Physics Foundations Society

The

Dynamic Universe

Toward a unified picture of physical reality

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1. Introduction

1.1 The Dynamic Universe

The holistic perspective

The Dynamic Universe theory is meant for a holistic description of observable physical reality. It is built on very few postulates, and it aims for an understandable picture of reality. The perspective adopted in the Dynamic Universe enables a unified expression of energies and the use of absolute coordinate quantities, time and distance in the description of the observable physical reality.

The holistic approach in the Dynamic Universe means that local structures and phenomena in space are related to whole space, and the locally expressed energy is related to the total energy in space. Relativity in the DU is not relativity between observer and an object but relativity between local and the whole. Such an approach shows relativity as a consequence of the finiteness of the total energy in space — relativity is a measure of the locally available share of the total energy.

The construction of the Dynamic Universe theory starts from the definition of space and the basic expressions for energy. Derivation of the energy buildup in whole space is based on the zero-energy principle. The predictions for observable phenomena in space are derived by conserving the total energy in space. *The Dynamic Universe theory does not need the relativity principle, the equivalence principle, the Lorentz transformation, the postulation of constant velocity of light, or a space-time concept. The Dynamic Universe theory does not require dark energy or accelerating expansion of space either. The velocity of light in DU space is not constant although it is observed as being constant in several experimental situations.*

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 the 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.

Roots of the prevailing theories

In its basic approach modern physics relies on the Galilean and Newtonian tradition of connecting observer, observation and a mathematical description of the observation. Observations required the definition of the observer's position, and the state of rest. Newton's great breakthrough was the equation of motion, which linked acceleration to the mass of the accelerated object, and thus defined the concept of force. The linkage of force to acceleration allowed the definition of gravitation as a force resulting in the acceleration of a falling object, which allowed the physical interpretation of Kepler's laws of the motion of celestial bodies.

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, time is absolute without beginning or end, and velocities in Newtonian space grow linearly as long as there is constant force acting on an object. Velocities in Newtonian space are summed up linearly without limitations.

The success of Newtonian physics led to a well-ordered mechanistic picture of physical reality. The nice Newtonian picture dominated until the results of the experiments on the velocity of light in late 19th century demonstrated that the observer's velocity did not add to the velocity of light. The velocity of light looked like an upper limit to all velocities in space.

The observed finiteness of velocities and the unique properties of the velocity of light created the need for relativity theory. In the theory of relativity the finiteness of velocities was solved by defining the coordinate quantities, time and distance, as functions of velocity and gravitational state so that the velocity of light appears as an invariant and the maximum velocity obtainable in space. In the framework of relativity theory, clocks in a high gravitational field and in fast motion conserve the local *proper time* but lose coordinate time related to time measured by a clock at rest in a zero gravitational field.

The concept of proper time relies on the *relativity principle*, which requires the laws of nature to look the same for any observer independent of the state of motion or gravitation. As in Newtonian space, gravitation and motion in relativistic space are linked to each other by the *equivalence principle*, which equalizes inertial acceleration and gravitational acceleration.

The cosmological appearance of relativistic space is derived assuming a uniform distribution of mass at cosmological distances. Due to the local nature of the relativity theory, relativistic space conserves the gravitational energy, and hence the dimensions of local gravitational systems. The expansion of relativistic space occurs as "Hubble flow" in empty space between the local systems — probably speeded up by a gravitational push provided by dark energy.

Spherically closed space

The Dynamic Universe model is primarily an analysis of energy balances in space. Absolute time is postulated, and a fourth dimension of metric nature is required for the dynamics of spherically closed 3-dimensional space. Closing space as a 3-dimensional surface of a four-dimensional sphere minimizes the gravitational energy and maximizes the symmetry in the structure. As an initial condition and for calculating the primary balance of the energies of motion and gravitation, mass is assumed to be uniformly distributed in space, which in the Dynamic Universe model is called "hypothetical homogeneous space".

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 [1]. 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. Dynamic space requires metric fourth dimension, which does not fit to the concept of four-dimensional spacetime the theory of relativity is relying on. In his lectures on gravitation in early 1960's Richard Feynman [2] stated:

> *"...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."*

In the same lectures [3] Feynman also pondered the equality of the rest energy and gravitational energy in space:

> *"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* $M_{tot}c^2$*. — 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."*

Obviously, 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. In fact, such a solution does not work in the framework of the relativity theory which is based on time as the fourth dimension.

