Relativity defines the locally available share of total energy

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The Dynamic Universe model introduced in previous PIRT conferences is based on a zero energy balance of motion and gravitation in spherically closed space. Such an approach explains the rest energy of matter as the energy of motion mass in space possesses due to the motion of space, and allows the study of space as a closed energy system. Due to the spherical symmetry, a universal reference at rest *in* space is a state with zero velocity in space directions, directions perpendicular to the motion *of* space along the 4-radius of the spherical structure. Following the zero energy principle all local energy systems in space become related to the universal rest frame. Conservation of the total energy relates local velocities *in* space to the velocity *of* space and local gravitation *in* space to the gravitation *of* whole space — thus replacing observer oriented reference frames to energy system oriented reference frames like intrinsically applied in thermodynamics, quantum mechanics, and celestial mechanics or any mechanical system.

A zero energy balance means that the energy of motion is obtained against release of potential energy, the principle first time introduced by Gottfried Wilhelm Leibniz in late 17th century using the terms *vis viva*, "living force " obtained against release of *vis mortua* "dead force". Such an approach fixes a local frame of reference to the local energy system instead of fixing it to an inertial observer as allowed by Newton's laws of motion and the Galilean relativity, the forerunners of physical thinking for the upcoming centuries.

In the Dynamic Universe framework the conservation of energy in space is manifested through a chain of cascaded energy frames which extend the zero energy balance of whole space to local reference frames. As a fundamental difference to Einsteinian relativity, which relies on relativity principle and locally modified coordinate quantities, relativity in the DU defines the locally available share of the total energy — conserving the absolute nature of the coordinate quantities and making relativity an integral part of quantum mechanics, electromagnetism, mechanics, and thermodynamics.

In the Dynamic Universe framework, the expressions of the rest energy of matter, the energy of a quantum, and the energy of electromagnetic radiation obtain a unified form, which demonstrates the abstract nature of mass as the substance for the expression of energy and the primary role of the conservation laws. Based on very few assumptions, the Dynamic Universe model gives a coherent description of the structure of space and matter and produces precise predictions to physical phenomena throughout the scale from microstructures to cosmological distances.

Introduction

The Dynamic Universe [1,2,3] gives a holistic view of the observable physical reality. Starting from the overall structure and zero-energy dynamics of space, the dynamic universe approach allows a unifying analysis of the conservation of energy at all scales and shows the essence of relativity as an energetic coupling of local energy frames to the energy frame of whole space. Energy frames in the dynamic universe can be characterized as a chain of inbuilt Hamiltonian frames with potential energy and the energy of motion in balance.

In the DU, space is described as "a three dimensional zero-energy surface" in a four-dimensional universe. The minimum volume of a closed 3-surface has the shape of the surface of a 4-sphere, the shape space was widely assumed to posses before Friedman generalized the interpretation of space-time in general relativity. In the DU, the local geometry of space is derived from the conservation of total energy in mass center buildup. The dynamic approach links the rest energy of matter to the energy of motion mass has due to the motion of space in the fourth dimension, the direction of the 4-radius of the spherically closed structure. The velocity of light in space becomes linked to the velocity of space, and the fourth dimension, although not accessible from space, obtains a direct geometrical meaning allowing time to be treated as a universal scalar.

By converting the Einsteinian spacetime in dynamic coordinates into dynamic space in absolute coordinates, the Dynamic Universe perspective provides a unifying view on physical phenomena in a solid linkage to the cosmological structure and the development of space and the universe.

The Dynamic Universe model is primarily an analysis of energy balances in space — starting from whole space as an energy frame for interactions of motion and gravitation in cosmological scale and ending to elementary particles as microscopic energy objects in their parent frames. Such an approach is possible only in structured space and it leads to a holistic view of the physical reality. Energy available to local phenomena is linked to the energetic state of whole space through a system of cascaded energy frames. Such a linkage makes *the laws of nature common to all phenomena* and allows the use of universal coordinate quantities, absolute time and distance.

Relativity in the Dynamic Universe results from the conservation of total energy in space – relativity is not related to observer or observation but to the energetic state of the object observed. The laws of nature common to all energy frames obviate the need for the relativity and equivalence principles.

1. The primary energy buildup

The zero energy balance

In the early 1900’s when the theory of relativity was formulated the view of the structure of space was quite limited. The expansion of space had not been detected and the galactic structures were unknown. It was natural to think space as static entity without a specific center or a universal reference at rest. When Einstein in 1917 published his view of the cosmological structure of space as the “surface” of a 4-sphere, he needed the famous cosmological constant to prevent a collapse of space into singularity [4].

In static space the interpretation of the observed constancy of the velocity of light led to a spacetime concept with a time-like fourth dimension and variable distance and time coordinates characterized as proper time and proper distance. Dilated time was explained as a consequence of the velocity the object relative to the observer, and through a curved spacetime, a property of the spacetime geometry.

If spherically closed space is allowed to contract and expand in a zero-energy balance of motion and gravitation, the Einsteinian time-like fourth dimension becomes replaced by a purely metric dimension in the direction of the motion of space along the 4-radius of the structure. The center of symmetry and the reference at rest for the expansion and contraction of spherically closed space is in the center of the 4-sphere. Expansion of spherically closed space does not create motion within space; the momentum of the expansion appears only in the direction of the 4-radius perpendicular to all space directions. The related energy of motion appears as the rest energy of matter in space. A homogeneous expansion of the 4-sphere is observed as recession of objects in space at a velocity proportional to their distances from the observer.

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. As a consequence of the conservation of the primary energy created in the contraction-expansion process, the velocity of space in the fourth dimension sets the upper limit to velocities obtainable in space. The “great mystery” of the equality of the rest energy and the gravitational energy of all mass in space is a direct indication of the zero-energy balance of motion and gravitation in space [5].

In contraction, started from a 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 (see Figure 1-1).

A detailed analysis of the intrinsic forms of the energies of motion and gravitation in a homogeneous 4-sphere allows the expression of the zero energy condition as

$$M_\Sigma c_4^2 - \frac{GM_\Sigma M''}{R_4} = 0 \qquad (1:1)$$

where G is the gravitational constant, c_0 is the velocity in the direction of the radius R_4 of the 4-sphere, and $M'' = I_g \cdot M_\Sigma$ is the mass equivalence of the total mass M_Σ in space. The factor $I_g = 0.776$ comes from the integration of the gravitational energy of a 4-sphere. Equation (1:1) links the velocity of the contraction or expansion along the 4-radius R_4 to the gravitational constant, the total mass in space, and the 4-radius as

$$c_4 = \pm\sqrt{\frac{GM''}{R_4}} = \pm\sqrt{\frac{GI_g M_\Sigma}{R_4}} \qquad (1:2)$$

Applying a mass density $\rho \approx 0.55 \cdot \rho_c$, where ρ_c is the Friedmann critical mass density, 4-radius $R_4 = 14 \cdot 10^9$ light years (= the present estimate of the Hubble radius), and the gravitational constant $G = 6.7 \cdot 10^{-11}$ [Nm^2/kg^2] equation (1:2) gives $c_0 = 300\,000$ km/s which is equal to the present velocity of light. Conservation of energy in interactions in space requires that the maximum velocity obtainable in space is equal to the expansion velocity c_4, which confirms the interpretation of $c_0 = c_4$ as the velocity of light in hypothetical homogeneous space. It also confirms the interpretation of the rest energy as the energy of motion mass has due to the motion of space in the direction of the 4-radius.

