Physical and mathematical postulates behind relativity

Tuomo Suntola

Physics Foundations Society, Finland, www.physicsfoundations.org

In this presentation we look for answers to questions: What was the problem solved with the relativity theory, and, did the theory solve the right problem?

Newtonian physics is local by its nature. No local frame is in a special position in space. There are no overall limits to space or to physical quantities. Newtonian space is Euclidean until infinity, and velocities in Newtonian space grow linearly as long as there is constant force acting on an object.

Observations on the properties of the propagation of light in late 19th century showed contradiction with the unlimited, linear Newtonian space. Relativity theory broke the linearity and the Euclidean appearance of Newtonian space by redefining the coordinate quantities, time and distance. In the redefined coordinates, the growth of velocities is limited to the velocity of light, which was defined as a natural constant. The local nature of Newtonian physics remains in relativistic space, justified by the relativity principle claiming the same formulation of the laws of nature for any observer.

In a holistic perspective, the finiteness of velocities can be seen as a consequence of the finiteness of total energy in space. In such an approach relativity appears primarily as relativity of the local to the whole, and is expressed in terms of the locally available share of total energy. Postulation of the finiteness of the total energy in space allows universal coordinate quantities, time and distance, and links the velocity of light to the energetic state of the universe. In spite of the totally different postulates and the different picture of reality in the two approaches, the predictions for local physical phenomena are essentially the same. Differences arise at the extremes, at cosmological distances and in the vicinity of local singularities in space. Global relativity links the sizes of gravitationally bound systems to the expansion of space, which explains the observed Euclidean appearance of galactic space. Magnitude observations of supernovas are explained with high accuracy – without accelerating expansion, dark energy, or any other additional parameter. Global relativity based on finite total energy in space is analyzed in detail in the Dynamic Universe model [1].

From Newtonian space to relativistic space

Newtonian physics is local by its nature. No local frame is in a special position in space. There are no overall limits to space or to physical quantities. Newtonian space is Euclidean until infinity, and velocities in space grow linearly as long as there is constant force acting on an object.

Finiteness of physical quantities was first observed about 100 years ago – as finiteness of velocities. As concluded from the experiments by Michelson and Morley in late 1800's, the velocity of an observer did not add to the phase velocity of light. The special theory of relativity introduced a mathematical structure for the description of the finiteness of velocities by modifying the coordinate quantities, time and distance in such a way that velocities in space never exceed the velocity of light, which was postulated to be a natural constant. In modified coordinates, the finiteness of the velocity obtainable by accelerating a mass object was illustrated as an increase of the mass of the object accelerated, Figure 1.

Extension of the saturation of velocities to the velocity obtained in free fall in gravitational field led to the generalization of the theory of relativity. Modification of the coordinate quantities is expressed in terms of a 4-dimensional spacetime system, where modification of time and distance is determined by mass density distribution in local space. In the vicinity of a local point-like mass center, spacetime is curved 90 degrees at a critical radius, which turns the velocity of free fall in the direction of non-curved space to zero (for an observer far from the mass center) as expressed in the Schwarzschild solution of general relativity, Figure 2. The Schwarzschild solution does not, however, affect the Newtonian orbital velocity, which exceeds the Schwarzschild velocity of free fall at the distance of three times the critical radius thus leading to unstable orbits below that limit [2].

(a) $\mathbf{v} = \int_0^t \mathbf{a}\, dt = \int_0^t \frac{\mathbf{F}}{m} dt = \frac{\mathbf{F}}{m} \cdot t$

(b) $\mathbf{v} = \int_0^t \frac{\mathbf{F}}{m} \left(1-\beta^2\right)^{3/2} dt$

$$dt' = dt\sqrt{1-\beta^2} \qquad \beta = \frac{v}{c}$$

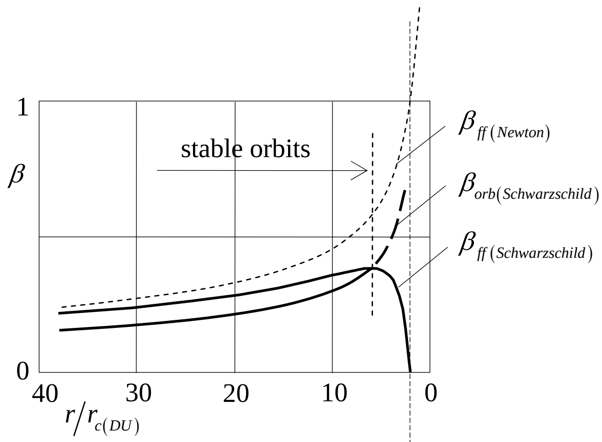
$$dx' = dx \Big/ \sqrt{1-\beta^2}$$

Figure 1. a) In Newtonian space the velocity of an object increases linearly as long as there is constant force acting on the object. b) In relativistic space the increase of the velocity of an object saturates to the velocity of light, which is defined as a constant and the maximum velocity obtainable in space. In special relativity (SR), the saturation of the velocity is obtained by re-defining the coordinate quantities, time and distance. Saturation of rectilinear motion is illustrated in the figure.