The Dynamic Universe approach is just a detailed analysis of combining Feynman's "great mystery" of zero-energy space to the "intriguing suggestion of spherically closed space" — by the dynamics of spherically closed space. The Dynamic Universe is a holistic model of physical reality starting from whole space as a spherically closed zero-energy system of motion and gravitation. Instead of extrapolating the cosmological appearance of space from locally defined field equations, locally observed phenomena are derived from the conservation of the zero-energy balance of motion and gravitation in whole space. The energy structure of space is described in terms of nested energy frames starting from hypothetical homogeneous space as the universal frame of reference and proceeding down to local frames in space. Time is decoupled from space — the fourth dimension has a geometrical meaning as the radius of the sphere closing the three-dimensional space.

> *In the Dynamic Universe, finiteness in space comes from the finiteness of the total energy in space — the finiteness of velocities in space is a consequence of the zero-energy balance, which does not allow velocities higher than the expansion velocity of space in the fourth dimension. The velocity of space in the fourth dimension is determined by the zero-energy balance of motion and gravitation of whole space, and it serves as the reference for all velocities in space.*

Relativity in Dynamic Universe means relativity of local to the whole. Local velocities become related to the velocity of space in the fourth dimension, and local gravitation becomes related to the total gravitational energy in space. The expansion of space occurs in a zero-energy balance of motion and gravitation. Local gravitational systems expand in direct proportion to the expansion of whole space.

The Dynamic Universe model allows a unified expression of energies and reveals mass as a wavelike substance for the expression of energies both in localized mass objects, in electromagnetic radiation and in Coulomb systems.

1.2 Presentation of the Dynamic Universe theory

1.2.1 Hypothetical homogeneous space

Assumptions

In comparison with the prevailing theories, the most significant differences in the Dynamic Universe approach come from the holistic perspective and the dynamics of space. In the Dynamic Universe the spherical shape of space is postulated, and the properties of local structures are derived from the whole by conserving the zero-energy balance in the structures.

The zero-energy principle follows a bookkeeper's logic: assets obtained are balanced by equal liabilities. In DU space, energy of motion is obtained against equal release of potential energy.

The inherent forms of the energy of motion and the energy of gravitation are defined in an undisturbed environment: Newtonian gravitational energy is assumed in hypothetical homogeneous space. The inherent form of the energy of motion — the product of the velocity and momentum is assumed in hypothetical environment at rest. The motion of space in the fourth dimension, the expansion of spherically closed space in the direction of the 4-radius of the structure, is considered as motion in an environment at rest.

In homogeneous space, the direction of the fourth dimension is the direction of the 4-radius of space. In locally curved space, the fourth dimension is the direction perpendicular to the three space directions.

It is very useful to describe the fourth dimension as the imaginary direction. Accordingly, phenomena that act both in the fourth dimension and in a space direction are expressed in the form of complex functions. For example, the energy of motion an object has due to the motion of space in the fourth dimension appears as the imaginary component of the total energy of motion. The real component comes from the motion of the object in space.

It should be noted that the concept of the energy of motion is not the same as kinetic energy in traditional sense. The complex energy of motion comprising momenta both in the imaginary direction and in a space direction is basically the same as the total energy in the special theory of relativity. Kinetic energy means the addition of the total energy of motion due to momentum in space added as a real component to the imaginary momentum due to the motion of space.

Traditionally, since Newton's time, the primary physical quantity postulated is force rather than energy. Newton's equation of motion linked force to acceleration *which enabled the linkage of acceleration to the gravitational force. This linkage created the equivalence principle that was used in the extension of the theory of relativity to gravitation, i.e. the general theory of relativity.*

The postulation of energy instead of force as a primary physical quantity creates an essential difference between the DU and traditional mechanics. In the DU, force is considered as a trend to minimum energy, and it is expressed in terms of the local gradient of energy or a change in momentum. Based on the conservation of the total energy in spherically closed space, the buildup of kinetic energy in gravitational acceleration in free fall in space *is not equivalent* to the buildup of kinetic energy at constant gravitational potential. The consequences of the difference are discussed in Chapter 4.

