is consistent with the definition of the redshift in the general theory of relativity.

The energy flux of an object with redshift z can be expressed as

$$\frac{F_{(obs)}}{F_{(e)}} = \frac{1}{z^2(z+1)} \tag{15}$$

corresponding to magnitude versus redshift relationship

$$m = m_0 + 5\log z + 2.5\log(z+1) \tag{16}$$

Equation (16) gives a perfect match to the observed redshift − magnitude dependence of supernovas as shown in Figure 7. Accordingly, recent confusion regarding the redshift versus magnitude observations becomes solved without any new assumption or parameter, the prediction derived from the dynamic spherical space is shown as the solid curve in Figure 7, also showing recently published observations on supernovas.
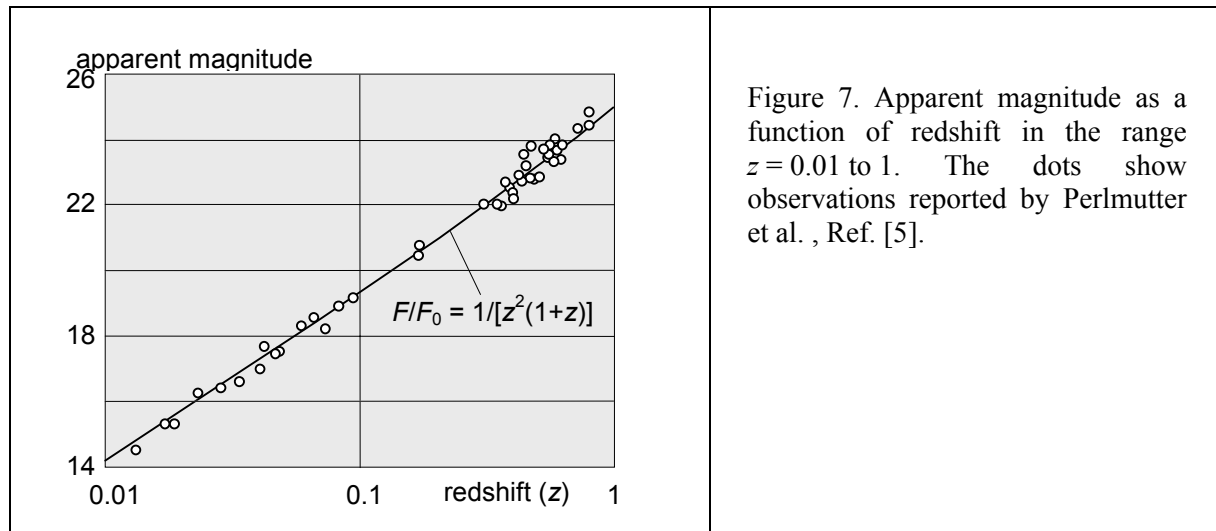
Figure 7. Apparent magnitude as a function of redshift in the range $z = 0.01$ to 1. The dots show observations reported by Perlmutter et al. , Ref. [5].

7 - Doppler effect and gravitational redshift of electromagnetic radiation

The combined gravitational shift of atomic oscillators and the Doppler effect of electromagnetic radiation in a particular gravitational frame has the form

$$ f_{A(B)} = f_B \frac{\left(1 - GM/r_A c^2\right)\sqrt{1 - \beta_A^2}\left(1 - \beta_B \, \hat{\mathbf{v}}_B \cdot \hat{\mathbf{r}}\right)}{\left(1 - GM/r_B c^2\right)\sqrt{1 - \beta_B^2}\left(1 - \beta_A \, \hat{\mathbf{v}}_A \cdot \hat{\mathbf{r}}\right)} \tag{17} $$

Equation (17) can be derived from the classical Doppler effect by taking into account the effects of gravitation and motion on the frequencies of oscillators.
In the general theory of relativity the Doppler equation corresponding to equation (17) has the form, Ref [3],

$$ f_{A(B)} = f_B \frac{\sqrt{1 - 2GM/r_A c^2 - \beta_A^2}\left(1 - \beta_B \, \hat{\mathbf{v}}_B \cdot \hat{\mathbf{r}}\right)}{\sqrt{1 - 2GM/r_B c^2 - \beta_B^2}\left(1 - \beta_A \, \hat{\mathbf{v}}_A \cdot \hat{\mathbf{r}}\right)} \tag{18} $$