(a) Newtonian velocity of free fall

$$\beta_{ff(Newton)} = \frac{v_{ff(Newton)}}{c} = \sqrt{\frac{2GM}{rc^2}}$$

$$\beta = \frac{v}{c}$$



(b) Proper distance and proper time in Schwarzschild space

$$dr' = dr \Big/ \sqrt{1-\beta^2} \quad \Rightarrow \quad dr' = dr \Big/ \sqrt{1-\frac{2GM}{rc^2}}$$

$$dt' = dt\sqrt{1-\beta^2} \quad \Rightarrow \quad dt' = dt\sqrt{1-\frac{2GM}{rc^2}-\beta^2}$$

Schwarzschild velocity of free fall

$$\beta_{ff(Schwarzschild)} = \frac{v_{ff(Schwarzschild)}}{c} = \sqrt{\frac{2GM}{r}} \cdot \left(1-\frac{2GM}{r}\right)$$

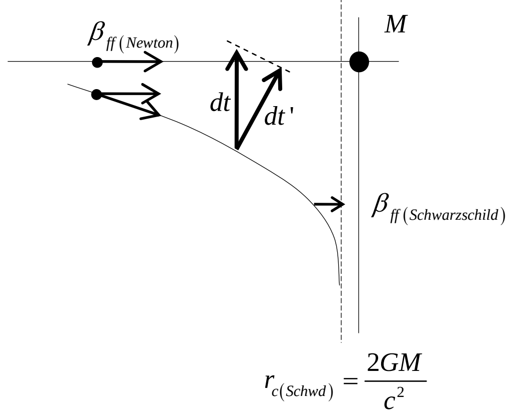


Figure 2. (a) The velocity of free fall in Newtonian space, $\beta_{ff(Newton)}$, approaches infinity when distance to a point-like mass center approaches zero. In Schwarzschild space, based on the general theory of relativity, the velocity of free fall goes to zero at critical radius r_c, where local spacetime is curved 90 degrees. The predicted orbital velocity at circular orbits in Schwarzschild space exceeds the velocity of free fall at $3 \cdot r_c$, which excludes stable orbits beyond that limit. (b) Proper distance in Schwarzschild space is obtained by substituting the velocity term of SR proper distance by Newtonian velocity of free fall, and the proper time by adding the Newtonian velocity of free fall as an orthogonal component to velocity β in the SR expression of proper time.

Like in Newtonian physics, no local frame, or inertial observer, is in a special position in space. According to the special and general theories of relativity there is no universal frame of reference in space; velocities and spacetime structures are studied relative to an observer in a local frame of reference. In the prevailing theory, the cosmological appearance of relativistic space is expressed in terms of the Friedman-Lemaître-Robertson-Walker metric [3]. The FLRW metric describes space as an expanding, gravitationally bound system as a whole but ignores the linkage of the expansion to gravitationally bound subsystems like galaxies or planetary systems in space [1].

Obtaining finiteness by modifying coordinate quantities may achieve a correct description of observations – and in many cases it does – but it does not tell the physical reasons for finiteness, e.g. why is the velocity of light the maximum velocity in space?

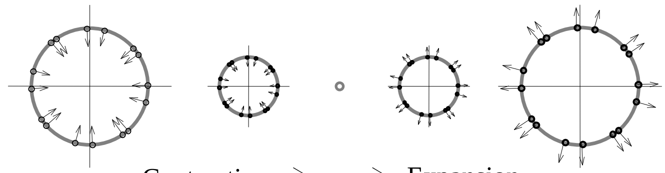
Physical basis of finiteness in space

In fact, there are many physical signs of finiteness in space. For example, the spectral distribution and power density of the Cosmic Microwave Background radiation (CMB) is, with high accuracy, equal to the spectral distribution and power density of radiation density *within* a black body source. Perhaps the most significant sign of finite and closed space comes from the equality of total rest energy and gravitational energy in space;

> In his lectures on gravitation in early 1960's Richard Feynman [4] stated: *"If now we compare the total gravitational energy $E_g = GM^2_{tot}/R$ to the total rest energy of the universe, $E_{rest} = M_{tot}c^2$, lo and behold, we get the amazing result that $GM^2_{tot}/R = M_{tot}c^2$, so that the total energy of the universe is zero. — It is exciting to think that it costs nothing to create a new particle, since we can create it at the center of the universe where it will have a negative gravitational energy equal to $M_\Sigma c^2$. — Why this should be so is one of the great mysteries — and therefore one of the important questions of physics. After all, what would be the use of studying physics if the mysteries were not the most important things to investigate."*
>
> Feynman pondered also the geometry of space [5]: *"...One intriguing suggestion is that the universe has a structure analogous to that of a spherical surface. If we move in any direction on such a surface, we never meet a boundary or end, yet the surface is bounded and finite. It might be that our three-dimensional space is such a thing, a tridimensional surface of a four sphere. The arrangement and distribution of galaxies in the world that we see would then be something analogous to a distribution of spots on a spherical ball."*

Space as the surface of a 4-sphere is quite an old concept of describing space as a closed but endless entity. Spherically closed space was outlined in the 19th century by Ludwig Schläfli, Bernhard Riemann and Ernst Mach. Space as the 3-dimensional surface of a four sphere was also Einstein's original view of the cosmological picture of general relativity in 1917 [6]. The problem, however, was that Einstein was looking for a static solution — it was just to prevent the dynamics of spherically closed space that made Einstein to add the cosmological constant to the theory. In fact, another problem arose from the spacetime concept established in the relativity theory. In fact, closing of three-dimensional space requires a fourth dimension of a metric nature, which infringes on the spacetime concept and accordingly on the basis of Einsteinian relativity. Obviously, this was also the reason Feynman did not take into consideration the possibility of a dynamic solution to the "great mystery" of the equality of the rest energy and the gravitational energy in space.

As soon as we neglect the spacetime concept and assume a fourth dimension of a metric nature, space can be closed as a 3-dimensional surface of 4-dimensional sphere with the radius in the fourth dimension. In such a structure Feynman's great mystery obtains a dynamic solution – spherically closed space appears as a spherical pendulum in the fourth dimension: In a contraction phase space gets motion from the gravitation of the structure converting the energy of gravitation into the energy of motion. The contraction turns into expansion by passing singularity – in the expansion phase the energy of motion gained in the contraction is paid back to gravitation. As in a pendulum, the sum of the energies of motion and gravitation are equal throughout the process. With the initial condition of rest at infinity, the sum of the energies of motion and gravitation is zero throughout the contraction – expansion process, Figure 3.