The primary energy buildup process

In Chapter 3, the buildup of the rest energy of matter is described as a contraction–expansion process of spherically closed space. Starting from the state of rest in homogeneous space with essentially infinite radius means an initial condition where both the energy of motion is zero and the energy of gravitation is zero, due to very high distances. A trend to minimum potential energy in spherically closed space converts gravitational energy into the energy of motion in a contraction phase. Space gains motion from gravitation in a contraction phase, and pays it back in an expansion phase after passing a singularity. The dynamics of spherically closed space works like that of a spherical pendulum in the fourth dimension as illustrated in Figure 1.2.1-1.

Applying the inherent energies of motion and gravitation to the zero energy balance of motion and gravitation, we get the equation for the zero-energy balance of homogeneous space

$$M_\Sigma c_4^2 - \frac{GM_\Sigma M''}{R_4} = 0 \qquad (1.2.1:1)$$

where M_Σ is the total mass in space, and $M'' = 0.776 \cdot M_\Sigma$ is the mass equivalence of whole space in the center of the spherical structure.

The contraction-expansion cycle creating the motion of space is referred to as the primary energy buildup process of space.

Using today's estimates for the mass density in space, and the 4-radius, which corresponds to the Hubble radius $R_H \approx 14$ billion light years, the present velocity of the expansion, c_4, in (1.2.1:1) is

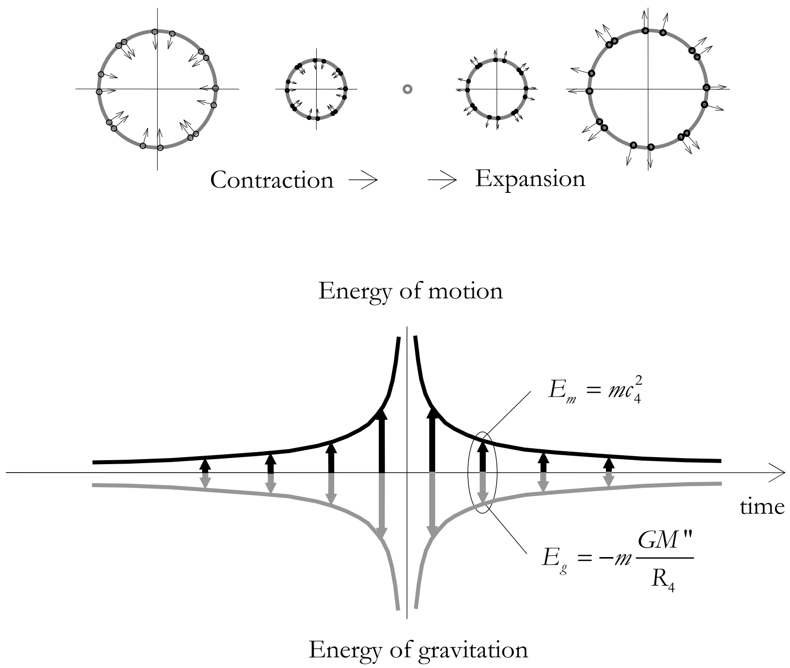


Figure 1.2.1-1. Energy buildup and release in spherical space. In the contraction phase, the velocity of motion increases due to the energy gained from the release of gravitational energy. In the expansion phase, the velocity of motion gradually decreases, while the energy of motion gained in contraction is returned to the energy of gravitation.

$$c_4 = \pm\sqrt{\frac{GM''}{R_4}} \approx 300\,000 \quad [\mathrm{km/s}] \tag{1.2.1:2}$$

which is equal to the present velocity of light. It can be shown, that the velocity of the expansion of space in the direction of the 4-radius determines the maximum velocity in space and the velocity of light.

Due to the dynamic nature of the zero-energy balance in space the velocity of space in the fourth dimension and, accordingly, the velocity of light slow down in the course of the expansion of space. The present annual increase of the R_4 radius of space is $dR_4/R_4 \approx 7.2 \cdot 10^{-11}$/year and the deceleration rate of the expansion is $dc_4/c_4 \approx -3.6 \cdot 10^{-11}$/year, which means also that the velocity of light slows down as $dc/c \approx -3.6 \cdot 10^{-11}$/year. In principle, the change is large enough to be detected. However, the change is reflected in the ticking frequencies of atomic clocks via the degradation of the rest momentum, i.e. the frequencies of clocks slow down at the same rate as the velocity of light, thus disabling the detection.