In the Earth gravitational frame the difference between equations (17) and (18) is too small to be detected (for example, in the famous Scout D experiment, Ref. [4], the difference between equations (17) and (18) is of the order 10^{-18}.
When related to the frequency of the transmitter, f_A, equations (17) obtain the form of the classical Doppler equation

$$ f_{A(B)} = f_A \frac{\left(1 - \beta_B \, \hat{\mathbf{v}}_B \cdot \hat{\mathbf{r}}\right)}{\left(1 - \beta_A \, \hat{\mathbf{v}}_A \cdot \hat{\mathbf{r}}\right)} \tag{19} $$

where the effect of the velocities of the transmitter and receiver β_A and β_B are velocities in the local rest frame.

8 - Discussion

The Dynamic Universe approach is an "energy based" description of observable reality instead of the "metrics based" description given by the theory of relativity. Unlike the theory of relativity, the Dynamic Universe is derived starting from structure and zero energy balance of whole space and then, by conserving the energy balance in the system, derived into local phenomena. Such approach relates all local phenomena to the energetic state of whole space, which can be found to result in the effects generally referred to as "relativistic effects". The DU approach re-establishes the classical meanings of time and distance, which as coordinate quantities, are not used as parameters in explaining observations. The DU approach gives

precise predictions to phenomena covered by the theory of relativity and the standard cosmology model. In addition, the DU approach explains the origin of inertia and the Mach's principle, the nature of mass as the substance for the expression of energy, and the physical mechanisms of the effects of motion and gravitation on the frequencies of atomic oscillators. It also describes the buildup and release of the rest energy of matter in the contraction and expansion of space in the zero-energy process of spherical space from infinity in the past to infinity in the future, Ref. [2].

References

[1] Einstein, A., Kosmologische Betrachtungen zur allgemeinen Relativitätstheorie, Sitzungsberichte der Preussischen Akad. d. Wissenschaften (1917)

[2] Suntola, T., The Dynamic Universe, A New Perspective on Space and Relativity, Suntola Consulting Ltd., ISBN 951-97938-6-0 (2002), www.sci.fi/~suntola

[3] Baker, M.L., Jr., Astrodynamics, Academic, New York (1967) 218

[4] Vessot, R.F.C., Levine, M.W. et al., Phys. Rev. Letters, **45**, 26 (1980) 2081

[5] Perlmutter, S. et al., 1998 AAS Meeting Jan 1998, Washington DC

- - - - -

Tuomo Suntola, Dr. Tech.
Senior Scientific Advisor
Fortum Corporation
POB 100, 00048 FORTUM, Finland

http://www.sci.fi/~suntola
tuomo.suntola@fortum.com

Tuomo Suntola *was born in Finland in 1943. Helsinki University of Technology, M. Sc. (1967), Ph. D. (1971), Scientist at State Research Centre, VTT, (1971-1973). Development of humidity sensor for Vaisala Oy (Humidity measuring instruments based on Humicapã sensors are still world market leaders in humidity sensing and monitoring). Chief Scientist Instrumentarium Oy/Lohja Corporation (1974-1987). Development of Atomic Layer Epitaxy, ALE, for manufacturing of electroluminescent thin films. Development of flat panel display product and production machinery, implementation of the technology into commercial activity. Managing director of Microchemistry Ltd, a research company in Neste Group (1987-1997). Development of solar cell technologies, extension of the use of Atomic Layer Epitaxy to the manufacturing of heterogeneous catalysts and a research tool for surface chemistry. Direction of the ALE technology and machinery to semiconductor applications, start up of business activity on Atomic Layer Deposition ALD for semiconductor manufacturers. Microchemistry Ltd's ALD business was merged into ASM (Holland) in 1998. ALD technology has become a main stream technology for*

nanoscale semiconductor devices, (e.g. Applied Materials, Veeco, IPS, Genus). Senior Scientific Advisor and R&D Fellow, Fortum Corporation since 1997. Docent at Physics Department of Tampere University of Technology since 1975. Lectures on semiconductor physics 1972-78. Member of the Finnish Academy of Technology, TTA since 1983, board member 1988-93. Board member of the Mentor Program since 1999. Deputy board member in the Foundation of Technology in Finland since 1991. He holds patents and has published widely in the fields of material science, thin film technology, and surface chemistry.

[See even the presentation of Dr. Suntola's book which is published in the first Section of this same number of *Episteme*]