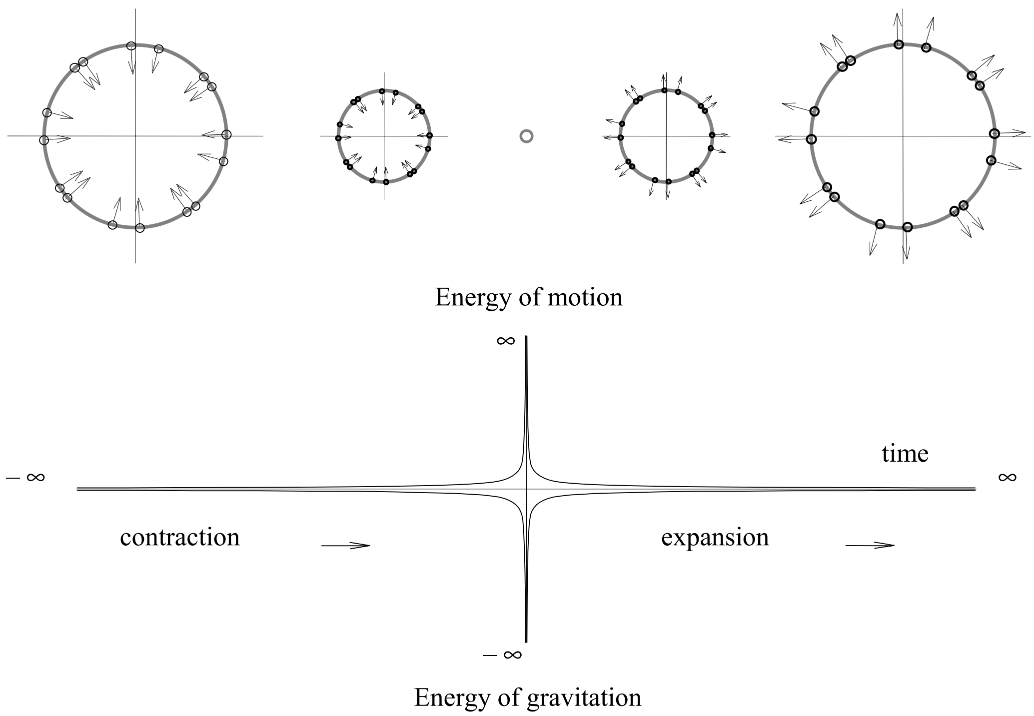

FIGURE 1-1. Energy buildup and release in spherical space. In the contraction phase, the velocity of space in the direction of the 4-radius increases due to the energy gained against loss of gravitation. In the expansion phase, the velocity gradually decreases, when the energy of motion gained in contraction is returned to gravity.

Time t from singularity can be expressed as

$$t = \frac{2}{3}\frac{R_4}{c_0} \tag{1:3}$$

which means that for a Hubble radius of 14 billion light years [corresponding to Hubble constant H_0 = 70 [(km/s)/Mpc], the age of the expanding universe since singularity is 9.3 billion years.

When solved for time t since singularity in expanding space, the expansion velocity and the velocity of light in homogeneous space obtain the form

$$c_0 = \frac{dR_4}{dt} = \left(\frac{2}{3}GM''\right)^{1/3} t^{-1/3} \tag{1:4}$$

While working against the gravitation of the structure, the velocity of expansion and, accordingly, the velocity of light in space slow down gradually. At present the deceleration is $dc/c \approx -3.6\cdot10^{-11}$ /year.

The rest energy of matter is built up against release of the gravitational energy of the structure in a contraction and expansion process in the fourth dimension. The expression of the rest energy of mass m means excitation of the energy of motion against the gravitational energy of whole space (see FIG. 1-2).

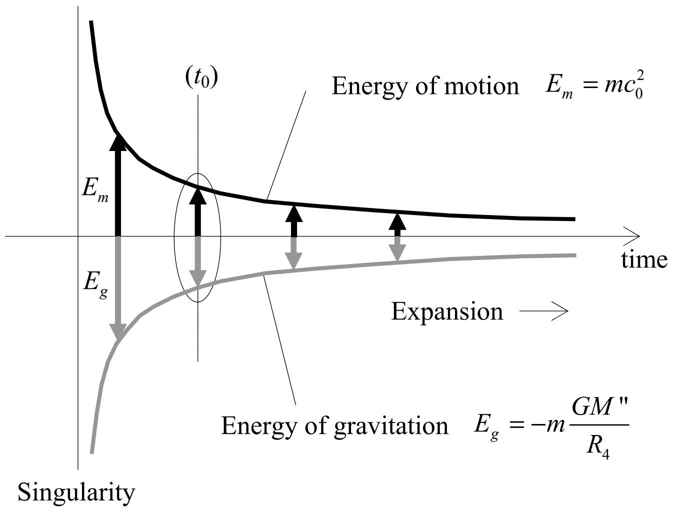

FIGURE 1-2. The dualistic expression of the rest energy of matter. In the expansion of space the rest energy gained in a pre-singularity contraction phase is gradually released back to the gravitational energy. The zero-energy linkage of the complementary expressions of energy links any localized mass object to the rest of space.

There is no need to assume antimatter in zero energy balanced space. The negative counterpart of the positive rest energy of matter is the gravitational energy due to all other mass in space. By its nature, the energy of gravitation is non-localized, contrast to the localized nature of the rest energy.

Closed spherical space gives an essentially more ordered picture of our universe and the prevailing laws of nature than do the standard cosmology model and the relativity theory behind it. Instead of a sudden appearance in a big bang, the buildup and release of the energy of matter in space can be described as a continuous process from infinity in the past through singularity to infinity in the future. Following the zero energy principle, any expression of energy in space becomes related to the energetic state of whole space through a chain of cascaded systems.

In historical context there is an obvious connection between the zero energy principle in the Dynamic Universe and the Leibniz's idea of *vis viva* obtained against the release of *vis mortua*, i.e. kinetic energy, the "living force" is obtained against the release of potential energy, the "dead force". Leibniz had a clear intuitive view of nature as a highly balanced system of complementary actions [6].

As an additional link to Leibniz's ideas, localized energy objects in the Dynamic Universe look like having something characteristic to Leibniz's *monads*. Like a Leibniz's monad, a localized energy object in the DU is a reflection of the rest of the universe — it can be equally described in terms of the rest energy of the localized object or the non-localized gravitational energy of the same due to all other mass in space. A localized mass object exists as an excited state based on "an energy loan" to be paid back with the completion of the cycle of physical existence.

The energy of motion in space

The Dynamic Universe relies on very few assumptions. The key assumptions are the closed spherical geometry of space and a zero-energy balance of motion and gravitation. Instead of postulating gravitational and inertial *forces*, the Dynamic Universe postulates inherent gravitational *energy* and inherent *momentum* as they would appear at rest in hypothetical homogeneous environment. Force is defined as the negative of the gradient of energy. The laws of motion, the relationship between force and acceleration, are not postulated but derived from the conservation of the total energy in space. As a part of that derivation, the maximum velocity obtainable in space is shown to be equal to the velocity of space in the fourth dimension.

Mass in the Dynamic Universe is the substance for the expression of the energies of motion and gravitation. The total mass in space, denoted as M_Σ, is a fundamental constant conserved throughout the energy buildup and release. The energies of gravitation and motion are based on the inherent forms of the energies defined in hypothetical "empty environment at rest" as

$$E_{g(i)} = -\frac{GmM}{r} \qquad (1:5)$$

and

$$E_{m(i)} = v\left|\mathbf{p}_{(i)}\right| = v \cdot m\left|\mathbf{v}\right| \qquad (1:6)$$

respectively. Quantity $\mathbf{p} = m\mathbf{v}$ in equation (1:6) is referred to as the inherent momentum of mass in motion at velocity $\mathbf{v}$.

The contraction and expansion of spherically closed space in the direction of the 4-radius is assumed to take place "in environment at rest" authorizing the use of the expression of the inherent energy of motion. The energy of motion due to the expansion of space at velocity c_4 in the fourth dimension is the rest energy of mass in space. For mass at rest in homogeneous space the rest energy is expressed in form

$$E_{rest} = c_4\left|\mathbf{p}_4\right| = mc_4^2 \qquad (1:7)$$

which is formally identical to the expression of the energy of electromagnetic radiation, $E = c\cdot|\mathbf{p}|$, propagating at velocity c in space. Unlike the momentum of radiation propagating in space, the rest momentum $\mathbf{p}_4$ in equation (1:7) appears in the fourth dimension perpendicular to the three space directions

$$\mathbf{p}_4 = m\mathbf{c}_4 \qquad (1:8)$$

For an object moving in space, the total momentum 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

$$\mathbf{p}_{tot} = \mathbf{p} + \mathbf{p}_4 \tag{1:9}$$

Motion in space is not motion in environment at rest but in environment moving at velocity c_4 in the fourth dimension. The total energy of motion becomes

$$E_{tot} = c_4 \, | \mathbf{p}_{tot} | = c_4 \, | \mathbf{p}_4 + \mathbf{p} | = c_0 \sqrt{|m\mathbf{c}|^2 + |\mathbf{p}|^2} \tag{1:10}$$

which is essentially equal to the well known expression of the total energy introduced by the theory of special relativity through a completely different reasoning. Velocity c_0 in equation (1:10) refers to the velocity of light in homogeneous space which is equal to velocity c_4.

