New cosmology model shows relativity in universal time and distant observations in Euclidean geometry

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It is natural to think of space as finite but without edges. The simplest geometry that eliminates the edges of a structure is a sphere, and to close a three-dimensional space we need a 4-sphere, the surface of a four-dimensional ball. Describing space as the surface of a four-dimensional sphere contracting and expanding in the direction of the 4-radius gives a view of closed dynamic space where relativistic phenomena appear as consequences of the zero-energy balance in the structure. Instead of being defined as a physical constant the velocity of light appears as the velocity of space in the fourth dimension. The rest energy of mass appears as the energy of motion that mass possesses due to the motion of space and the time-like line element, cdt, in Minkowski space and Schwarzschild metrics shows the distance the 4-radius of space increases in time differential dt.

The spherical geometry together with the changing velocity of light in dynamic, spherical space converts distant observations into Euclidean geometry. Clocks in motion or subject to local gravitational interaction do not lose time because time is distorted; they actually run slower as a result of their state of motion and gravitation in space. The Dynamic Universe model[1] based on the balance of the energies of motion and gravitation in spherically closed space gives precise mathematical expression to relativistic effects and cosmological observations and shows the energy build-up and release of space as a continuous dynamic process from infinity in the past to infinity in the future.

Keywords: Cosmology, relativity, zero-energy principle, Dynamic Universe

Introduction

In 1917 Einstein came very close to proposing a spherical space closed through the fourth dimension and he suggested that the volume of space should be calculated as the volume of the "surface" of a four-dimensional sphere, $V = 2\pi^2 R^3$ [2]. At cosmology level, such geometry would give a perfect view of continuous homogeneous space with no location in a special position relative to the rest of space. However, space as the surface of a 4-sphere requires the fourth dimension to be considered a purely geometrical dimension not a "time-like" dimension as suggested by the theory of relativity. Furthermore, Einstein was looking for a static model; in order to remain in static state the 4-sphere required a cosmological constant to offset the gravitation of the structure.

The choice made in the theory of relativity left the question of overall geometry of space unanswered and the fourth dimension was linked to time as a "time-like" dimension without direct spatial geometrical meaning.

If the choice had been made ten years later, after the findings of Edward Hubble, the result would have been different. The was no basis to look for static space, in fact, space as the surface of a 4-sphere expanding along the 4-radius had immediately explained the Hubble law which by assuming a linear Doppler effect related the recession velocity v $(v \ll c)$ of stellar objects to their distance D as

$$v = zc = H_0 D \tag{1}$$

where H_0 is the Hubble constant and z is the redshift of the radiation received from the object. Assuming space as the surface of a 4-sphere of radius R_4, a distance in space can be expressed as the length of the arc along the curved space as

$$D = \alpha R_4 \tag{2}$$

where α is the angle between the object and the observer in space.

If the radius of the 4-sphere increases at velocity v_4, distance D increases as

$$\frac{dD}{dt} = \alpha v_4 = \frac{D v_4}{R_4} = v \tag{3}$$

which is observed as the recession velocity v object. Comparison of equations (1) and (3) relates the Hubble constant to the 4-radius and its velocity of its increase as

$$H_0 = \frac{v_4}{R_4} \tag{4}$$

which, when substituted in (1), shows the Hubble law in form (see FIG.1)

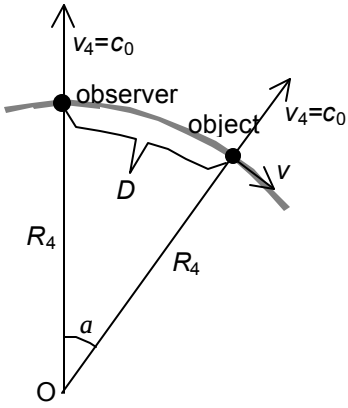

FIG 1. The Hubble law can be interpreted as a consequence of spherical space expanding at velocity c_0 in the direction of the radius in the fourth dimension. Distance D is the distance between the object and the observer as the arch along curved space.

$$v = \frac{v_4}{R_4} D \tag{5}$$

In the "Big Bang" model, the quantity $R_H = c/H_0$ is referred to as the Hubble radius, which has the meaning of the distance travelled at velocity c since the singularity when all objects in space were at one point (for $H_0 = 70$ [(km/s)/Mpc][3,4], $t = 1/H_0 \approx 14$ billion light years). Applying the Hubble radius equation (5) gets the form

$$v = \frac{c}{R_H} D \tag{6}$$

which implicitly means that the expansion velocity of space in a fourth dimension is the velocity of light. If space is described as the surface of a 4-sphere the radius of curvature, R_H, has the meaning of the 4-radius of the sphere, R_4.

Identifying the observed expansion of space as a consequence of the motion of space in the fourth dimension, the expansion of space as the surface of a 4-sphere, turns the time-like line element, cdt, of the theory of relativity into the distance moved by space at velocity c in time differential dt the direction of the 4-radius R_4,

$$ds_4 = cdt \tag{7}$$

Accordingly, time in dynamic space can be considered as a universal scalar. The fourth dimension of spherically closed space is geometrical in nature, although it is not accessible from space.