> *The velocity of light in the Dynamic Universe is not a natural constant, but is determined by the velocity of space in the fourth dimension — the velocity of space in the fourth dimension is determined by the zero-energy balance in equation (1.2.1:1).*

An important conclusion from the primary energy buildup process is that the rest energy is not a property of mass or matter but has the nature of the energy of motion — not due to motion *in space* but due to motion *of space*. In expanding space, the motion of space decreases due to the work the expansion does against the gravitation of the structure. It means that also the rest energy of mass in space diminishes, although the amount of mass in space is conserved.

The rest energy of mass is the energy of motion mass possesses due to the motion of space in the fourth dimension, Figure 1.2.1-2.

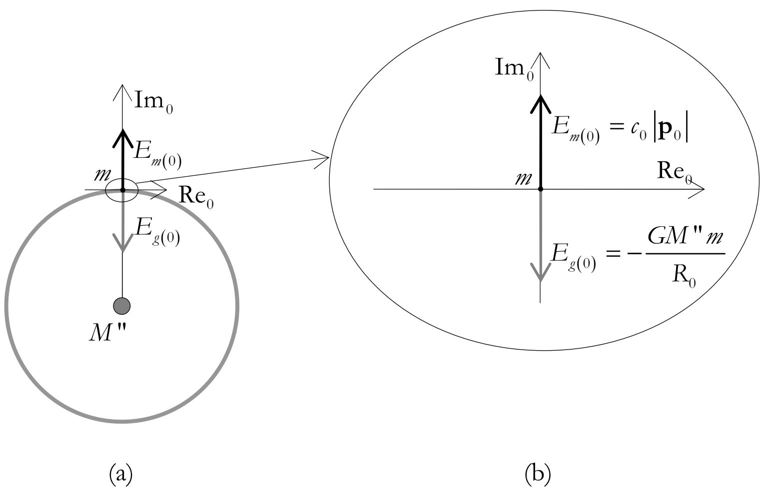


Figure 1.2.1-2. (a) Hypothetical homogeneous space has the shape of the 3-dimensional "surface" of a perfect 4-dimensional sphere. Mass is uniformly distributed in the structure and the barycenter of mass in space is in the center of the 4-sphere. Mass m is a test mass in hypothetical homogeneous space. (b) In a local presentation, a selected space direction is shown as the Re_0 axis, and the fourth dimension, which in hypothetical homogeneous space is the direction of R_0, is shown as the Im_0 axis. The velocity of light in hypothetical homogeneous space is equal to the expansion velocity $c_0 = c_4$.

In the prevailing Friedman-Lemaître-Robertson-Walker (FLRW) cosmology, or "Big Bang cosmology" all energy and the flow of time in space were triggered in a sudden event or quantum jump about 14 billion years ago. A major difference between the primary energy buildup in the DU and the energy buildup in the prevailing Big Bang cosmology is that the energy of matter in the DU has developed against reduction of the gravitational energy in a continuous process from infinity in the past. Space has lost volume and gained velocity in a contraction phase preceding the ongoing expansion phase where space looses velocity and gains back volume.

The basis of the zero-energy concept was first time expressed by Gottfried Leibniz, contemporary with Isaac Newton. Although the concept of energy was not yet matured, the idea of the zero-energy principle can be recognized in Leibniz's *vis viva*, the living force mv^2 (kinetic energy) that is obtained against release of *vis mortua*, the dead force (potential energy) – or vice versa [4].

Mass as the substance for the expression of energy

The Dynamic Universe theory means a major change in paradigm. We need to go back to the Greek philosophers to reawaken the discussion of the essence of mass as a substance. Mass as a wavelike substance for the expression energy in the DU has something in common with the Greek *apeiron* as the indefinite substance for material forms, originally introduced by Anaximander in the 6th century BC. *Apeiron* was not defined precisely; the descriptions given by different philosophers deviate substantially from each other, but comprise the basic feature of *apeiron* as the primary source for all visible forms in cosmos.

The DU concept shows "unity via duality"; mass is the substance in common for the energies of motion and gravitation that emerge and then vanish in a dynamic zero-energy process, giving existence to observable physical reality. As a philosophical concept the primary energy buildup process in the DU is related to the Chinese yin yang concept, where the two inseparable opposites are thought to arise from emptiness and end up in emptiness. In Greek philosophy, perhaps the ideas closest to the yin yang concept are expressed by Heraclitus, contemporary to Anaximander.