Kinetic energy, through a change in the total momentum, describes the local work done, or potential energy lost, in obtaining a velocity in space. A general expression of the kinetic energy obtains the form

$$E_{kin} = c_0 \cdot \Delta \, | \mathbf{p} | = c_0 \left(m\Delta c + c\Delta m \right) \tag{1:11}$$

In the framework of relativity theory, built on the constancy of the velocity of light, only the second term in equation (1:11) is relevant. As shown in [1], in the DU framework the term $m\Delta c$ in equation (1:11) applies to kinetic energy obtained in free fall in a local gravitational frame where the velocity of local space is changed through tilting of space, and the second term $c\Delta m$ in the case of motion obtained through acceleration at a constant gravitational potential in space.

In the DU framework, the locally observed total energy of motion obtains a generalized form

$$E_{m(tot)} = c_0 \, | \mathbf{p} | = c_0 m_{eff} c \tag{1:12}$$

where c_0 is the velocity of light in hypothetical homogeneous space equal to the velocity of the expansion of space in the fourth dimension, m_{eff} is the effective mass to be derived from the velocity of mass m in a local energy frame and the velocities of the local frame as energy object in its parent frames in a system of cascaded energy frames. Velocity c is the local velocity of light determined by the local gravitational state through the local tilting of space in the local gravitational frame and in the parent frames in the system of cascaded energy frames.

The locally available rest energy of matter obtains a generalized form

$$E_{rest} = c_0 \, | \mathbf{p}_4 | = c_0 mc \tag{1:13}$$

where the locally available rest mass and the local velocity of light are determined by the conservation of the rest energy obtained in through the contraction and expansion of space and expressed in equation (1:7).

Relativity in Dynamic Universe relates the local energy of motion and gravitation to the corresponding energies in hypothetical homogeneous space.

2. Buildup of kinetic energy through free fall in space

In real space mass is accumulated into mass centers, material structures moving in local energy systems in space. The basic mechanism of conserving the total energies of motion and gravitation in mass center buildup can be illustrated as a process of free fall where the velocity and momentum in space are obtained as orthogonal components of the velocity and momentum in the fourth dimension through tilting of local space. The conservation of the total momentum can be expressed with equation

$$\mathbf{p}''_{\delta} + \mathbf{p}'_{esc} = \mathbf{p}''_{0\delta} \tag{2:1}$$

where $\mathbf{p}''_{\delta}$ is the momentum in the local fourth dimension, $\mathbf{p}'_{esc}$ is the escape momentum back to homogeneous space, and $\mathbf{p}''_{0\delta}$ is the momentum in fourth dimension in homogeneous space.

Assuming mass to be conserved in the process, the conservation equation (2:1) can be written for corresponding velocities as

$$\mathbf{c}''_{\delta}+\mathbf{v}'_{esc}=\mathbf{c}''_{0\delta} \tag{2:2}$$

(see FIG. 2-1).

Figure 2-1 applies complex coordinates with the imaginary axis in the fourth dimension. In tilted space the direction of the local fourth dimension is Im_{δ} and in homogeneous space $\mathrm{Im}_{0\delta}$. The tilting angle ϕ of the local imaginary axis can be expressed in terms of the escape velocity and the imaginary velocities of space as

$$\sin\phi=\frac{v_{\delta}}{c_{0\delta}}=\frac{v_{0\delta}}{c_{\delta}}\equiv\beta \tag{2:3}$$

where v_{δ} is the escape velocity in the direction of the local space, the Re_{δ} axis, and $v_{0\delta}$ the escape velocity in the direction of homogeneous space, the $\mathrm{Re}_{0\delta}$-axis. The local velocity of light in the δ-state is the local imaginary velocity of space

$$c_{\delta}=c=c_{0\delta}\cos\phi \tag{2:4}$$

and the local rest energy obtains the form

$$E_{rest}=c_0\left|\mathbf{p}_{\delta}''\right|=c_0mc=E_{rest(0\delta)}\cos\phi \tag{2:5}$$

Free fall means accumulation of mass into mass centers in space which means breakage of the symmetry used in calculating the gravitational energy in homogeneous space. Mass M accumulated into a local mass center is no more contributing to the gravitational energy of mass equivalence M" in the center of symmetry of spherically closed space. Mass M at distance $r_{0\delta}$ from mass m removed from the symmetry reduces the gravitational energy of homogeneous space as

$$E''_{g(\delta)}=-\left(\frac{GM''m}{R_4}-\frac{GMm}{r_{0\delta}}\right)=E''_{g(0\delta)}\left(1-\delta\right) \tag{2:6}$$

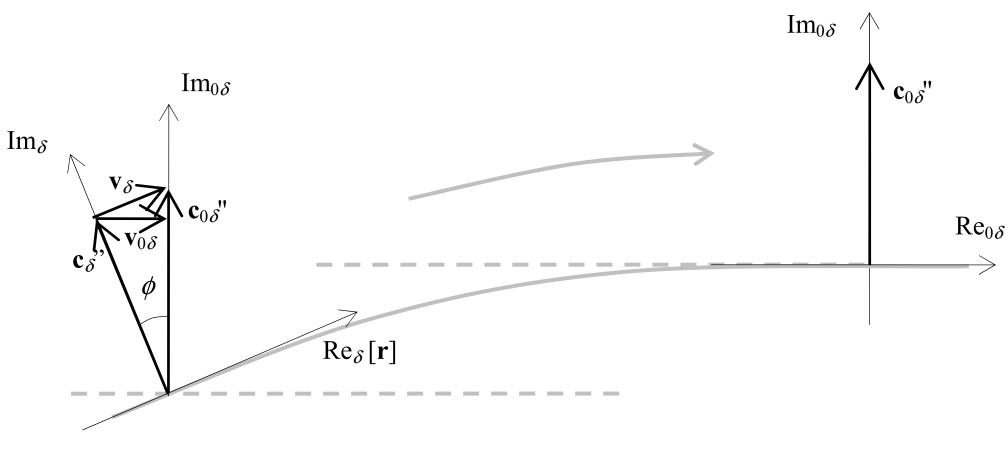

FIGURE 2-1. Escape velocity $v_{0\delta}$ in the direction of the Re_0 axis is the velocity at which escape proceeds in the direction of the non-tilted space. Angle ϕ approaches zero and velocity $v_{0\delta}$ approaches velocity v_{δ} when the escape approaches the non-tilted space. As illustrated in the figure, the momentum in equation (2.4:1) can be expressed as $\mathbf{p}_{\delta}'=mv_{\delta}\hat{\mathbf{r}}_{\delta}$ of mass object m moving at velocity v_{δ} in the local δ-frame (in the direction of the Re_{δ} axis) or momentum $\mathbf{p}_{\delta}'=m'v_{0\delta}\hat{\mathbf{r}}_{\delta}$ of mass object $m'=m\big/\sqrt{1-\beta^2}=m/\cos\phi$ moving at velocity $v_{0\delta}$ in homogeneous space frame (in the direction of the Re_0 axis). $\beta=v_{\delta}/c_{0\delta}=v_{0\delta}/c_{\delta}=\sin\phi$.

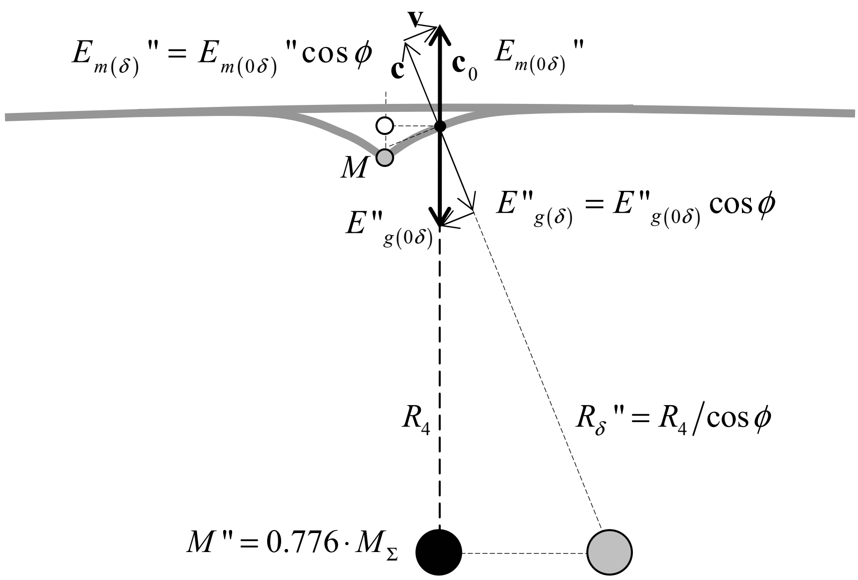

FIGURE 2-2. In tilted space (M<<M" and R_δ"<<R_4) the mass equivalence of homogeneous space appear in the direction of the local fourth dimension.