Energy balance and metrics in dynamic space

When the total mass in space and the gravitational constant are known the expansion velocity c_0 of spherically closed space can be derived from the balance of the energies of motion and gravitation in the structure. The energy of the motion related to the motion of mass due to the motion of space in the direction of the 4-radius is what appears as the rest energy of mass in space

$$E''_m = mc_0^2 \tag{8}$$

and the energy of gravitation is the gravitational energy integrated across spherical space

$$E''_g = -\frac{G_E GmM_\Sigma}{R_4} \tag{9}$$

where G is the gravitational constant, $G_E = 0.776$ is a geometrical factor due to the four-dimensional geometry, M_Σ is the total mass in space and R_4 is the radius in the fourth dimension. The zero energy condition

$$E''_m + E''_g = 0 \tag{10}$$

relates velocity c_0 to the gravitational constant, the total mass in space and the 4-radius of space as

$$c_0^2 = \pm\sqrt{\frac{GG_E M_\Sigma}{R_4}} = \pm\sqrt{\frac{GM''}{R''}} \tag{11}$$

where M'' ($M'' = 1.08 \cdot M_\Sigma$) is the mass equivalence of all mass in space, located at distance R'' ($R'' = 1.40 \cdot R_4$). Applying the present estimated radius $R_4 = 14 \cdot 10^9$ light years (for $H_0 = 70$ [(km/s)/Mpc]) and the mass density $r = 0.55 \cdot r_c$ (r_c = Friedmann critical density) we get

$$c_0 = \sqrt{\frac{GM''}{R''}} = 300000 \text{km/s} \tag{12}$$

which is equal to the velocity of light. The condition $r = 0.55 \cdot r_c$ is in a good agreement with present knowledge of the mass density in space[5].

The radial motion of space works against the gravitation of the structure, which means that the radial expansion velocity, and consequently the velocity of light, is gradually diminishing. The relative reduction of the velocity of light in the present state of the Universe is about $\Delta c_0 / c_0 \approx 4 \cdot 10^{-11} / \text{year}$. 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.

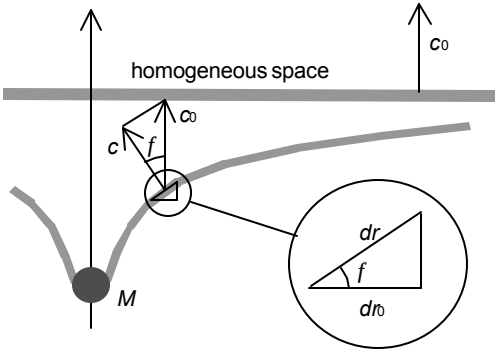

FIG. 2. In the vicinity of a mass centre local space is tilted by angle f relative to homogeneous space moving at velocity c_0. Accordingly, the velocity of space, c, in the local fourth dimension is $c = c_0 \cos f$ and the length of the local radial line element dr is $dr = dr_0/\cos f = dr_0/(1-d)$. Distance dr_0 is measured in the direction of homogeneous, non-tilted space.

A detailed analysis of the energy balances in space[1] shows that the velocity of light not only changes with time but it is also affected by the local gravitational environment which modifies the metrics near mass centres as

$$ds^2 = c_0^2 (1-d)^2 dt^2 + \frac{dr_0^2}{(1-d)^2} + r_0^2 \left(d^{\,2}\grave{e} + \sin^2 \quad \acute{g}\partial\right) \qquad (13)$$

where $d = GM/rc^2$ is the local gravitational factor. The first term in equation (13) describes the motion of space in the direction of the local fourth dimension showing the effect of the reduction of the velocity of space due to the tilting of space near a mass centre. The tilting of space also results in a lengthening of the line element dr in the radial direction (towards the mass centre). The lengths of transversal line elements perpendicular to the radial direction, shown by the last term of equation (13), are not affected by the mass centre.

Distance r_0 in the last term in (13) is measured in the direction of non-tilted space (see FIG. 2). A minor difference between equation (13) and the Schwarzschild metrics is that the modification factor of a squared line element due to a mass centre in the first and second term in (13) is $\left(1-GM/rc^2\right)^2$ instead of factor $\left(1-2GM/rc^2\right)$ suggested by the Schwarzschild metrics.

As a consequence of the zero-energy principle, the tilting angle of space, f, can be related to the gravitational factor $d = GM/rc^2$ as

$$\cos f = (1-d) = 1-GM/rc^2 \tag{14}$$

accordingly, the local velocity of space in the direction of the local fourth dimension can be expressed as

$$c = c_0 \cos f = c_0 (1-d) \tag{15}$$

Motion in space

Any motion in spherical space is central motion relative to mass equivalence $M"$ at distance $R"$ in the imaginary direction. The centrifugal acceleration created in the fourth dimension reduces the gravitational acceleration towards the mass equivalence $M"$. Accordingly, the reduced "effective" gravitational force can be expressed as

$$F"_g = E"_g/R" = E"_m/R" = m_{eff}c^2\left(1-b^2\right)/R" = m_I c^2/R" \tag{16}$$

where

$$m_I = m_{eff}\left(1-b^2\right) = m\sqrt{1-b^2} \tag{17}$$

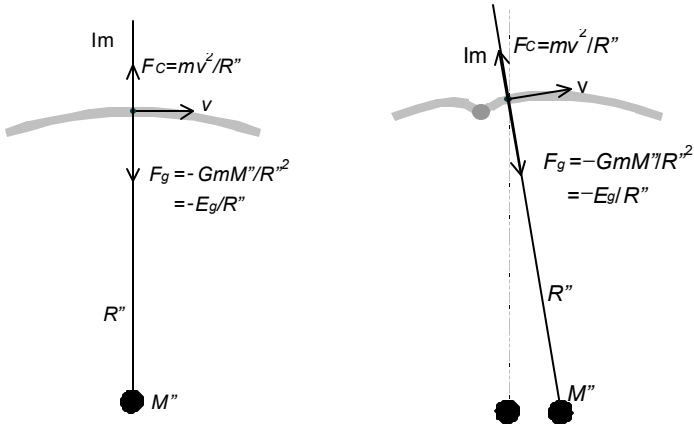

FIG. 3. Motion in space reduces the gravitational force of mass equivalence $M'' = 1.08 \cdot \mathbf{M}$ by the amount of the central force $\mathbf{F}_C$ created by the motion. The apparent imaginary radius $R"$ is perpendicular to the space directions everywhere in space. In hypothetical homogeneous space, $R"$ has the direction of the 4-radius of space and length $R" = 1.4 \cdot R_4$. As a consequence of the conservation of total gravitational energy in locally tilted space near a mass centre, distance $R"$ of the mass equivalence $M"$ is lengthened by factor $\left(1 - GM/r_0c^2\right)$ and it appears in the direction of the local fourth dimension.

is referred to as *the internal mass* of an object (see FIG. 3).