Mathematically, the abstract role of mass as the substance for the expression of the complementary energies of motion and gravitation is seen in the equation

$$E_m = mc_0^2 = \frac{GM''}{R_4} m = -E_g \qquad (1.2.1:3)$$

where mass m appears as a first order factor equally in the energy of motion and the energy of gravitation. The energy of motion expressed by mass m is local by its nature. The counterbalancing energy of gravitation is due to all the rest of mass in space.

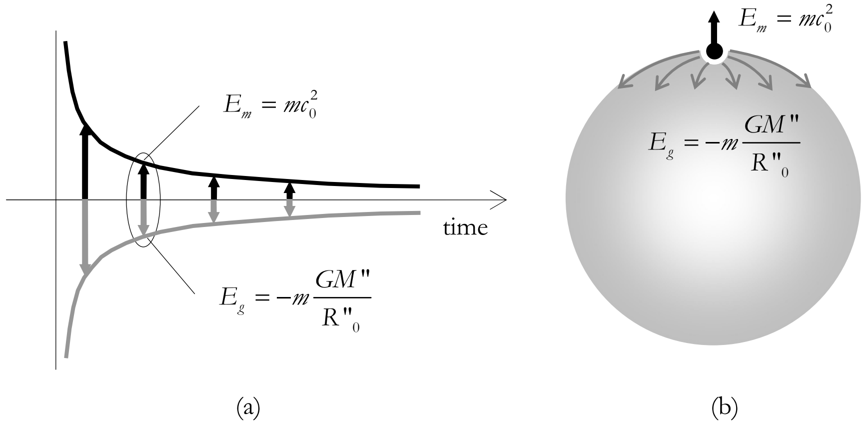


Figure 1.2.1-3(a) The twofold nature of matter at rest in space is manifested by the energies of motion and gravitation. The intensity of the energies of motion and gravitation declines as space expands along the 4-radius. (b). Complementarity of local and whole can be seen in the complementarity of the local rest energy and the global gravitational energy arising from all rest of mass in space. *The antibody of a local mass object is the rest of space.*

Equation (1.2.1:3) does not only mean complementarity of the two types of energies but also complementarity of the local and the whole. The antibody of a local mass object is the rest of space, Figure 1.2.1-3.

> *It looks like Leibniz's monads as "perpetual, living mirrors of the universe", reflected the idea of wholeness and the complementary nature of the local and the global in material objects in Dynamic Universe. There is no need to expect anti-matter for mass objects in space; via the zero-energy balance of motion and gravitation the rest energy of any localized mass object is counterbalanced by the global gravitational energy due to all the rest of mass in space.*

The energy of motion

The zero-energy balance of equation (1.2.1:3) is conserved in all interactions in space. The expression of the energy of motion in (1.2.1:3) has the form that we are used to seeing as the expression of the rest energy of matter. We can identify the inherent form of the energy of motion, applicable for mass and for electromagnetic radiation in space as the product of the velocity and momentum

$$E_m = c_0 \left|\mathbf{p}\right| \qquad (1.2.1:4)$$

Accordingly, the energy of motion of mass at rest in space results from the momentum in the fourth dimension $\mathbf{p}_4$ as

$$E_m = c_0 \left|\mathbf{p}_4\right| = c_0 mc \qquad (1.2.1:5)$$

where the velocity c in the momentum means the local velocity of light which in real space may be lower than the velocity of light c_0 in hypothetical homogeneous space.

A mass object with momentum $\mathbf{p}_\mathbf{r}$ in a space direction has the energy of motion comprising the momentum both in the fourth dimension and in space

$$E_m = c_0 \left|\mathbf{p}_4 + \mathbf{p}_\mathbf{r}\right| \qquad (1.2.1:6)$$

or

$$E_m = c_0 \sqrt{p_4^2 + p_r^2} = c_0 \sqrt{\left(mc\right)^2 + p_r^2} \qquad (1.2.1:7)$$

which is essentially the same expression we are used to seeing as the relativistic total energy. Equation (1.2.1:6) in the DU is obtained without the Lorentz transformation, the relativity principle, or any other assumption bound to the theory of relativity.