where δ is the gravitational factor

$$\delta = \frac{M}{r_{0\delta}}\frac{R_4}{M"} = \frac{GM}{r_{0\delta}c_0^2} \tag{2:7}$$

and, by combining equations (2:6) and (2:7), the tilting angle ϕ can be expressed in terms of the gravitational factor (see FIG. 2-2)

$$\cos\phi = \frac{E"_{g(\delta)}}{E"_{g(0\delta)}} = (1-\delta) \tag{2:8}$$

Substitution of (2:8) for cosϕ in (2:4) relates the local velocity of light to the local gravitational factor δ

$$c = c_\delta = c_{0\delta}(1-\delta) \tag{2:9}$$

The conservation of the total energy of motion in free fall can now expressed as

$$E_{tot(\delta)} = E_{rest(0\delta)} = c_0\left|\mathbf{p}"_{0\delta}\right| = c_0\left|\mathbf{p}"_\delta + m\mathbf{v}_\delta\right| = c_0\sqrt{(mc)^2 + (mv_\delta)^2} \tag{2:10}$$

or by relating the local total energy to the escape velocity in the direction of homogeneous space as

$$E_{tot(\delta)} = c_0\sqrt{(mc)^2 + \left(\frac{mv_{0\delta}}{\sqrt{1-\beta^2}}\right)^2} \tag{2:11}$$

where the square root term $\sqrt{1-\beta^2}$ can be interpreted as the correction of escape velocity due to the tilting of space or an increase of an effective mass for the momentum in the direction of the real axis in homogeneous space

$$p_{\delta(esc)} = mv_\delta = \frac{mv_{0\delta}}{\sqrt{1-\beta^2}} = m_{eff}v_{0\delta} \tag{2:12}$$

3. Kinetic energy and the Mach's principle

Kinetic energy in space is the increase in the absolute value of the energy of motion

$$\text{Mod}\left\{\Delta E_{m(tot)}\right\} = E_{m(tot)} - E_{rest} = E_{kin} = c_0 \Delta(mc) = c_0 \left(m\Delta c + c\Delta m\right) \qquad (3:1)$$

In free fall, kinetic energy is obtained against a reduction in the local velocity of light and the mass is conserved. Acceleration of mass in space at constant gravitational potential means conservation of the local velocity of light and the increase of kinetic energy is obtained through an increase in the mass of the object put in motion.

For a detailed study of the components of momentum and the energy of motion it is useful to define a vector like energy equivalent of momentum

$$\mathbf{E}^* = c_0\mathbf{p}^* = c_0\mathbf{p}' + \mathrm{i}\, c_0\mathbf{p}'' = \mathbf{E}' + \mathrm{i}\,\mathbf{E}'' \qquad (3:2)$$

or by using the scalar components in the real and imaginary directions as

$$E^* = c_0 p' + \mathrm{i}\, c_0 p'' = E' + \mathrm{i}\, E'' \qquad (3:3)$$

Figure 3-1 illustrates the energy equivalents of momenta for the rest energy, total energy and kinetic energy in the local complex coordinate system. It also illustrates the negative gravitational energy in the direction of negative imaginary axis.

For an object at rest in a local energy frame in space the total energy motion has the imaginary component only, $E^* = E'' = E_{rest}$ [FIG. 3-1 (a)].

$$E^*_{m(0)} = \mathrm{i}\, E''_m = \mathrm{i}\, c_0 p'' = \mathrm{i}\, c_0 mc \qquad (3:4)$$

When momentum **p**' in a space direction is added, the total momentum obtains a complex form

$$E^*_{tot(\phi)} = c_0\mathbf{p}^* = c_0 p' + c_0\, \mathrm{i}\, mc = \frac{c_0 mc}{\cos\phi}\left(\sin\phi + \mathrm{i}\cos\phi\right) \qquad (3:5)$$

where the modulus can be written as the scalar sum of the rest energy and kinetic energy as

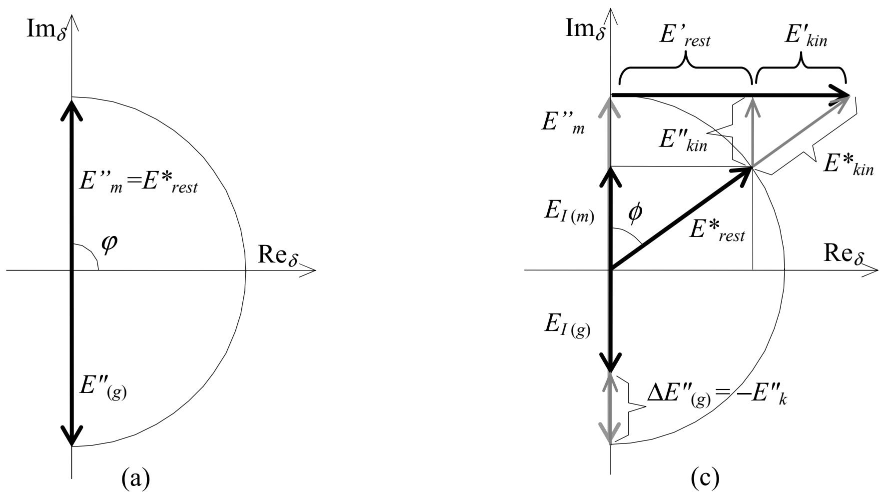

FIGURE 3-1. Energy equivalence of momenta for the rest energy, total energy and kinetic energy in local space. (a) For an object at rest in a local energy frame in space the total energy motion has the imaginary component only, $E^* = E'' = E_{rest}$. (b) turn of rest momentum by angle $\phi = \text{arc}(\sin\beta)$ results in a real component $p' = mv$ by reducing the imaginary component by the factor $\sqrt{1-\beta^2}$. (c) the momentum in space required to result in the turn of total momentum by angle ϕ is $p' = mc\tan\phi$. Energy E^*_k is the complex kinetic energy, the work done in space for changing the state of rest into the state of motion at velocity v in the local frame. The imaginary part of the kinetic energy is the work done in reducing the imaginary energy of gravitation $E^*_k = -\Delta E''_g$.

$$E^*_{tot(\beta)} = c_0\mathbf{p}^* = \left[c_0 mc + c_0 mc\left(\frac{1}{\cos\phi} - 1\right)\right]\left(\sin\phi + \mathrm{i}\cos\phi\right) \tag{3:6}$$

Angle ϕ can be expressed in terms of the real part of the complex rest momentum

$$\phi = \mathrm{arc}\left(\sin\frac{p'_{rest}}{p_{rest}}\right) = \mathrm{arc}\left(\sin\frac{mv}{mc}\right) = \mathrm{arc}\left(\sin\beta\right) \quad ; \quad \beta = \frac{v}{c} \tag{3:7}$$

Substitution of (3:7) transforms equation (3:5) into form

$$E^*_{tot(\beta)} = c_0\left(\frac{vm}{\sqrt{1-\beta^2}} + \mathrm{i}\,cm\right) \tag{3:8}$$

which is the sum of the complex rest energy

$$E^*_{rest(\beta)} = c_0 mv + \mathrm{i}\,c_0 mc\sqrt{1-\beta^2} \tag{3:9}$$

and the complex kinetic energy

$$E^*_{kin(\beta)} = c_0 mv\left(\frac{1}{\sqrt{1-\beta^2}} - 1\right) + \mathrm{i}\,c_0 mc\left(1 - \sqrt{1-\beta^2}\right) \tag{3:10}$$

The scalar value of the kinetic energy in equation (3:10) is

$$E_{kin(\beta)} = \left|E^*_{kin(\beta)}\right| = c_0 mc\left(\frac{1}{\sqrt{1-\beta^2}} - 1\right) = c_0\Delta m\cdot c \tag{3:11}$$

where

$$\Delta m = m\left(\frac{1}{\sqrt{1-\beta^2}} - 1\right) \tag{3:12}$$

results in the buildup of effective mass

$$m_{eff} = m + \Delta m = \frac{1}{\sqrt{1-\beta^2}} \tag{3:13}$$

The complex rest momentum $\mathbf{p}^*_{rest(\beta)}$ contributes to the real part of the total momentum, the momentum observed in space, and the corresponding energy equivalence as

$$E'_{rest} = c_0 p'_{rest} = c_0 mv \tag{3:14}$$

As a consequence, the imaginary component of the rest energy is reduced to

$$E''_{rest} = c_0 p''_{rest} = c_0 mc\sqrt{1-\beta^2} = c_0 m_I \tag{3:15}$$

Motion in space does not change the imaginary velocity of space c, which means that motion in space reduces the *internal mass*, m_I, available to contribute to the imaginary part of the rest momentum

$$m_I = m\sqrt{1-\beta^2} \tag{3:16}$$

The internal mass is the counterpart of effective mass; the buildup of kinetic energy in space reduces the energetic excitation of the moving object in the imaginary direction, and the zero energy balance in the imaginary for a moving object is