Denoting the direction of the fourth dimension as the imaginary direction (orthogonal to the three space directions) the total energy of motion, comprising the contributions of the motion of space in the imaginary direction and the motion in space in a selected space direction, can be expressed as a complex function

$$E^*_{tot} = c_0\,(p' + \mathrm{i}p'') = c_0 m_{eff} c\left(b + \mathrm{i}\sqrt{1-b^2}\right)$$
$$= c_0 m c\left(b \Big/ \sqrt{1-b^2} + \mathrm{i}\right) \tag{18}$$

where asterisk (*) is used to denote a complex function, single apostrophe (') the real part of the complex function in the selected space direction, and double apostrophe (") the imaginary part. The rest energy of mass m can be expressed as

$$E^*_{rest} = c_0 mc\left(b + \mathrm{i}\sqrt{1-b^2}\right) = c_0 m_I c\left(b \Big/ \sqrt{1-b^2} + \mathrm{i}\right) \tag{19}$$

In equations (18) and (19) c_0 means the imaginary velocity of homogeneous space and c the imaginary velocity of locally tilted space, the local velocity of light.

The scalar values of the total energy of motion and the rest energy in equations (18) and (19) are

$$E_{tot} = \left|E^*_{tot}\right| = c_0 m_{eff} c = c_0 mc \Big/ \sqrt{1-b^2} \approx m_{eff} c^2 \tag{20}$$

and

$$E_{rest} = \left|E^*_{rest}\right| = c_0 mc = c\,mc^2 \approx mc^2 \tag{21}$$

where $c = c_0/c$ is referred to as the frame conversion factor showing the effect of the local gravitational state on the rest energy of matter. Kinetic energy means the work done in changing the state of motion. As a complex function the kinetic energy can be expressed as

$$E^*_{kin} = E_{tot} - E^*_{rest} = c_0 mc\left[b\left(1\Big/\sqrt{1-b^2} - 1\right) + \mathrm{i}\left(1 - \sqrt{1-b^2}\right)\right] \tag{22}$$

with scalar value

$$E^*_{kin} = \left|E^*_{kin}\right| = c_0 mc\left[1\Big/\sqrt{1-b^2} - 1\right] \tag{23}$$

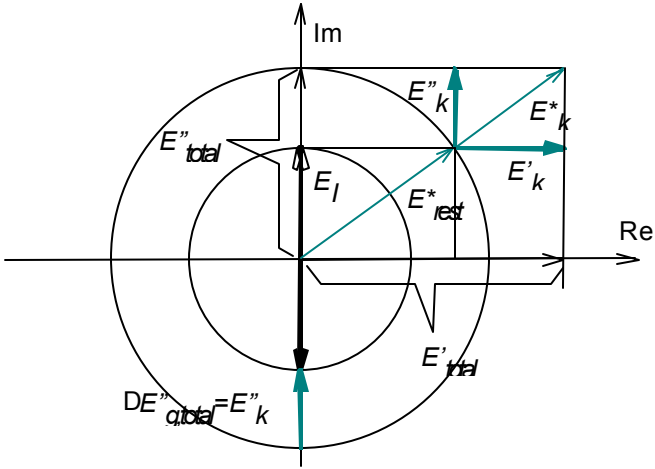

FIG. 4. The effect of the imaginary part of the kinetic energy appears as a reduction of the internal energy of the object through a reduction of the imaginary energy of gravitation. The real part of the kinetic energy increases the momentum of the object and, accordingly, the real part of the total energy of motion.

Equations (20), (21), and (23) are essentially the same as their counterparts in the theory of relativity.

The imaginary component of the kinetic energy, E''_k, in equation (22) is the work done in reducing the gravitational effect of the total mass in space on the object accelerated (see FIG. 4), which gives a quantitative expression to Mach's principle. The imaginary component of the rest energy, referred to as the internal energy of the object

$$E_I = E''_{rest} = c_0 p_I = c_0 m_I c = c_0 mc \Big/ \sqrt{1-b^2} \qquad (24)$$

shows the effect of motion on the energetic excitation of the object in the imaginary direction. The characteristic frequencies of atomic

oscillators are directly proportional to the internal momentum, $p_I = m_I c$, which explains the effects of motion and local gravitation (through c) on atomic clocks and the spectral lines emitted by excited atoms.

Mass in dynamic space is the substance for the expression of energy. Mass as such is not an expression of energy. Mass is energised by motion. The rest energy of matter is the energy mass possesses due to the motion of space.

Cascaded gravitational frames

Each gravitational centre in space can be regarded as a gravitational frame where the local geometry of space is described with metrics given in equation (13). Equation (14) relates the local tilting of space to surrounding space regarded as apparent homogeneous space of the local gravitational frame. The local gravitational centre with the associated gravitational frame can be regarded as an object in the parent frame, like the Earth with its gravitational frame in the solar gravitational frame. The local velocity of light is affected by the tilting of space in the local gravitational frame as shown by equation (15). By including the effects of the parent frames, the local velocity of light can be related to the imaginary velocity of hypothetical homogeneous space, c_0, which is the actual expansion velocity of spherical space

$$c = c_0 (1-d) \prod_{n=o}^{i} (1-d_i) \tag{25}$$

where the gravitational factor d shows the gravitational state of the object in the local frame and gravitational factors d_i the gravitational state of the local frame in the parent frames (see FIG. 5).