The unified expression of energies

The motion in space at the velocity of light in the fourth dimension shows the rest energy in the form of the energy of motion. In a time interval Δt, space moves the distance $\Delta r_4 = c\ \Delta t$ in the fourth dimension. An interesting consequence is that a point source of electromagnetic radiation, like an emitting atom, can be regarded as a one-wavelength dipole in the fourth dimension. Applying Maxwell's equations, the energy emitted by such a one-wavelength dipole in a cycle per a unit charge transient in the dipole, appears as equal to a quantum of radiation

$$E_\lambda = 1.1049 \cdot 2\pi^3 e^2 \mu_0 c \cdot f = h \cdot f = h_0 c_0 \cdot f = c_0 \frac{h_0}{\lambda} c = c_0 m_\lambda c \qquad (1.2.1:8)$$

which shows the composition of the Planck constant, and discloses the *intrinsic Planck constant* $h_0 \equiv h/c$.

Applying the *intrinsic Planck constant,* $h_0 = h/c$*,* the energy of electromagnetic radiation in space is expressed as

$$E_{rad} = c_0 \left|\mathbf{p}\right| = c_0 \frac{h_0}{\lambda} \cdot c = c_0 m_\lambda c \qquad (1.2.1:9)$$

where λ is the wavelength of radiation.

The intrinsic Planck constant has the dimensions of [kg·m], which means that the quantity h_0/λ has the dimensions of mass [kg]. The quantity m_λ in (1.2.1.9) is referred to as the mass equivalence of electromagnetic radiation.

Equation (1.2.1:9) demonstrates the nature of mass as a wave-like substance for the expression of energy. The concept of the mass equivalence of radiation applies in an inverted way as the wavelength equivalence of mass, λ_m. Applying the wavelength equivalence of mass, the rest energy becomes

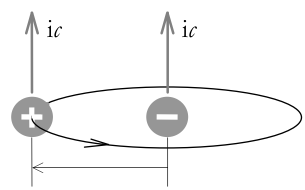
$$E_{rest} = c_0 \left|\mathbf{p}_{rest}\right| = c_0 mc = c_0 \frac{h_0}{\lambda_m} \cdot c \qquad (1.2.1:10)$$

Figure 1.2.1-4 summarizes the unified expression of energy for the rest energy of mass, the energy of a cycle of radiation, and the Coulomb energy.

Localized mass objects are described as standing wave structures with rest momentum in the fourth dimension (Section 5.6). As the sum of the Doppler shifted front and back waves of a "moving standing wave structure", the momentum of a mass object in space can be expressed as the momentum of a wave front propagating in parallel with the moving object

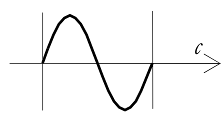
Coulomb energy

$$E_{\mathrm{c}} = N^2 \frac{e^2 \mu_0}{4\pi r} c_0 c = N^2 a \frac{h_0}{2\pi r} c_0 c = c_0 m_{\mathrm{c}} c$$



Unit energy of a cycle of electromagnetic radiation

$$E = c_0 \left|\mathbf{p}\right| = \frac{h_0}{\lambda} c_0 c = c_0 m_\lambda c$$



Rest energy of localized mass object

$$E_{(0)} = c_0 \left|\mathbf{p}\right| = c_0 mc = c_0 \frac{h_0}{\lambda_m} c$$

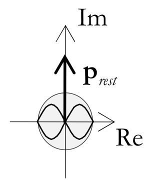


Figure 1.2.1-4. Unified expressions for the Coulomb energy, the energy of a cycle of electromagnetic radiation, and the rest energy of a localized mass object.

$$\mathbf{p}_{\beta} = \frac{h_0}{\lambda_{\beta}} \cdot \beta c = \frac{h_0}{\lambda_{dB}} c \quad \left(= \frac{h}{\lambda_{dB}} \right) \tag{1.2.1:11}$$

where the wavelength λ_β is the wavelength equivalence of the effective mass of the moving object. Equation (1.2.1:11) shows that the momentum of a mass object can equally be described as a wave front with wavelength λ_β propagating at velocity βc, or a wave with the de Broglie wavelength propagating at velocity c. The wave front expression of momentum is illustrative, for example, in the description of the double slit experiment [5].