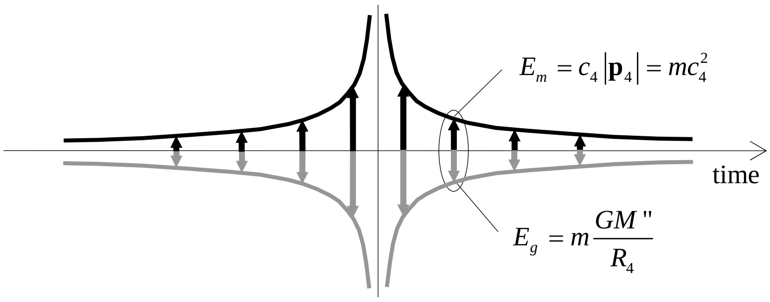


Figure 3. Energy buildup and release in spherical space. In the contraction phase, the velocity of motion increases due to the energy gained from the release of gravitational energy. In the expansion phase, the velocity of motion gradually decreases, while the energy of motion gained in contraction is returned to the energy of gravitation.

Obviously, the energy of motion mass in space possesses due to the motion in the fourth dimension is observed as the rest energy of matter in space. It can be shown, that for maintaining the zero-energy condition in space, the velocity of space in the fourth dimension appears as the maximum velocity obtainable in space. The conclusion is that the velocity of light is not a physical constant but determined by the velocity space has in the fourth dimension.

The zero-energy balance of motion and gravitation in spherically closed space binds the total rest energy of matter to the size, and accordingly to the state of expanding space. The expansion of space works against the gravitation of the structure, which means that the velocity of expansion, and accordingly, the velocity of light in space decreases in the course of the expansion. Many physical processes, like planetary motions and characteristic oscillation frequencies of atomic clocks are linked to the expansion velocity of space, which means that the velocity of light in most measurements is *observed* as being a constant.

The dynamic zero-energy balance of motion and gravitation means that the total energy (the absolute value of the positive rest energy and negative gravitational energy), at any time, is finite and specifically determined by the state of the expansion. The postulates needed are:

1. Space is spherically closed through a fourth dimension of a metric nature.
2. Time is a universal scalar.
3. Total mass, including the mass equivalence of electromagnetic energy, in space is a primary conservable throughout the development of space.
4. The zero-energy balance of motion and gravitation prevails in space.

Adopting the postulates above we have to reject two of prevailing postulates:

1. The constancy of the velocity of light.
2. The space-time concept.

Global relativity in zero-energy space

It can be shown that

1. ***Relativity of observations within space, at any time, can be seen as a consequence of the finiteness of total energy in space.***

2. ***Relativity in zero-energy space is not local relativity between an observer and an object, but global relativity between the local and the whole.***

In order to derive the properties of global relativity we need to add one more postulate, which completes the list of postulates:

1. Space is spherically closed through a fourth dimension of a metric nature.
2. Time is a universal scalar.
3. Total mass, including the mass equivalence of electromagnetic energy, in space is the primary conservable throughout the development of space.
4. The zero-energy balance of motion and gravitation prevails in space.
5. *Total energy is conserved in all interactions in space.*

Adopting the postulate of conserving the total energy, we reject three more postulates behind Einsteinian relativity. The list of rejected postulates becomes:

1. The constancy of the velocity of light.
2. The space-time concept.
3. *The relativity principle.*
4. *The equivalence principle.*
5. *The Lorentz transformation.*

A full analysis of the properties of matter, electromagnetic radiation, relativity, celestial mechanics, and the cosmological appearance of zero-energy space is presented as the Dynamic Universe theory (DU) [1].

Hypothetical homogeneous space

In zero-energy space the primary energy buildup creates the rest energy of matter as momentum and the energy of motion due to the motion of space in the fourth dimension. As the initial condition, in hypothetical homogeneous space, all mass is assumed to be uniformly distributed in spherically closed space forming an ideal, fully symmetric 3-dimensional “surface” of a four-dimensional sphere. There is no motion within space, i.e. the only momentum of mass in space occurs in the direction of the 4-radius of the structure. The gravitational force, as the gradient of gravitational energy, appears in the direction of the 4-radius only. Locally, such a situation can be described as equal energies of motion and gravitation in the opposite directions in the direction of the 4-radius, the local fourth dimension, which is conveniently described as the imaginary direction.

Local space

Conservation of the zero-energy balance of motion and gravitation in mass center buildup appears as a local bending of space in the fourth dimension. DU space has velocity c_0 in the direction of the 4-radius R_0. Bending of space means that locally, in bended space, the velocity of space and, accordingly, the local velocity of light are reduced by the cosine of the bending angle. The situation is not much different from locally bended spacetime in the Schwarzschild solution of general relativity, however, there are remarkable consequences from that difference.