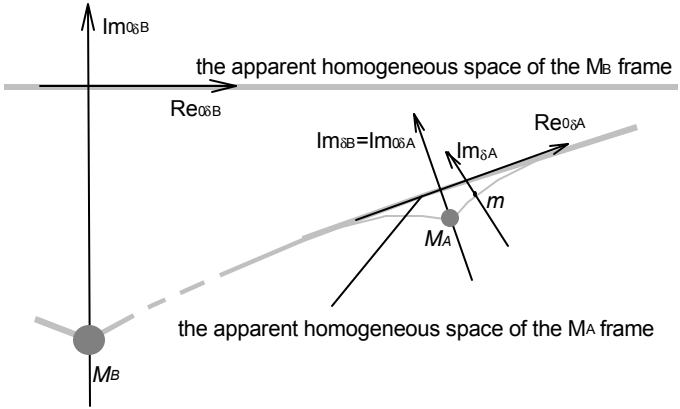

FIG. 5. Apparent homogeneous space of the M_A-frame around mass center M_A follows the direction o f space in the M_B-frame as it were without the M_A centre.

As shown by equation (17) motion in space reduces the internal mass of the object, the mass "available" for the expression of energy in a state of motion. Following the zero-energy principle it can be shown that the motion of local energy in its parent frames reduces the rest mass of an object in the local energy frame as

$$m = m_0 \prod_{n=0}^{i} \sqrt{1 - b_i} \tag{26}$$

where m_0 is the mass of the object at rest in hypothetical homogeneous space. Combining equations (21), (25), and (26) the rest energy of an object in a d -state in the local gravitational frame can be expressed as

$$E_{rest} = mc_0^2 \left(1-d\right) \prod_{i=0}^{n} \left(1-d_i\right) \sqrt{1 - b_i} \tag{27}$$

which relates the rest energy of an object in a local energy state to the rest energy of the object at rest in hypothetical homogeneous space.

Denoting the ratio of the imaginary velocity of hypothetical homogeneous space to the local velocity of light as

$$c = c_0 / c = 1 \Big/ \left[(1-d) \prod_{i=0}^{n} (1-d_i) \right] \tag{28}$$

the rest energy of an object can be expressed as

$$E_{rest} = c\, mc^2 \tag{29}$$

where m is the locally available rest mass given in equation (26). Equation (29) differs by factor c from the famous equation, $E_{rest} = mc^2$, for rest energy in the theory of relativity. In the gravitational state on the Earth, factor c can be estimated to be about $c \approx 1 + 10^{-6}$. In practice, the effect of c is included in the mass measured.

Electromagnetic radiation

The requirement of conservation of energy demands that the conventionally defined Planck constant h is proportional to the velocity of light, or more precisely, to the velocity of space in the direction of R_4 as

$$h = h_0 c_0 \tag{30}$$

where h_0 is defined as the *intrinsic Planck constant.* The dimensions of the intrinsic Planck constant are mass-length, instead of momentum-length as in the conventional formalism. Accordingly, we can interpret the quantum of action as the quantum of mass, or the quantum of "substance for the expression of energy".

Applying the intrinsic Planck constant, the energy of electromagnetic radiation can be expressed as

$$E_{rad} = \frac{h_0}{l} \; c_0 c \tag{31}$$

Since $E^* = c_0 p^*$, the momentum of electromagnetic radiation can be expressed as

$$\mathbf{p}_{rad} = \frac{h_0}{l} \; \mathbf{c} = m_{rad}\mathbf{c} \tag{32}$$

where $\mathbf{c}$ is the propagation velocity of radiation in space and m_{rad} is the mass equivalence of radiation. Electromagnetic radiation propagates at velocity c, which means propagation in a "satellite orbit", where the central acceleration due to the motion in spherical space is counterbalanced by the gravitational acceleration of mass equivalence M''. Accordingly, the internal mass electromagnetic radiation is zero [see equation (17)] and the momentum of radiation in the imaginary direction is zero. Electromagnetic radiation has its momentum in the direction of propagation only.

The scalar value of the momentum can be expressed in terms of the frequency as

$$p_{rad} = |\mathbf{p}_{rad}| = \frac{h_0}{l} \; c = h_0 f \tag{33}$$

which also shows, that the conservation of momentum is equivalent to the conservation of frequency. The frequency of electromagnetic radiation does not change when the radiation travels from one gravitational state to another. However, the wavelength of the radiation is shifted due to the different velocity of light in different gravitational states. The frequency of an atomic oscillator, however, is directly proportional to the local velocity of light in the gravitational state of the oscillator.

An analysis of Schrödinger's equation for the energy states of electrons in atoms shows that the dimensions of atoms are independent of the velocity of light and, accordingly, independent of the expansion of space. The Bohr radius of an atom, however, is related to the velocity of the atom in the local frame and in the parent gravitational frames as

$$a_{0(b)} = a_0 \prod_{i=0}^{n} \sqrt{1 - b_i^2} \tag{34}$$

which, through Balmer's formula, makes the wavelength of the characteristic electromagnetic emission dependent on the velocity of the atom as

$$l_{(n1,n2)} = \frac{4p\, a_{0(b)}}{a\, Z^2 \left[1/n_1^2 - 1/n_2^2 \right]} \tag{35}$$

where a is the fine structure constant. In fact, Balmer's formula relates the emission wavelengths to the Bohr radius a_0 which is affected by the motion of the atom through the reduction of the rest mass of electrons according to equation (26). Although the Bohr radius is not a part of the modern quantum mechanical model of an atom, the correlation between the physical dimensions of an atom and the characteristic wavelengths emitted remains the same.