1.2.2 From homogeneous space to real space

Buildup of mass centers in space

For conserving the total energies of motion and gravitation in mass center buildup, the momentum of free fall, $\mathbf{p}_{ff}$ is obtained against reduction of the local rest momentum $\mathbf{p}_{rest(\phi)}$ in tilted space. The aggregate momentum $\mathbf{p}_{rest(0)}$ is conserved:

$$\mathbf{p}_{rest(\phi)} = \mathbf{p}_{rest(0)} - \mathbf{p}_{ff(\phi)} \tag{1.2.2:1}$$

where

$$p_{rest(\phi)} = p_{rest(0)} \cos\phi = mc_0 \cos\phi \tag{1.2.2:2}$$

showing the reduction of the velocity of space in local fourth dimension and, accordingly, the reduction of the velocity of light in the vicinity of a mass center, Figure 1.2.2-1. Tilting of space is associated with release of global gravitational energy because mass M at distance r_0 from mass m is removed from the symmetry required by the global gravitational energy. The reduced global gravitational energy in tilted space becomes

$$E''_{g(\phi)} = -E_{g(0)}\left(1 - \frac{GM}{r_0 c_0^2}\right) = E_{g(0)}\left(1-\delta\right) = E_{g(0)}\cos\phi \tag{1.2.2:3}$$

where δ is referred to as the gravitational factor

$$\delta = \frac{MR''}{M''r_0} = \frac{GM}{r_0 c_0^2} \tag{1.2.2:4}$$

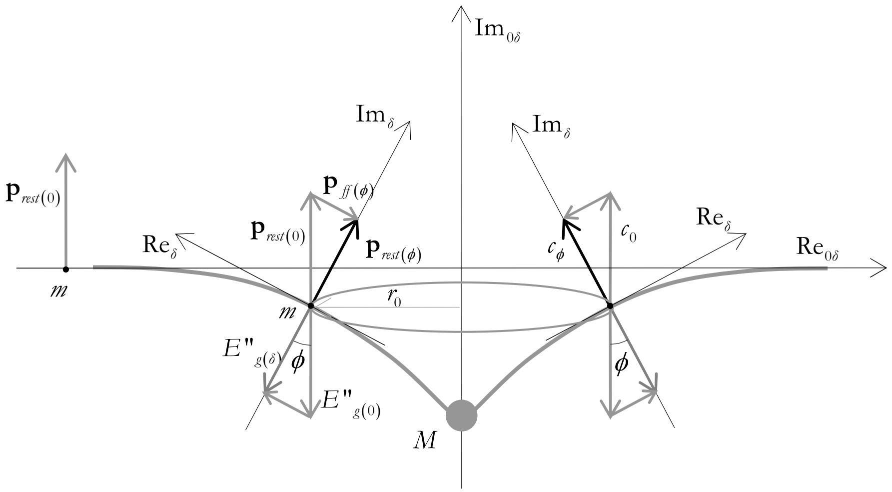


Figure 1.2.2-1. Free fall of mass m towards mass center M in space. The velocity and momentum of free fall is obtained against a reduction of the local rest momentum in tilted space.

Conservation of the total energies of motion and gravitation in the buildup of local mass centers in space is obtained via tilting of space — at the cost of reduced local rest energy and global gravitational energy in tilted space, and the reduced velocity of light.

In real space the buildup of mass centers occurs in several steps, Figure 1.2.2-2. Following the same procedure as for the mass center, the global gravitational energy in the n:th mass center is

$$E''_{g(n)} = E''_{g(0)} \prod_{i=1}^{n} \cos\phi_i = -\frac{GM''m}{R''_0} \prod_{i=1}^{n} \cos\phi_i = -\frac{GM''m}{R''_0} \prod_{i=1}^{n} (1-\delta_i) = -\frac{GM''m}{R''} \qquad (1.2.2:5)$$

and the local velocity of light is

$$c = c_n = c_0 \prod_{i=1}^{n} (1-\delta_i) \qquad (1.2.2:6)$$

where δ_i is the gravitational factor in the i:th gravitational frame.