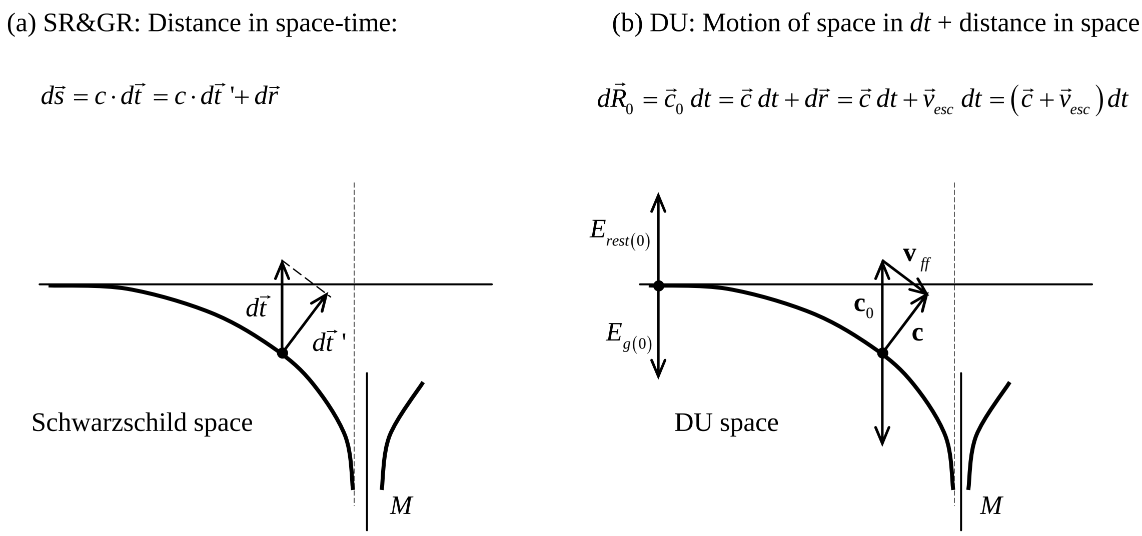


Figure 4. Spacetime geometry and the reduction of the time differential in the vicinity of a mass center in Schwarzschild space based on general relativity, and the motion of space and reduction of the velocity of space in the local fourth dimension in DU space. In Schwarzschild space, in the distance differential $c{\cdot}dt'$, time is vector quantity and c is a scalar. In DU space, c as a velocity, is a vector quantity and the time differential dt is a scalar operating equally in space directions and in the fourth dimension.

In Schwarzschild space based on general relativity, bending of spacetime in the vicinity of a mass center in space results in a reduction in the time differential dt and an increase of the distance differential dr, Figure 4(a). In DU space, bending of space in the vicinity of a mass center results in a reduction in the velocity of space in the local fourth dimension. The reduction of the local velocity of space creates a velocity of free fall as an orthogonal component of the velocity of space in the local fourth dimension in bended space, Figure 4(b). The motion of space in time differential dt can be expressed as the vector sum of the local 4-velocity of space and the escape velocity opposite to the velocity of free fall. As a property of the universal scalar time in the DU, time is used equally in space and in the fourth dimension, which is essential for understanding the nature of the rest energy of matter as the energy of motion, the product of velocity of space and the momentum in the fourth dimension

$$E_{rest} = c_0 \left|\mathbf{p}\right| = c_0 \left|m\mathbf{c}\right| \tag{1}$$

where c_0 is the velocity of space in hypothetical homogeneous space, and $\mathbf{c}$ is the velocity of space in the local fourth dimension. In the Earth gravitational frame the local velocity of light $c = |\mathbf{c}|$ can be estimated to be on the order of parts per million (ppm) lower than the velocity of space in hypothetical homogeneous space.

Celestial mechanics in GR space and in DU space

In GR based Schwarzschild space, in the time-like distance differential $c{\cdot}dt'$, time is a vector quantity and c is a scalar. In DU space, c as a velocity, is a vector quantity and time is a scalar operating equally in space directions and in the fourth dimension. An important consequence of the difference appears in celestial mechanics near a local singularity in space. As illustrated in Figure 2, the orbital velocity in Schwarzschild space exceeds the velocity of free fall near the critical radius thus disabling stable orbits. In DU space, orbital velocities remain below the velocity of free fall down to the critical radius, predicting slow orbits in the range of $0 < r < 2r_c$ essential for hosting the mass of the local singularity, Figure 5. Predictions for perihelion advance, Shapiro delay, and the bending of light near mass centers are essentially the same in Schwarzschild space and in DU space.

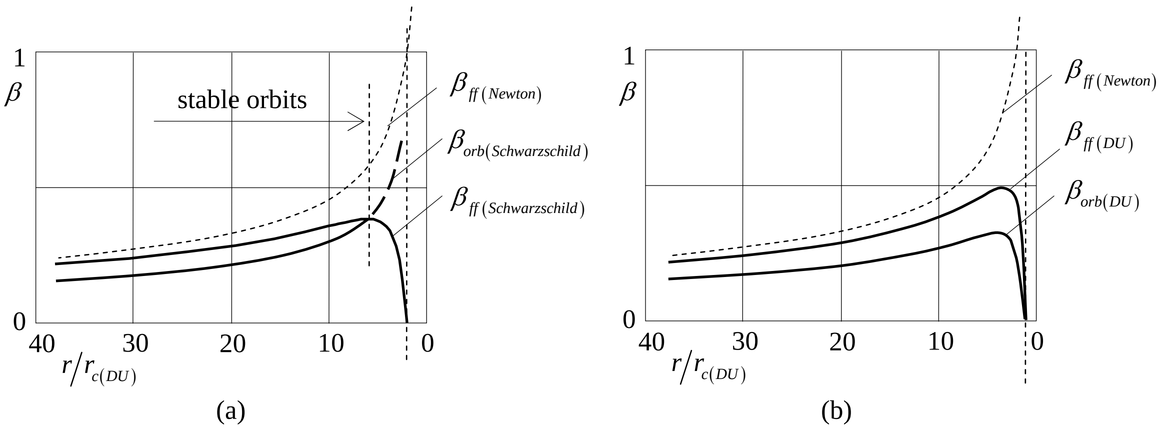


Figure 5. Velocities of free fall and orbital motion at circular orbits in (a) Schwarzschild space, and (b) in DU space. The horizontal scale is drawn in units of the critical radius in DU space, where the critical radius is half of the critical radius in Schwarzschild space. The velocity of free fall in Newton space is used as a reference in both charts.