The increase of wavelength given in equation (35) and the related reduction of the emission frequency is what the special theory of relativity explains as time dilation or transversal Doppler effect of moving oscillators and emitters. The frequency of atomic oscillators can be generally expressed as

$$f_{d,b} = f_0 \prod_{i=0}^{n} \left[(1 - d_i) \sqrt{1 - b_i^2} \right] \tag{36}$$

where f_0 is the frequency of the oscillator in hypothetical homogeneous space and d_i and b_i mean the gravitational factors and velocities of the oscillator in the local frame and the parent frames.

The frequency of electromagnetic radiation does not change when the radiation travels from one gravitational state to another. However, the wavelength of the radiation is shifted due to the different velocity of light in different gravitational states. Accordingly, the gravitational red- and blue-shift of oscillators is a shift of frequency and the gravitational red- and blue-shift of electromagnetic radiation is a shift of wavelength.

The Doppler shifted frequency, received by object B moving at velocity $\hat{\mathbf{a}}_B$ in a gravitational state characterised by gravitational factor d_B, of electromagnetic radiation emitted by oscillator A moving at velocity $\hat{\mathbf{a}}_A$ in a gravitational state characterised by gravitational factor d_A in the local gravitational frame can be expressed as

$$f_{(dA,bA)dB,bB} = f_{dA,bA}\frac{\left(1-\hat{\mathbf{a}}_B\cdot\hat{\mathbf{r}}\right)}{\left(1-\hat{\mathbf{a}}_A\cdot\hat{\mathbf{r}}\right)} \tag{37}$$

where $f_{dA,bA}$ is the frequency of oscillator A given by equation (36) and $\hat{\mathbf{r}}$ is the unit vector in the direction of the signal transmission path from A to B. Equation (37) is closely related to the corresponding expression in the general theory of relativity. An implicit message of equation (37) is that the motion of the source affects the frequency of radiation emitted in different directions like in the classical Doppler theory. When received in a frame moving with the source both the frequency and the wavelength observed are independent of the transmission direction relative to the direction of the motion of the frame. In the case of the famous Michelson-Morley experiment this

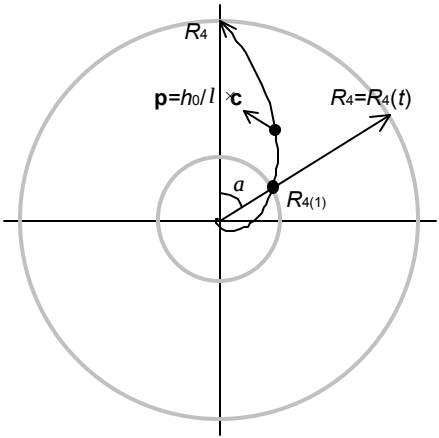

FIG. 6. At cosmic distances the propagation path of light appears as a spiral in four dimensions.

means zero result without an assumption of length contraction in the direction of the motion of the frame.

Cosmological observations

At cosmic distances the path of electromagnetic radiation appears as a spiral in four dimensions (see FIG. 6). The Hubble law for the red-shift, z, gets the form

$$z = \frac{D}{R_{4(1)}} = \frac{D}{R_4} e^a = e^a - 1 \qquad (38)$$

where D is the optical distance of the object, a the distance angle in spherical space, and $R_{4(1)}$ and R_4 are the 4-radii of space when the light was emitted and received, respectively. Equation (38) differs from the classical Hubble law by the factor e^a, which becomes meaningful for objects at large distances.

Applying equation (38) the observed angular separation of two objects with redshift z can be expressed in terms of the optical distance D and the separation d of the objects at the time the light was emitted as

$$q = \frac{d}{D} = \frac{D}{zR_{4(1)}} = \frac{a_d}{z} \tag{39}$$

where a_d means the angular separation of the objects in spherical space. Equation (39) means that the separation of objects in space appears in Euclidean geometry.

As a consequence of the conservation of energy, the radius of galactic and other orbiting stellar systems grow directly proportional to the growth of the 4-radius of space. A detailed analysis of the development of the surface brightness of stellar objects and the transmission of the light in expanding space shows that the observed energy densities of equivalent stellar objects depend on their redshift as

$$F_{obs} = \frac{F_0}{z^2 (z+1)^n} \tag{40}$$

where F_0 is a reference energy density proportional to the surface brightness of the object and $0 < n < 2$ depending the development of the emitting surface area with the radius of the object. For high density objects with the effective emitting surface proportional to the square of the radius, n is equal to two. For a low density objects with the effective emitting surface independent of the radius, n is equal to zero. Best fit between equation (40) and recent observations is obtained when $n \approx 1.5$ [6].

One of the cornerstones of the "Big Bang" theory is the background radiation observed essentially uniformly in all directions

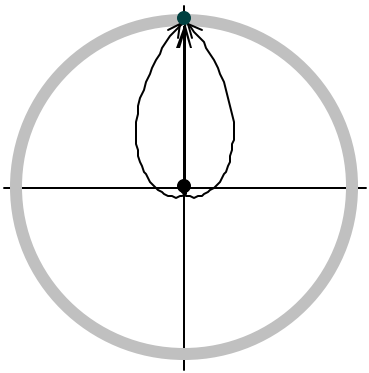

FIG. 7. Propagation of light through a 360° path. The radius of the Universe at the time the light was emitted was $R_{4(1)} \approx 26$ million light years and the corresponding time since singularity was $t_1 \approx 750000$ years. The velocity of light at that time was about 23 times the present velocity of light.

in space. In the DU the propagation of light follows a spiral path. The background radiation thus appears as 360° degree propagation of light from the observer's location in space (see Figure 7). The redshift of such radiation is

$$z = e^{2p} - 1 \approx 534.5 \tag{41}$$

which means that the radiation originated about 750 000 years after the singularity of the primary energy build-up when the 4-radius of space was about 23 million light years and the expansion velocity of space about 23 times the present velocity.