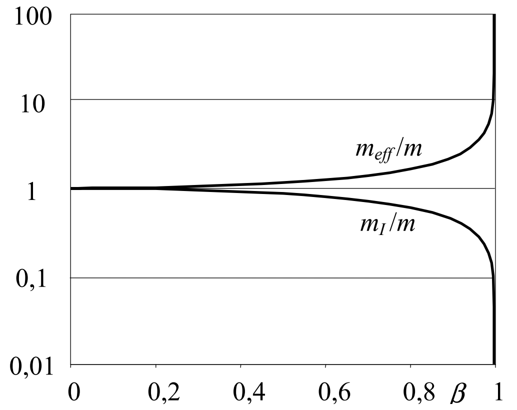

FIGURE 3-2. The development of the effective mass m_{eff} and internal mass m_I with the increasing velocity $\beta = v/c$ in an energy frame. The product of the effective and internal masses, $m_{eff} \cdot m_I = m^2$, remains constant conserving the geometric mean of the two masses.

$$E''_{rest(\beta)} = c_0 m_I = \frac{GM'' m_I}{R''} \tag{3:17}$$

This also shows that the imaginary part of the kinetic energy is work done for reducing the gravitational energy due to all other mass in space

$$\Delta E''_{g(\beta)} = \frac{GM''\left(m - m_I\right)}{R''} = E''_{kin} = c_0\left(m - m_I\right)c \tag{3:17}$$

which gives a quantitative expression to Mach's principle.

The reduction in the internal mass m_I is counterbalanced by the increase of the effective mass m_{eff}. By combining equations (5:13) and (5:16) the product of the effective and internal mass can be expressed as

$$m_{eff} \cdot m_I = m^2 \tag{3:18}$$

which shows that the geometric mean of the effective and internal masses is equal to the rest mass m of the mass object studied (see FIG. 3-2).

The internal mass m_I appears as the rest mass for motion built up *in the local frame in the moving object* (see FIG. 3-3).

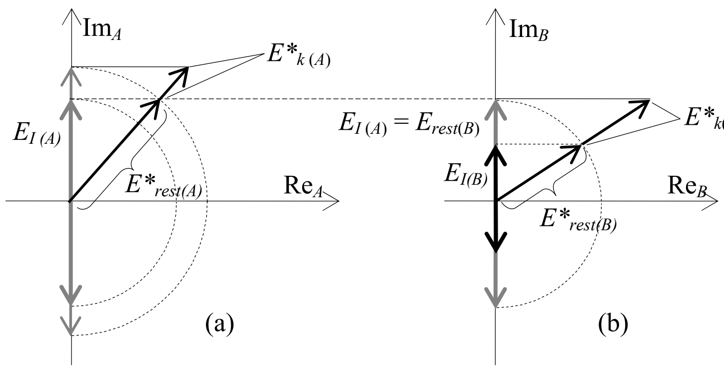

FIGURE 3-3. Kinetic energy (a) in frame A (the parent frame to frame B), and (b) in frame B moving in frame A. The internal energy $E_{I(A)}$ of mass m in frame A appears as the rest energy mass has available in frame B. Accordingly, the kinetic energy $E_{k(B)}$ of mass m in frame B is subject to the effects of motions both in frame B and the motion of frame B its parent frame A.

4. Buildup of mass centers in real space, cascaded energy frames

In real space mass is aggregated into mass centers in several steps. Homogeneous space has curled into galactic structures inhabiting galaxies with numerous stellar systems, stars and planetary systems, all in motion in their parent frames (see FIG. 4-1).

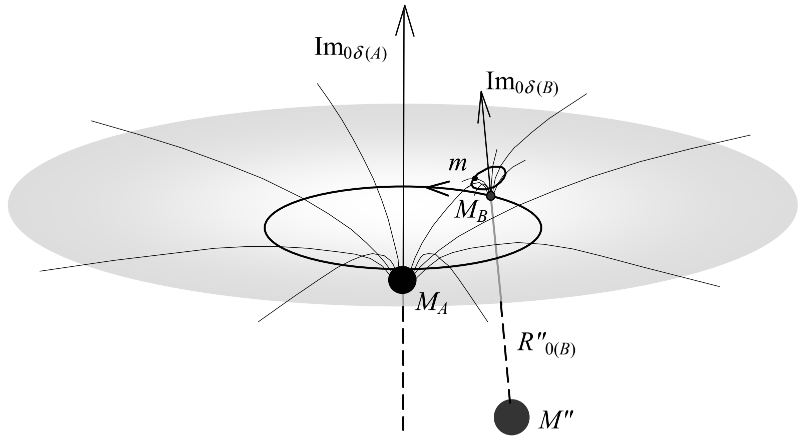

FIGURE 4-1. Mass object m rotating in the M_B gravitational frame rotates with the M_B-frame in the M_A-frame. Each mass center creates a local dent in space. Each dent in space reduces the local velocity of light and the motion of each frame reduces the mass of an object in a local frame.

Each mass center creates a dent in space in the fourth dimension resulting in a tilt in the direction of the local imaginary axis. As a consequence, the local imaginary velocity of space, and accordingly the local velocity of light are reduced in each step. Further, each sub-frame is in motion in its parent frame, which results in a reduction in the internal mass in each sub-frame.

By starting from hypothetical homogeneous space and by combining the effects of gravitation and motion in each step, the rest energy of mass m in the n:th of the cascaded frames is

$$E_{rest} = c_0 mc \tag{4:1}$$

where the rest mass m in the n:th frame is

$$m = m_{rest(n)} = m_0 \prod_{i=1}^{n-1} \sqrt{1-\beta_i^2} \tag{4:2}$$

and the local velocity of light

$$c = c_{(n)} = c_0 \prod_{i=1}^{n} \left(1-\delta_i\right) \tag{4:3}$$

In each local frame, the rest energy can be related to the rest energy in the immediate parent frame as

$$E_{rest} = c_0 mc = c_0 m_{0\delta} c_{0\delta} \left(1-\delta\right)\sqrt{1-\beta_{0\delta}^2} = E_{rest(0\delta)} \left(1-\delta\right)\sqrt{1-\beta_{0\delta}^2} \tag{4:4}$$

where δ is the gravitational state of the object in the local frame and $\beta_{0\delta}$ is the velocity of the local frame in the parent frame. Subscript "$_{0\delta}$" is generally used to refer to the parent frame of a local frame.

In the chain of cascaded gravitational frames the parent frame of the next sub-frame is referred to as *apparent homogeneous space* to the sub-frame (see FIG. 4-2). Space in the M_A-frame in Figure 4-2 serves as apparent homogeneous space for the local dent around mass center M_B.

The system of cascaded energy frames is a central feature in the Dynamic Universe model. The cascaded energy frames create a link from any local energy frame to hypothetical homogeneous space, which serves as a universal reference to all energy states in space (see FIG. 4-3). The system of cascaded energy frames is a consequence of the zero-energy principle and the conservation of the energetic excitation built up in the primary energy build-up process.

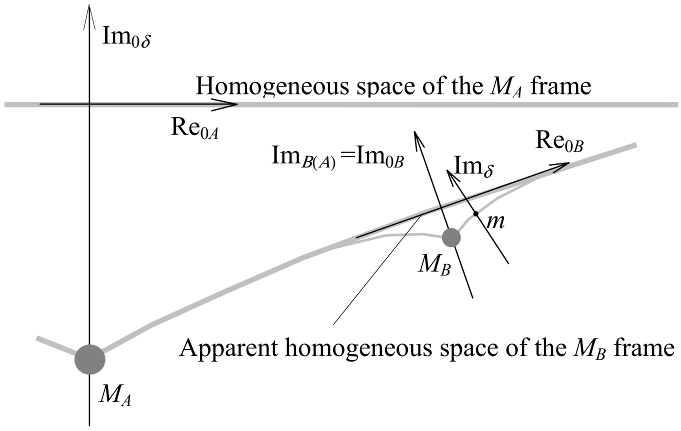

FIGURE 4-2. The apparent homogeneous space of the M_B-frame around mass center M_B follows the direction of space in the M_A-frame as it would be without the M_B center.