Global relativity

In DU space, relativity appears as a reduction of the rest energy due to local gravitation and motion in space. As illustrated in Figure 4, local mass centers create a dent in the surrounding homogeneous space. In bended space in a dent, the velocity of space in the local fourth dimension and, accordingly, the local velocity of light are reduced. The local velocity of light can be expressed in terms of the tilting angle and the global gravitational energy arising from all mass in spherically closed space

$$c_\delta = c_0 \cos\phi = \frac{E_{g(\phi)}}{E_{g(0)}} c_0 = c_0 \left(1 - \frac{GM}{r_0 c_0^2}\right) = c_0 \left(1-\delta\right) \quad (2)$$

Local momentum in the fourth dimension is affected by both the gravitational state through the gravitational factor δ and the local velocity in space. The effect of local velocity on the rest mass available in the moving object can be expressed as

$$m_{rest(\beta)} = m_0 \sqrt{1-\beta^2} \quad (3)$$

In equation (3) the square root factor has nothing to do with the Lorentz transformation although it is formally identical with the Lorentz factor. In the DU, the square root term can be derived from the conservation of total energy, both in the case of free fall and in the case the velocity is obtained via insertion of additional mass like the mass equivalence of Coulomb energy in an accelerator, Figure 6.

Combining the effects of motion and gravitation on the locally available rest energy we get

$$E_{rest(\delta,\beta)} = E_{rest(0)} \left(1-\delta\right)\sqrt{1-\beta^2} \quad (4)$$

Kinetic energy obtains a general form

$$E_{kin} = \Delta E_m = c_0 \left|\Delta \mathbf{p}\right| = c_0 \left|c\Delta m + m\Delta c\right| \quad (5)$$

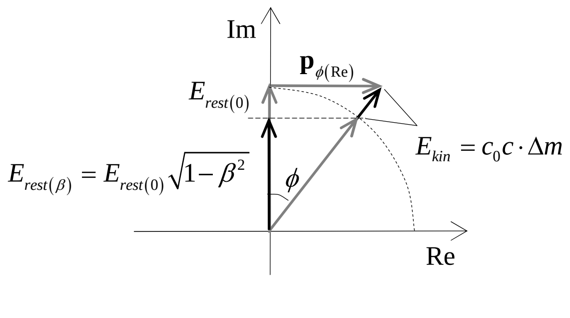


Figure 6. Reduction of the rest mass available in an object moving at velocity $v=\beta c$ in space. The increase of mass Δm is obtained from the mass equivalence of Coulomb energy

$$\Delta E_C = E_{kin} = \frac{q_1 q_2 \mu_0}{2\pi r}\left(\frac{1}{r_1} - \frac{1}{r_2}\right) c_0 c = \Delta m_C \cdot c_0 c$$

which in the case of mass insertion obtains the form

$$E_{kin(\beta),DU} = E_{total(\beta)} - E_{total(0)} = c_0 mc\left(\frac{1}{\sqrt{1-\beta^2}} - 1\right) \tag{6}$$

Equation (6) is essentially equal to the expression derived in special relativity

$$E_{rest(\beta),SR} = mc^2\left(\frac{1}{\sqrt{1-\beta^2}} - 1\right) \tag{7}$$

Equations (4) and (6) are derived solely from the conservation of total energy in space. The derivation has nothing to do with the Lorentz transformation, spacetime, the relativity principle, or the equivalence principle.

The relativistic mass $m_\beta = m_{rest}\big/\sqrt{1-\beta^2}$ *is not a consequence of the velocity in space but it is the mass contribution needed to build up the velocity of a mass object at constant gravitational potential.*

In a complete form, the rest energy in DU space comprises all the velocities a local object is subject to in space, e.g. in the Earth gravitational frame we are subject to, the rotational motion and gravitation of the Earth, the orbital velocity and the gravitational state of the Earth in the solar frame, the velocity and the gravitational state of the solar frame in the Milky way frame, the velocity and the gravitational state of the Milky way in the local galaxy group, etc. until we have hypothetical homogeneous space as our reference

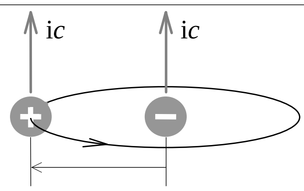
$$E_{rest(n)} = E_{rest(0)} = c_0 m_0 c_0 \prod_{i=1}^{n}\left(1-\delta_i\right)\sqrt{1-\beta_i^2} \tag{8}$$

Unified expression of energy

In DU space, the velocity of light changes with time. It is also a function of the local gravitational environment. For a precise analysis of the conservation of energy it is useful to apply the unified expressions of energies given in Figure 7.

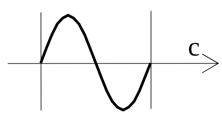
Coulomb energy

$$E_C = N_1 N_2 \frac{e^2\mu_0}{2\pi r} c_0 c = N_1 N_2 \alpha \frac{h_0}{2\pi r} c_0 c = N_1 N_2 m_C \cdot c_0 c$$



Energy of a cycle of electromagnetic radiation

$$E_{\lambda(N)} = c_0\left|\mathbf{p}\right| = c_0\left|N^2 m_\lambda \mathbf{c}\right| = N^2 m_\lambda \cdot c_0 c$$



Rest energy of a localized energy object

$$E_{(rest)m} = c_0\left|\mathbf{p}_4\right| = m \cdot c_0 c = \frac{h_0}{\lambda_m} c_0 c = \hbar_0 k_m \cdot c_0 c$$

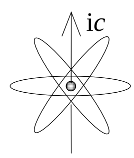


Figure 7. Unified expressions for the Coulomb energy, the energy of a cycle of electromagnetic radiation, and the rest energy of a localized mass object.