Build-up and release of the energy of matter in space

The Dynamic Universe requires major rethinking of the development of the Universe. Instead of an instantaneous Big Bang, the primary build-up and release of the energy of the Universe is described as a zero energy process from infinity in the past, through singularity, back to infinity in the future. At all times the positive energy of

motion is counterbalanced by the negative energy of gravitation. The primary build-up takes place through free fall of spherical space from the state when the 4-radius is infinite to the state when it is zero. In spherical geometry the process can be described as homogeneous contraction of space, culminating in a singularity where space is reduced to a single point. At singularity, the mass in space has infinite momentum, which throws the process into expansion. In the expansion phase the 4-radius increases back to infinity, while the energy of motion gained in the contraction is returned to gravitational energy. Free fall in the contraction phase and free escape in the expansion maintain zero total energy in the system

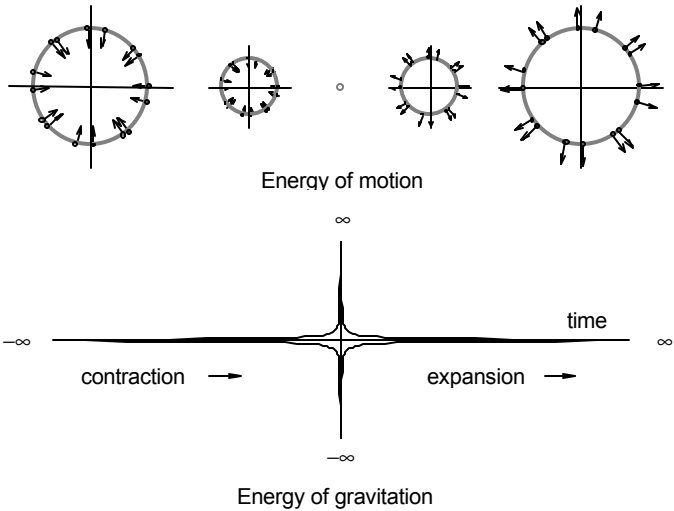

FIG. 8. Energy build-up and release in spherical space. In the contraction phase the velocity of the imaginary motion increases due to the energy gained from loss of gravitation. In the expansion phase the velocity of the imaginary motion gradually decreases, while the energy of motion gained in contraction is returned to gravity.

$$E_{tot} = M_{\Sigma} c_0^2 - \frac{G M_{\Sigma} M''}{R''_0} = 0 \qquad (42)$$

where $M_{\Sigma} = \sum m$ is the total mass in space.

In the contraction phase, mass in space gains energy of motion through its own gravitation. Space loses volume and gains motion. In the following expansion phase, space gains back volume while losing motion. Space with infinite 4-radius continues to host all mass, but the mass is without energy: the energy of gravitation is zero because of

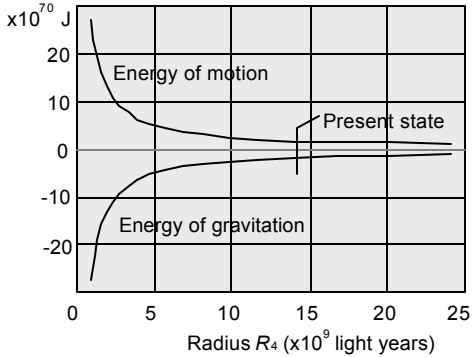

FIG. 9. The two-fold nature of matter at rest in space is manifested by the energies of motion and gravitation. The intensity of the energies of motion and gravitation declines as space expands along the 4-radius.

the infinite distances and the energy of motion is zero because all motion has ceased.

The build-up and disappearance of the observable physical reality is described as an inherently driven zero-energy process from emptiness at infinity in the past through singularity to emptiness at infinity in the future (see FIG. 8).

Equation (42) describes the two-fold nature of matter manifesting itself through the energy of motion and the energy of gravitation. The balance of the energies of motion and gravitation can be understood as the excited state of two complementary forms of energy. The excitation amplitude of the energies of motion and gravitation decreases as the Universe expands (see FIG. 9).

The rest energy, the energy of motion due to the motion of space in the fourth dimension, can be considered as a localised manifestation of the energy of matter, which is in counterbalance with the non-localised manifestation of the energy of matter, the energy of

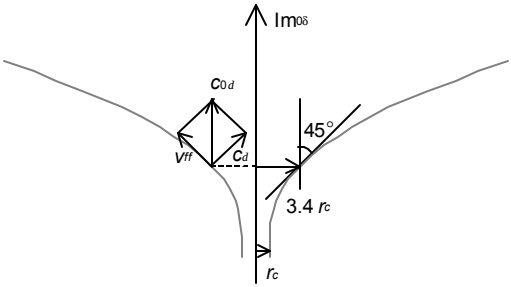

FIG. 10. Conserving the total energy of motion the imaginary velocity of homogeneous space, c_{0d}, is divided into the velocity of free fall, v_{ff}, and the imaginary velocity of local space c_d. At $r_{0d} = 3.414 \cdot r_c$ the velocity of free fall is equal to the local imaginary velocity of space.

gravitation. We do not need to assume the existence of anti-matter to balance the rest energy of matter.