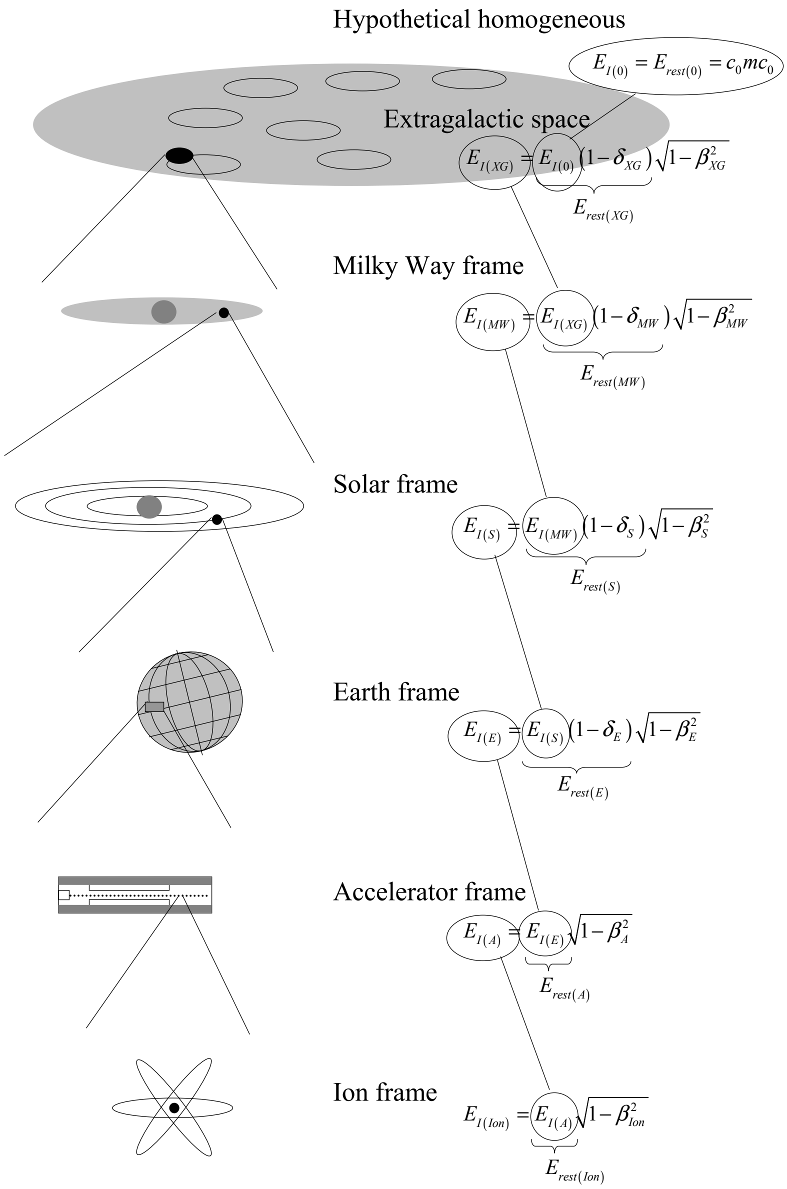

FIGURE 4-3. The rest energy of an object in a local frame is determined by the internal energy of the local frame in its parent frame. The internal energy is the imaginary component of the rest energy. The system of cascaded energy frames relates the rest energy of an object in a local frame to the rest energy of the object in hypothetical homogeneous space. As a consequence of the conservation of the total energy in space, motion and local gravitation of each parent frame reduce the rest energy available in the local frame.

The local state of rest in an energy frame is established through the separation of the effective mass related to the motion of the local frame in its parent frame, and the complementary internal mass available as rest mass in the local frame.

Motion of a local frame, or energy object, in its parent frame, results in a central force reducing the gravitation of the mass equivalence *M"* of whole space. When mass *m* in the local frame is studied as effective mass m_{eff} moving at velocity β in the parent frame, the effective gravitational force of mass *M"* of whole space is reduced due to the central acceleration as

$$\frac{\mathbf{F}"_{(\beta)}}{\mathbf{F}"_{(0)}} = \frac{m_{eff}}{m}\left(1-\beta_n^2\right) = \sqrt{1-\beta_n^2} \tag{4:5}$$

When the same mass is studied as the internal mass at rest in the local frame [*n*+1] the effective gravitational force of mass *M"* of whole space is reduced due to the reduction of the locally available rest mass in the frame [*n*+1] moving at velocity β_n in the parent frame as

$$\frac{\mathbf{F}"_{(0)[n+1]}}{\mathbf{F}"_{(0)}} = \frac{m_{rest[n+1]}}{m} = \frac{m_{I[n]}}{m} = \sqrt{1-\beta_n^2} \tag{4:6}$$

The equality of equations (4:5) and (4:6) means that the replacement of the effective mass in motion in the parent frame with the internal mass at rest in the local frame results in no change in the balance of forces in the fourth dimension (see FIG. 4-4).

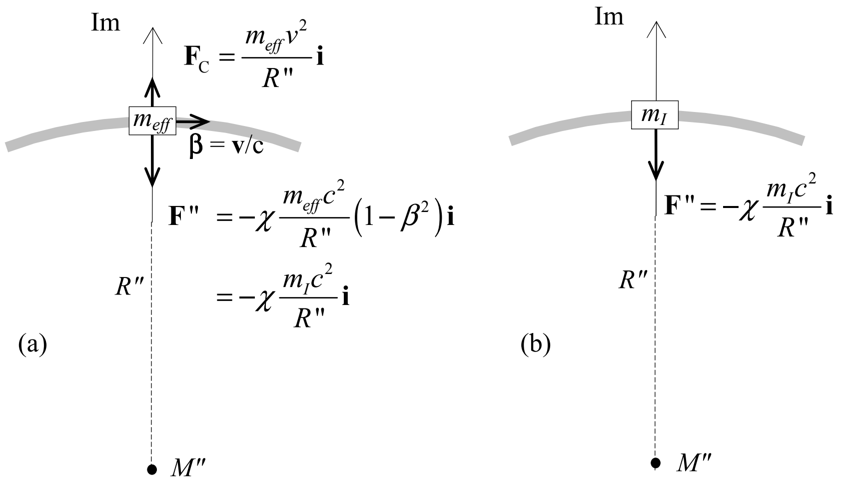

FIGURE 4-4. (a) The gravitational force of mass equivalence *M"* on mass m_{eff} moving at velocity **v** with a local frame is reduced by the central force F_C, which makes it equal to the gravitational force of mass equivalence *M"* on mass m_I at rest in the local frame as illustrated in figure (b).

5. The energy of a quantum and the characteristic frequencies of atoms

Quantum as the minimum dose of electromagnetic radiation

The Dynamic Universe approach unifies the local expressions of energy by identifying mass as the substance and the primary conserving quantity for all forms of energy — including electromagnetic energy and photons.

As a "hidden" message in Maxwell's equations, an intrinsic form of Planck's constant, $h_0 = h/c$ [kg·m], shows the mass equivalence and the energy of a single cycle — or a wavelength of electromagnetic radiation as

$$E_{\lambda(0)} = \frac{h_0}{\lambda}c_0 = m_{\lambda(0)}c_0 c \tag{5:1}$$

or in a generalized form

$$E_\lambda = N^2 \frac{h_0}{\lambda} c_0 c = N^2 m_{\lambda(0)} c_0 c = c_0 m_\lambda c \tag{5:2}$$

where N is the number of unit charges oscillating in a hypothetical dipole emitting N quanta of radiation in a cycle [7]. The energy conserving structure of space is reflected in the energy of a wavelength of radiation through quantities c_0 and c, the velocity of light in hypothetical homogeneous space and in local space, respectively. The local velocity of light is equal to the velocity of space in the direction of local fourth dimension which deviates from the direction of the 4-radius due local tilting of space related to mass center buildup.