There are several important findings in the unified expressions of energies in Figure 7. In DU space moving at velocity c in the fourth dimension, a point emitter of electromagnetic radiation can be regarded as a one-wavelength dipole in the fourth dimension. Solved from Maxwell's equations, the energy emitted by a dipole of length z_0, in one cycle of oscillation of N unit charges in the dipole is

$$E_\lambda = \frac{P}{f} = \frac{N^2 e^2 z_0^2 \mu_0 16\pi^4 f^4}{12\pi c f} = N^2 \left(\frac{z_0}{\lambda}\right)^2 \frac{2}{3}\left(2\pi^3 e^2 \mu_0 c_0\right) f = N^2 \left(\frac{z_0}{\lambda}\right)^2 \frac{2}{3} \cdot 1.1049 \cdot h \cdot f \tag{9}$$

where

$$h = 1.1049 \cdot 2\pi^3 e^2 \mu_0 \cdot c = h_0 \cdot c \tag{10}$$

showing that the velocity of light is a hidden factor in the Planck constant h. Removal of c from the Planck constant reveals the intrinsic Planck constant $h_0 = h/c$ with dimensions [kg·m]. The intrinsic Planck constant shows the mass equivalence of a cycle of electromagnetic radiation as

$$m_\lambda = N^2 \frac{h_0}{\lambda} = N^2 \hbar_0 k \qquad [\mathrm{kg}] \tag{11}$$

where $k = 2\pi/\lambda$ and $\hbar_0 = h_0/2\pi$. With a single transition of a unit charge ($N = 1$) in a point emitter we get a quantum of radiation

$$E_{\lambda(0)} = \frac{h_0}{\lambda} c_0 c = \hbar_0 k \cdot c_0 c = m_{\lambda(0)} c_0 c = c_0 \left|\mathbf{p}_{\lambda(0)}\right| \tag{12}$$

We also find that by applying the Planck constant in (10), the fine structure constant α appears as a purely numerical factor without any connection to physical constants

$$\alpha = \frac{e^2 \mu_0}{2h_0} = \frac{e^2 \mu_0}{2 \cdot 1.1049 \cdot 2\pi^3 e^2 \mu_0} = \frac{1}{1.1049 \cdot 4\pi^3} \approx \frac{1}{137.036} \tag{13}$$

The breakdown of the Planck constant into its constituents, and the identification of the intrinsic Planck constant is an exceedingly important step for the unified expression of energies and for understanding the wave-like nature of mass as the substance for all expressions of energy. Applying the intrinsic Planck constant, mass can be expressed in terms of a wavelength equivalence or wave number equivalence. A mass object moving at velocity $\beta = v/c$ in space can be described in terms of a wave structure in four dimensions by rewriting the energy-momentum four-vector

$$E^2 = c_0^2 \left(mc\right)^2 + c_0^2 p^2 \tag{14}$$

into the form

$$c_0^2 \cdot \hbar_0^2 k_{(m+\Delta m)}^2 c^2 = c_0^2 \cdot \hbar_0^2 k_{(m+\Delta m)}^2 \beta^2 c^2 + c_0^2 \cdot \hbar_0 k_{(m)}^2 c^2 \tag{15}$$

and further

$$k_{(m+\Delta m)}^2 = \beta^2 k_{(m+\Delta m)}^2 + k_{(m)}^2 \tag{16}$$

or as a complex wave structure

$$k_{(m+\Delta m)}^* = \beta k_{(m+\Delta m)} + \mathrm{i}\, k_{(m)} \tag{17}$$

where (*) is used as the notation for a complex function.

Equations (14) to (17) have a major impact on the picture of reality and the physical interpretation of quantum mechanics.

From time dilation to reduced clock frequencies

Applying equation (8) to Balmer's equation, the characteristic emission and absorption frequencies atomic objects become functions of the gravitational state and velocity of the emitting or absorbing atom

$$f_{(n1,n2)} = \frac{\Delta E_{(n1,n2)}}{h_0 c_0} = f_{0,0(n1,n2)} \prod_{i=1}^{n} \left(1-\delta_i\right)\sqrt{1-\beta_i^2} \qquad (18)$$

Using the frequency $f_{0,0}$ at rest in apparent homogeneous space of the local frame as the reference, the local characteristic frequency can be expressed as

$$f_{\delta,\beta(DU)} = f_{0,0}\left(1-\delta\right)\sqrt{1-\beta^2} \approx f_{0,0}\left(1-\delta-\frac{1}{2}\beta^2-\frac{1}{8}\beta^4+\frac{1}{2}\delta\beta^2\right) \qquad (19)$$

In general relativity, the combined effect of motion and gravitation on the "proper frequency" of atomic oscillators in a local (Schwarzschild) gravitational frame is given by equation

$$f_{\delta,\beta(GR)} = f_{0,0}\sqrt{1-2\delta-\beta^2} \approx f_{0,0}\left(1-\delta-\frac{1}{2}\beta^2-\frac{1}{8}\beta^4-\frac{1}{2}\delta\beta^2-\frac{1}{2}\delta^2\right) \qquad (20)$$

On Earth and in near space conditions the difference in the frequencies given by equations (19) and (20) appears in the 18th decimal or beyond, which is too small a difference to be detected.

The DU predictions (18) and (18) do not rely on any assumptions of the relativity theory but are just consequences of the conservation of total energy in spherically closed space.

Momentum of radiation and a mass object in a moving frame

In the DU framework, the Doppler effect of electromagnetic radiation can be derived following the classical procedure taking into account both the velocity of the source and the receiver in a frame in common to the source and the receiver.

Let's assume that the radiation source *A* is at rest in a propagation frame and the receiver *B* is moving at velocity $v = \beta c$ in the direction of the radiation received. The wavelength λ_B of the radiation observed at *B* is increased compared to the wavelength and frequency measured at rest in the propagation frame and the momentum of the radiation observed at *B* becomes

$$\mathbf{p}_B = \frac{h_0}{\lambda_B}\mathbf{c} = \frac{h_0}{\lambda_0}\mathbf{c}\left(1-\beta\right) = \mathbf{p}_0\left(1-\beta\right) \qquad (21)$$

where h_0 is the intrinsic Planck constant defined in (10) and $\mathbf{p}_0$ is the momentum observed at rest in the propagation frame.