Secondary energy build-up

Mass centre build-up in space is designated as the process of secondary energy build-up, which occurs as local accumulation of matter into mass centres. The secondary energy build-up is driven by free fall of matter due to local gravitation in space. The conversion of non-structured matter into radiation can be assumed to occur when the velocity of free fall reaches the local velocity of light. That occurs when the tilting angle of space reaches 45° at distance $r_{0d} = 3.414 \cdot r_c$ $\left(r_c = GM / c\, c_{0d}^2 \right)$ from a local singularity. By way of comparison, the critical radius of the Sun is $r_{c(Sun)} \approx GM/c^2 \approx 1.5\text{km}$. Typical neutron stars have a mass of about $\approx 1.5\, M_{Sun}$ and an radius of about 8 km, which corresponds to about $r_{0d} \approx 3.4 \cdot r_c$.

Because the conditions in local singularities are essentially those described for the hot Big Bang, we can presume that the next steps in the conversion follow the procedures of elementary particle build-up proposed by the Big Bang theory. According to the DU model matter in its basic form, when energised by the process of primary energy build-up, has the character of dark matter. In the process of secondary energy build-up, a portion of the matter is converted into radiation, elementary particles, and material.

Summary

Application of the zero energy principle on the dynamics of spherically closed, structured space leads to a detailed description of relativistic and cosmological phenomena in absolute co-ordinates of time and distance. The conversion from space-time in dynamic co-ordinates into dynamic space in absolute co-ordinates requires a major reorientation of our thinking about physical reality. Instead of being defined as a constant, the velocity of light is determined by the velocity of space in the fourth dimension. Mass appears as the substance for the expression of energy, and the rest energy of matter is the energy possessed by matter due to the motion of space.

The Dynamic Universe model relates any energy state of an object to the state of rest in hypothetical homogeneous space and produces mathematically closed expressions for the ticking frequencies of atomic oscillators in any state of motion and gravitation. It also gives closed mathematical expressions to the cosmological and local geometry of space and the propagation of electromagnetic radiation both at cosmological distances and in local space — all in a complete agreement with observations.

The following table gives a general comparison between the special and general theory of relativity, the standard cosmology model and the Dynamic Universe:

Basic assumptions

The theory of relativity and standard cosmology model	Dynamic Universe
Space-time is a four-dimensional continuum with local structure dependent on the distribution of mass density.	Space is a dynamic spherical structure closed through the fourth dimension. Local mass centres result in certain topology in space in the fourth dimension.
Time is considered as the fourth dimension.	The fourth dimension is geometrical in nature, but unaccessible from space.
In cosmological scale space is homogeneous, i.e. it looks essentially the same at any location (the cosmological principle).	In cosmological scale mass is uniformly distributed in space, which together with the spherical symmetry makes space look essentially the same at any location.
Gravitational interaction between masses is actuated by gravitons propagating at the velocity of light.	Gravitational interaction between masses is instantaneous. It can be described as an interaction between mass objects and space shaped in the fourth dimension.
The velocity of light is a physical constant and the maximum velocity by definition. Mathematically, the velocity of light is made the maximum velocity in space through the Lorentz transformation.	The velocity of light is determined by the local velocity of space in the fourth dimension, which, owing to the dynamics of space, is the maximum velocity achievable in space. The maximum velocity of light, which occurs in hypothetical homogeneous space, is determined by the state of the Universe $c = \sqrt{GG_E M_\Sigma / R_4}$ where

	G = gravitational constant G_E = 0.776 (geometrical factor) M_Σ = total mass in space R_4 = 4-radius of space
Energy is conserved in all interactions in space.	Energy is conserved in all interactions in space. Total energy is zero.
Mass is an expression of energy.	Mass is the substance for the expression of energy.
The total energy in space appeared instantaneously in the Big Bang and it stays the same forever or until the Big Crush.	The total energy (of all mass) in space can be expressed as the energy of motion gained against the release of the gravitational energy in the contraction and lost back to gravitational energy in the expansion of space.
The flow of time started at the Big Bang. Locally, the flow of time (proper time) depends on the state of motion and gravitation of the object.	Time is eternal and absolute in nature, but the characteristic frequencies of objects (like the ticking frequencies of atomic clocks) depend on the energetic state of the object.

Physics

The Theory of relativity	Dynamic Universe
Rest energy is a property of mass.	Rest energy is the energy of a mass object due to the motion of space in the fourth dimension.
Any state free of acceleration can be defined as a state of rest.	An energy frames defines the local state of rest, in which an object has the imaginary velocity of space only.
The explanation of the zero-result of the Michelson-Morley experiment requires length contraction and time dilation.	The explanation of the zero-result of the Michelson-Morley experiment can be derived from the Doppler effect of

	electromagnetic radiation without assumptions of length contraction or dime dilation.
Proper time and unit length are dependent on the state of motion and gravitation of the observer.	The flow of time and the unit length in the universal co-ordinate system are constant.
The rest energy of matter is $E_{rest} = mc^2$ where both m and c are independent of the state of motion and gravitation.	The rest energy of matter is an attribute of the local gravitational state $E_{rest} = m_0 c_0^2 \prod_{i=1}^{n} (1 - d_i) \prod_{i=1}^{n-1} \sqrt{1 - b_i^2}$ where $m_0 c_0^2$ is the reference energy in hypothetical homogeneous space. Factors d_i and b_i define the effect of gravitation and motion of the object in energy frame i. By applying the local velocity of light c, $c = c_0 \prod_{i=1}^{n} (1 - d_i)$ the local rest mass m $m = m_0 \prod_{i=1}^{n-1} \sqrt{1 - b_i^2}$ and the frame conversion factor $c = c_0 / c$, the rest energy can be expressed as $E_{rest} = c_0 m_0 c = c\, mc^2$
The total energy of an object is expressed as a scalar sum of the rest energy and the kinetic energy $E_{tot} = E_{rest} + E_{kin}$ or in terms of the rest energy and the momentum as the orthogonal sum	The total energy of an object is expressed as a complex function $E^*_{tot} = c_0 p^* = c_0 (p + i \quad mc)$ with scalar value expressed as $\mathrm{E_{tot}} = \mathrm{E_{rest}} + \mathrm{E_{kin}}$ or