Applying the intrinsic Planck's constant, h_0, the momentum of a quantum of radiation is expressed as

$$\mathbf{p}_\lambda = m_\lambda \mathbf{c} = \frac{h_0}{\lambda} \mathbf{c} = h_0 f \tag{5:3}$$

A message of equation (5:3) is that the conservation of momentum is equivalent to conservation of frequency, which implicitly means absolute time in space. The energy and momentum of radiation are conserved in changing gravitational potential (i.e. the energy and momentum of radiation are independent of the local velocity of light). The gravitational blue/redshift is observed as a shortening or increase in the wavelength against shortening or increase in the local velocity light. In the emission of electromagnetic radiation, on the other hand, the wavelength is independent but the frequency is directly proportional to the local velocity of light, i.e. radiation propagating in space conserves the energy content obtained in the emission. However, as meaningful at cosmological distances, electromagnetic radiation is subject redshift due to the expansion of space.

The interpretation of a quantum obtained from Maxwell's equations shows quantum as the elementary energy of one wavelength of electromagnetic radiation in a closed wave front, thus showing quantum a property of wave-like expression energy. Such a quantum property means that an energetically balanced dose of radiation in a closed system assumes an integer number of wavelengths or cycles, which always is the case in closed radiation systems described in terms of standing waves. Extension of the wavelike description of energy objects more generally to mass objects occurs by applying the deBroglie wavelength just as done by Bohr in his historical solution of the basic quantum states of a hydrogen atom.

In agreement with the wave description of quantum continuum a localized expression of quantum has been derived from Maxwell's equations by G. Hunter [8]. Hunter's quantum, called soliton, is an ellipsoid with the length of one wavelength in the direction of propagation and the diameter of λ/π perpendicular to the propagation direction. The diameter of Hunter's soliton is in perfect agreement with the resolution of electron microscopes and the measured penetration of circularly polarized microwaves through holes in a metal mask. Also, the capturing area of an antenna with gain one is equal to λ/π, which can be interpreted as capturing of a quantum of radiation from a plane wave into a detectable soliton.

Characteristic emission and absorption of hydrogen like atoms

The effects of motion and gravitation are transferred to the energy states and characteristic absorption and emission frequencies of atoms through the rest energy of electron. By applying equations (4:1) to (4:3) for the rest energy of electron the standard solution of the energy states of hydrogen like atoms can be expressed as

$$E_{Z,n} = \frac{\alpha^2}{2}\left(\frac{Z}{n}\right)^2 m_0 c_0^2 \prod_{i=1}^{n} \left(1-\delta_i\right)\sqrt{1-\beta_i^2} \tag{5:6}$$

and the corresponding characteristic frequencies as

$$f_{(n1,n2)} = \frac{\Delta E_{(n1,n2)}}{h_0 c} = f_{0(n1,n2)} \prod_{i=1}^{n} (1-\delta_i)\sqrt{1-\beta_i^2} \qquad (5:7)$$

where $f_{0(n1,n2)}$ is the frequency of the transition for an atom at rest in hypothetical homogeneous space

$$f_{0(n1,n2)} = Z^2 \left[\frac{1}{n_1^2} - \frac{1}{n_2^2} \right] \frac{\alpha^2}{2h_0} m_{e(0)} c_0 \qquad (5:8)$$

As an implication of the cross-linkage of the effects of motion and gravitation, the local velocity of light is an attribute of the gravitational state of the object in the local frame and in the parent frames, and the locally available rest mass is an attribute of the velocity of the local frame in its parent frame and the velocities of each parent frame in the "grand" parent frame.

The wavelength of the characteristic emission and absorption of hydrogen like atoms is

$$\lambda_{(n1,n2)} = \frac{2h_0}{Z^2 \left[1/n_1^2 - 1/n_2^2 \right] \alpha^2 m_{e(0)} \prod_{i=1}^{n} \sqrt{1-\beta_i^2}} \qquad (5:9)$$

Applying the standard solution of the Bohr radius and equation (4:2) for the rest mass, the radius of the hydrogen atom can be expressed as

$$a_0 = \frac{h_0^2}{\pi\mu_0 e^2 m_{e(N)}} = \frac{a_{0(0)}}{\prod_{i=1}^{n} \sqrt{1-\beta_i^2}} \qquad (5:10)$$

where $a_{0(0)}$ is the Bohr radius of an hydrogen atom at rest in hypothetical homogeneous space

$$a_{0(0)} = \frac{h_0^2}{\pi\mu_0 e^2 m_{e(0)}} = \frac{h_0}{2\pi\alpha m_{e(0)}} \qquad (5:11)$$

The square root expression in equations (5:10) and (5:11) has the form of the Lorentz factor, however, it has nothing to do with Lorentz transformation. The square root expression $\sqrt{1-\beta^2}$ shows the reduction in the internal energy of an object in motion in an energy frame. In the DU framework, the factor can be derived as a consequence of the conservation of energy. Originally, Lorentz identified the same factor as an experimental correction to Coulomb's force between moving charges.

The Coulomg energy

By applying the intrinsic Planck's constant and the fine structure constant, the Coulomb energy obtains the form

$$E_{EM} = \frac{q_1 q_2 \mu_0}{4\pi r} c_0 c = N_1 N_2 \frac{e^2 \mu_0}{2\pi r} c_0 c = N_1 N_2 \alpha \frac{h_0}{2\pi r} c_0 c = c_0 m_{EM} c \qquad (5:12)$$

where the quantity m_{EM} [kg] is the energy equivalence of Coulomb energy for N_1 and N_2 elementary charges at distance r from other

$$m_{EM} = \frac{q_1 q_2 \mu_0}{4\pi r} \qquad (5:13)$$

As shown by equation (5:13) Coulomb energy releases mass when distance r between charged objects q_1 and q_2 is reduced. The mass released appears as buildup of effective mass in the charged object accelerated through the reduction of r.

6. Resonator as an electromagnetic energy object

Electromagnetic radiation localized in a resonator behaves like any other energy object. The effective mass equivalence created by the motion of the resonator frame in its parent frame becomes counterbalanced by the internal mass equivalence and internal wavelength within the moving resonator frame. Accordingly, waves with the internal wavelength in the resonator are observed as propagating at the velocity of light relative to the state of rest in resonator, an effect that was first observed by Michelson and Morley in their interferometric measurements in late 1800's. The search for an explanation to the findings of Michelson and Morley led to the declaration of the velocity of light a physical invariant for the observer, the choice which became the cornerstone of the theory of relativity.

Propagation of electromagnetic radiation can be equally interpreted as taking place in a local frame or its parent frame. An observer at rest in local a frame, moving at velocity β_r in the direction of radiation propagating in the parent frame, observes the frequency of the radiation Doppler shifted

$$f_{obs} = f_0\left(1-\beta_r\right) = \frac{c}{\lambda_0/\left(1-\beta_r\right)} = \frac{c\left(1-\beta_r\right)}{\lambda_0} \tag{6:1}$$

which he can equally interpret as radiation with wavelength $\lambda_0/(1-\beta)$ and phase velocity c in the observer's frame or radiation with wavelength λ_0 and phase velocity $c(1-\beta)$ in the parent frame. The momentum of radiation with frequency f_{obs} in equation (6:1) is

$$\mathbf{p} = \frac{h_0}{\lambda_0}\left(1-\beta_r\right)\mathbf{c} = \frac{h_0}{\lambda_0/\left(1-\beta_r\right)}\mathbf{c} = f_0\left(1-\beta_r\right)\mathbf{c} \tag{6:2}$$

which shows that the conservation of momentum is equivalent to the conservation of frequency in frame to frame observations.

The study of energy frames and the local state of rest in Sections 6 and 7 was made for mass objects as closed energy systems. It can be shown, that closed in a closed system like in a resonator the mass equivalence of electromagnetic radiation behaves just like the mass of "conventional" mass objects. When a resonator is put into motion in its parent frame in space the mass equivalence of the standing wave in the resonator shows an increased effective mass equivalence relative to the parent frame and a reduced internal mass equivalence relative to the state of rest in the resonator frame.

A resonator creates a closed energy object by capturing the radiation of two opposite plane waves between the reflectors at the opposite ends of the resonator cavity. As taught by classical wave mechanics, a resonant superposition of waves in opposite directions produces a standing wave

$$A = 2A_0 \sin 2\pi\frac{r}{\lambda}\cos 2\pi f t = 2A_0 \sin kr \cos \omega t \tag{6:3}$$

with nodes at $r = n\cdot\lambda/2$. The momenta in a resonator at rest have a zero vector sum but a non-zero scalar sum

$$\mathbf{p}_{tot} = ½\mathbf{p}_{(+)} + ½\mathbf{p}_{(-)} = 0 \quad ; \quad \left|½\mathbf{p}_{(+)}\right| + \left|½\mathbf{p}_{(-)}\right| = p_{tot} = \left|\mathbf{p}_{tot}\right| \tag{6:4}$$

where $p_{tot} = p_{I(EM)}$ is the internal momentum, the scalar sum of the momenta of the waves in opposite directions.