The wavelength of the observed radiation is increased and the frequency of the observed radiation is reduced by factor $(1-\beta)$ due Doppler effect. As the result, the phase velocity of radiation observed in frame *B* moving at velocity β is

$$c_B = f_B\lambda_B = f_0\left(1-\beta\right)\cdot\frac{\lambda_0}{\left(1-\beta\right)} = f_0\lambda_0 = c \qquad (22)$$

i.e. the phase velocity of radiation observed in the moving frame is equal to the phase velocity of radiation in the rest frame (propagation frame). *The observer's velocity does not change the velocity of the radiation in observer's frame; the momentum of the radiation is changed as a consequence of the change in the frequency due to the Doppler effect.*

If the source is taken to the same moving frame with the receiver, there is no change in the momentum of radiation between the source and the receiver even if we think that the propagation of radiation occurs in the underlying rest frame.

When a mass object with momentum $\mathbf{p}_0 = m\mathbf{v}_0$ in a rest frame is taken to a frame moving at velocity $\mathbf{v}_B$, ($\mathbf{v}_0 \parallel \mathbf{v}_B$) momentum $\mathbf{p}_0$, as observed in the moving frame, is reduced by receiver's velocity as

$$\mathbf{p}_B = \mathbf{p}_0 \left(1 - \frac{v_B}{v_0} \right) = \mathbf{p}_0 \left(1 - \beta_B \right) \tag{23}$$

where $\beta_B = v_B/v_0$. Comparison of (21) with (23) shows that the reduction of momentum of radiation and a mass object is equal, but:

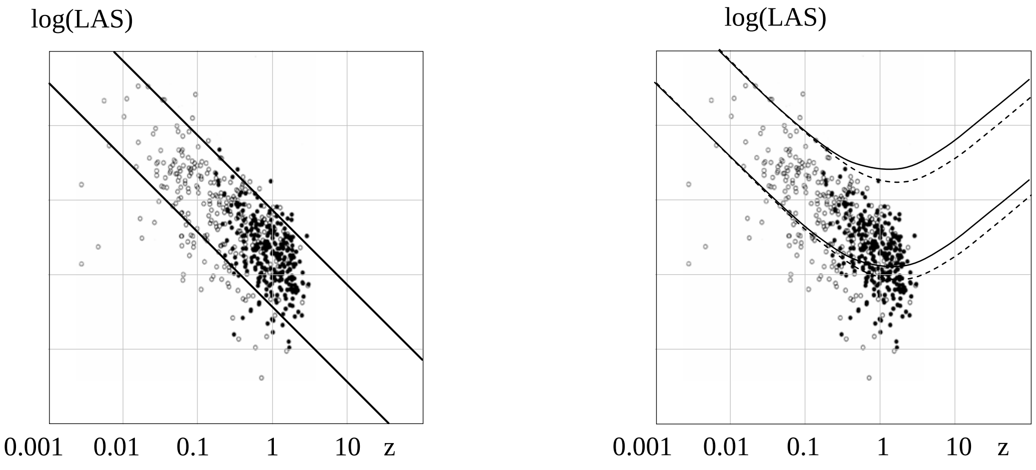
In the case of a mass object the change in momentum is observed as change in velocity. In the case of radiation the change in momentum is observed as a change in the wavelength and frequency.

Cosmological appearance of zero-energy space

The precise geometry, absolute time, and the linkage of the velocity of light to the velocity of the expansion of space along the 4-radius allow a parameter-free derivation of primary cosmological quantities. Global relativity links local gravitational systems to whole space, which means that gravitationally bound local systems expand in direct proportion to the expansion of space. As a consequence, galactic space is observed in Euclidean geometry, i.e. the angular size decreases linearly with the increased redshift. In FLRW cosmology, due to the local nature of general relativity, gravitationally bound systems conserve their size in expanding space. The FLRW prediction for the angular size versus redshift of galaxies and quasars is not linear but turns into increase above redshifts $z > 1$, Figure 8.

The precise geometry and the conservation of the zero-energy balance in space produce a parameter free prediction for the magnitudes of standard candles as function of redshift

$$\mu = m - M = 5\log\frac{R_4}{10\ \text{pc}} + 5\log z + 2.5\log\left(1+z\right) \tag{24}$$



(a) DU-prediction (Euclidean)

(b) FLRW-prediction

——— Ω_m= 1, Ω_Λ= 0 (no dark energy)

-------- Ω_m= 0.27, Ω_Λ= 0.73 (dark energy added)

Figure 8. Dataset of observed Largest Angular Size (LAS) of quasars and galaxies in the redshift range $0.001 < z < 3$. Open circles are galaxies, filled circles are quasars. (Data collection [7]: K. Nilsson et al., Astrophys. J. 413, 453, 1993). In (a) observations are compared with the DU prediction. In (b) observations are compared with the FLRW prediction with Ω_m= 0 and Ω_Λ = 0 (solid curves), and Ω_m= 0.27 and Ω_Λ= 0.73 (dashed curves).

where m is the apparent magnitude and M is the absolute magnitude of the reference source at distance 10 parsec. R_4 is the 4-radius of spherically closed space, which corresponds to the Hubble radius in FLRW space. The value used for R_4 is 14 billion light years corresponding to Hubble constant $H_0 \approx 70$ [(km/s)/Mpc]. Equation (24) applies for the K-corrected distance modulus in multi-bandpass detection used in recent supernova observations. Equation (24) is the DU replacement for the corresponding FLRW prediction

$$\mu = m - M = 5\log\frac{R_H}{10\text{ pc}} + 5\log\left[\left(1+z\right)\int_0^z \frac{1}{\sqrt{\left(1+z\right)^2\left(1+\Omega_m z\right) - z\left(2+z\right)\Omega_\Lambda}}\,dz\right] \tag{25}$$

where Ω_m is the assumed mass density and Ω_λ the assumed dark energy density in space. Figure 9 shows a comparison of the predictions in (24) and (25) with Supernova Ia observations [8,9]. The difference between the two predictions is negligible in the redshift range $0 < z < 2$ but becomes meaningful at higher redshifts.