$E_{tot} = c\sqrt{(mc)^2 + p^2}$	$E_{tot} = \lvert E^*_{tot} \rvert = c_0\sqrt{(mc)^2 + p^2}$ The velocity of light, c, as well as the mass, m, are characteristic of the particular gravitational state.
Planck constant h is constant with time. The quantum of action has dimensions of momentum-distance [kgm^2/s]	Intrinsic Planck constant $h_0 = h/c$ is constant with time. The quantum of action has dimensions of mass-distance [kgm].
Inertia is a property of mass. It is the same everywhere in space.	Inertia is related to the work done in reducing the gravitational effect of all mass in space on the object accelerated. Inertia is an attribute of the gravitational state.

Metrics and celestial mechanics

General theory of relativity	Dynamic Universe
Elliptic planetary orbits are associated with a perihelion advance $\Delta y \approx \frac{6p\,GM}{ac^2\left(1-e^2\right)}$ for a full cycle. Δy obtained from Schwarzschild metric diminishes gradually. The orbit obtained from Schwarzschild metric is also associated with a cumulating increase of eccentricity and aphelion distance[7,8].	Elliptic planetary orbits are associated with a perihelion advance $\Delta y = \frac{6p\,GM}{ac^2\left(1-e^2\right)}$ and a perturbation of the ellipticity $\Delta r\left(j\right) = \frac{6eGM\left(1-\cos j\right)}{c^2\left(1-e^2\right)}$ with the maximum at aphelion ($j = p$).
Deflection of light near mass centres can be expressed as $f = \frac{4GM}{r_d c^2}$	Deflection of light near mass centres can be expressed as $f = \frac{4GM}{r_d c^2}$
Delay of light near a mass centre is the consequence of two phenomena equal in quantity: the increase of distance and the reduction of the flow of time near a mass centre.	Delay of light near a mass centre is the consequence of two phenomena: the increase of distance and the reduction of the velocity of light near a mass centre. The increase of distance is relevant for the radial component of the propagation path only, whereas the reduction of the velocity of light affects equally in the radial and the tangential components of the path.

Cosmology

Standard cosmology model	Dynamic Universe
The Universe came into being in a "Big Bang" about 12-18 billion years ago (according to the inflation theory 8-12 billion years), and obtained its energy instantaneously as in a quantum jump. The energy created in the Big Bang has been conserved as a constant.	The energy of the Universe was built up gradually in contraction of space through a balanced interaction of motion and gravitation. The primary energy build-up culminated in a singularity 8-12 billion years ago when the contraction of space was turned into expansion. As space expands, the energy built up in the contraction phase is gradually released. The energy of the motion of space appears as the rest energy of matter.
The future of the Universe is unclear. The expansion of space continues forever if the density of mass in space is less than or equal to the Friedmann critical mass density. Alternatively it collapses in a "Big Crunch". The total energy in space is conserved in all alternatives.	The expansion continues to infinity but in the process the energies of motion and gravitation are consumed, and all expression of matter and radiation terminates. The Universe began in emptiness at infinity in the past and it returns to emptiness at infinity in the future. The mass density of space is 0.55 times the Friedmann critical mass density.
Light propagates along geodetic lines of space-time. The geometry of the geodetic lines at cosmological distances is not defined.	Light follows the shape of space. At cosmological distances the propagation path of light is a spiral in the fourth dimension.
The Hubble law for redshift is $z = \frac{H_0 D}{c} = \frac{D}{R_H}$	The Hubble law for redshift has the form

where R_H is the Hubble radius, D is the distance of the object, and H_0 is the Hubble constant. The originally experimental Hubble law assumes uniform distribution of matter and uniform expansion of space.	$$z = \frac{D}{R_4} e^a = e^a - 1$$ where R_4 is the 4-radius of space, D is the optical distance of the object, and a is the angular distance of the object in the universal co-ordinate system.
The interpretation of the angular size of a standard rod and the size of objects at cosmological distances is dependent on the deceleration factor related to the mass density in space.	The angular size of distant galaxies and the angular separation of interstellar distances are observed in Euclidean geometry $$q = \frac{a_d}{z}$$ where z is the redshift observed and a_d is the angular size of the object or the interstellar angular distance in the universal co-ordinate system with origin in the 4-center of space.
Observations on the magnitude and red shift of distant objects suggests that that the expansion of space is accelerating, which required a new unknown force against gravitation.	Observations on the magnitude and red shift of distant objects are in a complete agreement with the DU prediction without new assumptions.
Matter identified through its gravitational effect alone is referred to as dark matter. There is no theoretical description of dark matter.	(Dark) matter is the basic form of energised mass, which is converted into visible, structured material during the secondary energy build-up in space.
The background radiation observed in space is “afterglow” of the “Big Bang”.	Background radiation is focal point detection of light propagated through a 360° path in spherical space. The

	observer today sees light emitted from his own location in space about 750 000 years after the singularity.
The geological estimates of the age of stellar systems approach or exceed the structural age of the Universe estimated from the Hubble constant.	Geological estimates of the age of stellar systems are vastly reduced when the earlier higher energy state of the Universe is taken into account. A good match with the structural age of the Universe results.

Acknowledgements

I am grateful to Dr. Ari Lehto, Dr. Heikki Sipilä, Lic.Phil. Tarja Kallio-Tamminen, Dr. Pentti Passiniemi, M.Sc. Jouko Seppänen, M.Sc. Paul Talvio and Dr. Johannes Hopiavuori for insightful discussions on the laws of nature and the theoretical basis of the Dynamic Universe model.

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