When a resonator is in motion in the direction of its longitudinal axis in its parent frame, the internal momenta and wavelengths of the waves sent by the end plates of the resonator are subject to Doppler shift when observed at rest in the parent frame of the resonator. The wavelength of the wave sent in the direction of the velocity $\boldsymbol{\beta}$ of the resonator is Dopler shifted due to the motion of the resonator as

$$\lambda_{(+\beta)} = \frac{\lambda_0}{\sqrt{1-\beta^2}}(1-\beta) = \lambda_I (1-\beta) \tag{6:5}$$

and in the opposite direction as

$$\lambda_{(-\beta)} = \frac{\lambda_0}{\sqrt{1-\beta^2}}(1+\beta) = \lambda_I (1+\beta) \tag{6:6}$$

The sum of the momentums of the Doppler shifted waves in the parent frame now becomes

$$\mathbf{p}_{tot(\beta)} = ½\mathbf{p}_{(+\beta)} + ½\mathbf{p}_{(-\beta)} = \left(\frac{1}{2}\frac{h_0\sqrt{1-\beta^2}}{\lambda_0(1-\beta)} - \frac{1}{2}\frac{h_0\sqrt{1-\beta^2}}{\lambda_0(1+\beta)} \right)\mathbf{c} \tag{6:7}$$

Multiplication of the nominators and denominators of the terms in parenthesis in equation (6:7) by the factor $\sqrt{1-\beta^2}$ gives

$$\mathbf{p}_{tot(\beta)} = \frac{h_0}{\lambda_0\sqrt{1-\beta^2}}\left[½(1+\beta) - ½(1-\beta) \right]\mathbf{c} = \frac{h_0}{\lambda_0\sqrt{1-\beta^2}}\beta\mathbf{c} \tag{6:8}$$

or applying the mass equivalence of electromagnetic radiation as

$$\mathbf{p}_{tot(\beta)} = \frac{m_{\lambda(0)}}{\sqrt{1-\beta^2}}\beta\mathbf{c} = m_{\lambda(eff)}\mathbf{v} \tag{6:9}$$

Equations (6:8) and (6:9) show that motion of a resonator, as a closed electromagnetic energy object in its parent frame, creates momentum through the increase of the “effective mass equivalence” exactly in the same way as any other mass object. As a part of the balance, the internal momentum in the resonator, the momentum in the resonator frame, is reduced due to the reduced “internal mass equivalence” of the radiation (see FIG. 8-1)

$$\mathbf{p}_{I(\beta)} = \left(½m_{I(EM)} - ½m_{I(EM)} \right)\mathbf{c} = 0 \tag{6:10}$$

In the resonator frame the reference at rest is the resonator body. Accordingly, for waves in both directions in the resonator the frequencies and wavelengths are the internal frequency and wavelength

$$f_{I(\beta)} = \frac{c}{\lambda_{I(\beta)}} \tag{6:11}$$

where β refers to the velocity of the resonator in its parent frame.

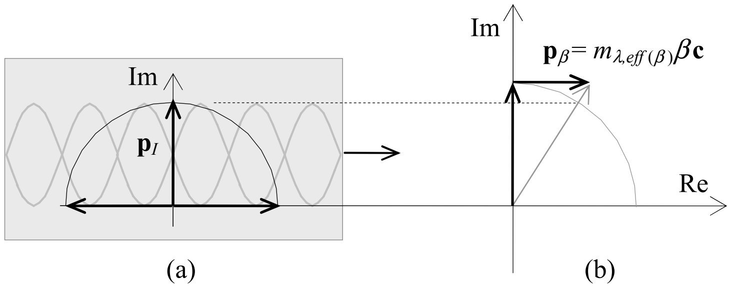

FIGURE 8-1. (a) The momentum of an electromagnetic resonator can be expressed in terms of an internal momentum $\mathbf{p}_I$ of the standing wave in the resonator frame and (b) the external momentum $\mathbf{p}_\beta$ of the resonator as an energy object moving at velocity $v = c\cdot\beta$ in the parent frame.

When studied as a closed energy system, momenta of the waves in opposite directions in a resonator result in radiation pressure at the reflectors. In a physical resonator, the recoil due to the radiation pressure at the opposite ends of the resonator is compensated through a tension and an excited state in the chemical bonds between atoms in the resonator body. Such a closed energy system is fully comparable to a gas container, a rotating centrifuge, or a particle accelerator where the reference at rest of the energy frame is the physical body of the system or the internal zero momentum point. Lasers, masers and Michelson-Morley interferometers define each their local energy frame and, accordingly, the local state of rest serving as the reference for the velocity of light in the frame. As shown by equations (5:9) and (5:10) both the emission wavelength and the atomic radius are functions of the velocity of the atom in the local energy frame and the velocities of local frame and the parents frames. It means that the resonance condition and the number of nodes in a standing wave in a resonator are independent of the velocity of the resonator in the parent frame.

The description of electromagnetic resonators as energy objects with localized dimensions, and the buildup of effective and internal masses due to motion in the parent frame demonstrates the nature of localized energy structures as propagating waves “packaged” by the local potential energy structure. The Dynamic Universe concept does not recognize classical mass particles but energy objects as closed energy structures comprising the balance of the local potential energy and the energy of motion.

7. Conclusions

The Dynamic Universe gives a highly order and balanced picture of space both at cosmological scale and in localized energy structures. The complementary expression of energy, through the system of cascaded energy frames in the Dynamic Universe, serve as the replacement to ether concepts in classical physics, and to the geometrized spacetime in the theory of relativity. An essential difference between the DU and the relativity theory comes also from the holistic nature of the Dynamic Universe — the study of the energy balances in the DU is started from whole space and then, step by step, derived into localized structures. Such an approach fixes the local states of rest to local energy frames like implicitly done in thermodynamic and quantum mechanical systems and, as an important additional feature, links the local energy frames to their parent frames and finally to hypothetical homogeneous space which serves as the universal reference to all local frames in space.

Local energy frames in the Dynamic Universe have certain characteristics of classical ether, however, a decent description of the local energetic state as well as frame to frame observations require the system of cascaded energy frames, and thereby the co-existence of the parent frames behind any local frame. While the classical ether can be characterized as “global, static environment”, the energy frame system in the DU can be characterized as a multilevel ether system, with each of the coexisting frames sensitive to their angle relative to the local fourth dimension.

The Newtonian approach was primarily guided by immediate observations, which is quite natural in such a pioneer’s situation. Force, relative motion, and momentum formed the cornerstones in Newton’s mechanics. Energy, as a more abstract concept, was added to classical mechanics through several steps as the integrated force [9].

Newton’s equations of motion were perhaps too excellent at their time, making motion more or less independent of its origin. When combined with Galilean relativity, Newtonian motion found its reference at the observer, an obvious misconception that was inherited to the theory of relativity. Relative velocity is well justified in kinematic sense as the rate of the change in the distance between an object and the observer. Relative velocity does not, however, tell the amount of effective mass and kinetic energy stored in a moving object; the buildup of effective mass and kinetic energy are related to the work done in obtaining the motion in the relevant energy frame.

Classical ether was implicitly fixed to the observer which made Newton’s laws of motion applicable to any observer “as such”. The observer oriented approach claiming for “same observations" to any observer was reflected in the relativity principle, which was presented to justify the modification of the local ether environment so that observations looked the same for any observer. The result was the Lorentz modified inertial frames and spacetime modified gravitational frames.

The DU "multilevel ether" is built up from the system of cascaded energy frames. Motion gained from potential energy in a local frame, is paid back in the same frame. Energy bookkeeping actuates through the reduction of the rest energy in each frame, or more precisely, through the rest momentum which also carries the information about the direction of the fourth dimension relevant to the frame.

In the DU framework, there is an essential difference between velocity in kinematic sense and velocity as an expression of kinetic energy. In kinematic sense, velocity means the rate of the change in the distance between two locations or velocity relative to a fixed or moving point in space. Galilean relativity and the Galilean transformation of velocities apply to kinematic velocity everywhere in space.

When expressing kinetic energy, velocity appears as a square term which cancels the vector nature of velocity and makes the concept of relative velocity irrelevant. Kinetic energy follows the structure of energy frames as a part of the conservation of the total zero energy balance in space.

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