The key message of equation (24) and its complete fit with observations is that there is no dark energy or acceleration of expansion. The expansion of spherically closed space continues in a zero-energy balance of motion and gravitation with a decelerating velocity due to the work the expansion does against the gravitation of the structure.

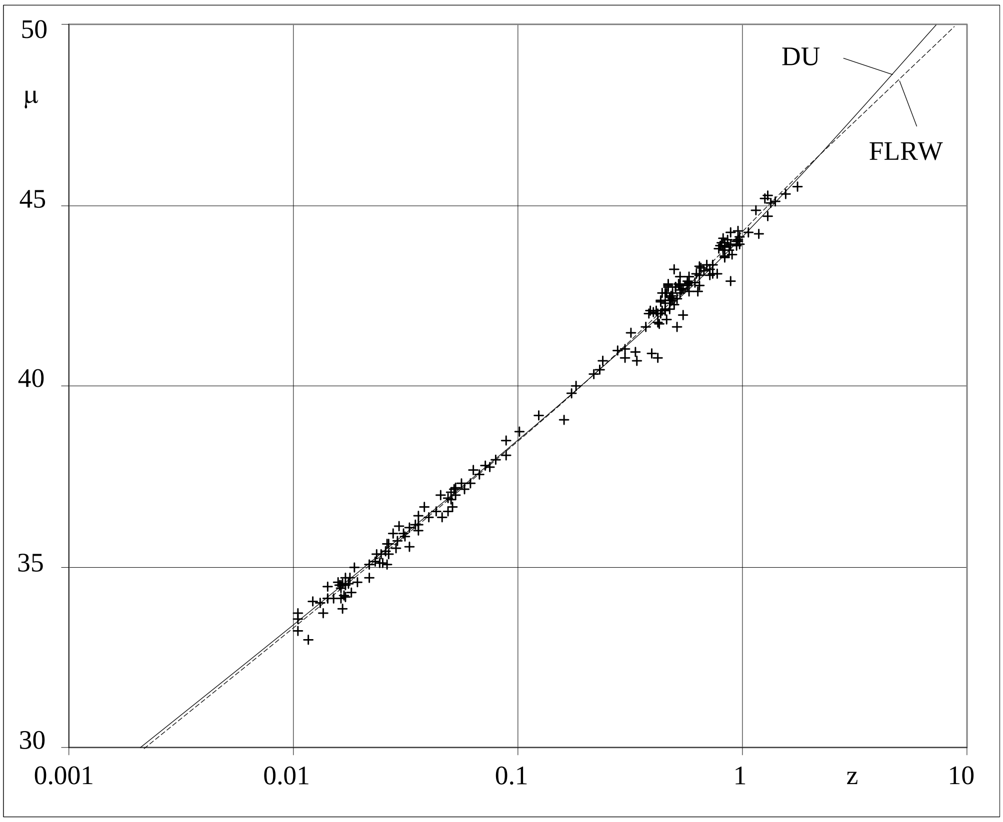


Figure 9. Distance modulus $\mu = m - M$, vs. redshift for Riess et al. "high-confidence" dataset and the data from the HST, Riess [8]. The optimum fit for the FLRW prediction (25) is based on $\Omega_m = 0.27$ and $\Omega_\Lambda = 0.73$. The difference between the DU prediction (24) and the prediction of the standard model (25) is very small in the red-shift range covered by observations, but becomes meaningful at redshifts above $z > 3$.

Summary

Replacement of the mathematical postulates of modified coordinate quantities, time and distance in special and general relativity, with the physical postulates of a spherically closed structure and zero-energy balance in the Dynamic Universe, turns local relativity between observer and object into global relativity between the local and the whole. Global relativity appears as the locally available share of total energy in space – clocks in motion or in a local gravitational field in the Dynamic Universe do not lose time because of slower flow of time but because part of their energy is used for motion and local gravitation in space, thus leaving less energy to run the oscillation.

The Dynamic Universe describes the finiteness of physical resources in space as a consequence finite total mass in spherically closed space. Such an approach converts the infinite Newtonian space and mathematically postulated Einsteinian relativity into a closed but edgeless space ~~and~~ having a global relativity based on physical postulates. The Dynamic Universe allows universal coordinate quantities, time and distance, essential for human conception and a holistic picture of reality.

There is no space-time linkage in the Dynamic Universe; time is universal and the fourth dimension is metric by its nature. The local state of rest is linked – through a chain of nested energy frames – to the state of rest in hypothetical homogeneous space – space as it would be without accumulation of mass into mass centers in space.

The linkage of the local to the whole is a characteristic feature of the Dynamic Universe. The whole in the Dynamic Universe is not considered as the sum of elementary units – the multiplicity of elementary units in space is considered as the result of diversification of whole. There are no independent objects in space – everything is linked to the rest of space.

Predictions for local phenomena in DU space are essentially the same as the corresponding predictions given by the special and general theories of relativity. At extremes – at cosmological distances and in the vicinity of local singularities in space – differences in the predictions become meaningful. The reasons for the differences can be traced back to the differences in the basic assumptions and in the structures of the two approaches. The Dynamic Universe is essentially based on the conservation of a zero-energy balance in spherically closed space, which shows relativity as a consequence of finite resources in space thus replacing the mathematical postulates of Einsteinian relativity by postulates with purely physical nature.

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