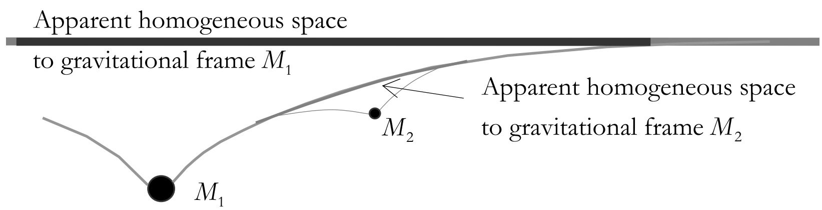


Figure 1.2.2-2. Space in the vicinity of a local frame, as it would be without the mass center, is referred to as apparent homogeneous space to the gravitational frame. Accumulation of mass into mass centers to form local gravitational frames occurs in several steps. Starting from hypothetical homogeneous space, the "first-order" gravitational frames, like M_1 in the figure, have hypothetical homogeneous space as the apparent homogeneous space to the frame. In subsequent steps, smaller mass centers may be formed within the tilted space around in the "first order" frames. For those frames, like M_2 in the figure, space in the M_1 frame, as it would be without the mass center M_2, serves as the apparent homogeneous space to frame M_2.

Kinetic energy

Derivation of the kinetic energy is carried out in Section 4.1.2. A key message is that kinetic energy of free fall is obtained against reduction of the local rest energy and the velocity of light due to tilting of space, whereas kinetic energy at constant gravitational potential requires insertion of mass for the buildup of kinetic energy.

Applying the unified expressions of energy, a release of Coulomb energy can be expressed as a release of the mass equivalence Δm_{EM}

$$\Delta E_C = c_0 \Delta m_{EM} c \tag{1.2.2:7}$$

The total energy of a charged object accelerated in Coulomb field receives mass equivalence $\Delta m = \Delta m_{EM}$ which results in an increase in the total energy

$$E_{m(tot)} = E_{rest} + E_{kin} = c_0 mc + c_0 \Delta m \cdot c = c_0 c \left(m + \Delta m \right) \tag{1.2.2:8}$$

The kinetic energy can be expressed generally as the change of the total energy of motion

$$E_{kin} = c_0 \Delta \left| \mathbf{p} \right| = c_0 \left(\left| m \Delta c \right| + \left| c \Delta m \right| \right) \tag{1.2.2:9}$$

where the first term means kinetic energy obtained in free fall in a gravitational field and the second term kinetic energy via an insertion of mass, Figure 1.2.2-3.

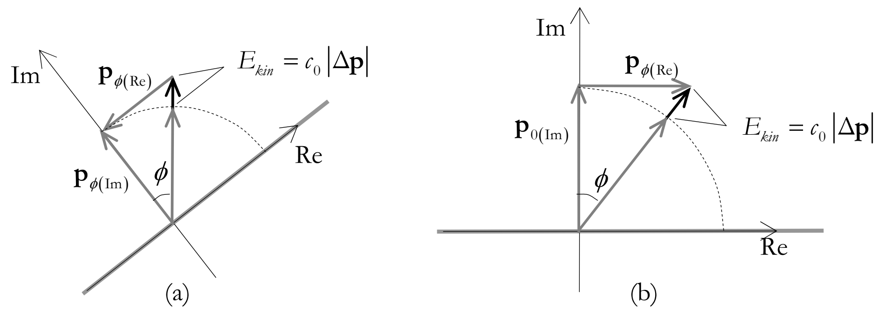


Figure 1.2.2-3. (a) Kinetic energy in free fall by change in the local rest momentum via tilting of space. (b) Kinetic energy by insertion of excess mass.

The difference between the mechanisms of kinetic energy in free fall and in insertion of mass means that the equivalence principle does not apply in DU space.

In complex form the total energy of an object moving at velocity βc at constant gravitational potential is

$$\begin{aligned} E_{m(tot)} &= c_0 |\mathbf{p}^*| = c_0 |\mathbf{p}' + i\,\mathbf{p}_0''| = c_0 |(m+\Delta m)\mathbf{v} + \mathbf{i}\; mc| \\ &= c_0 \sqrt{(mc)^2 + (m+\Delta m)^2 (\beta c)^2} \end{aligned} \qquad (1.2.2:10)$$

which allows solving of the increased mass in terms of β as

$$m_\beta = m + \Delta m = \frac{m}{\sqrt{1-\beta^2}} = m_{eff} \qquad (1.2.2:11)$$

which is equal to the expression of the effective mass or relativistic mass in the theory of special relativity.

The increase of effective mass is not a consequence of the velocity but the extra substance needed in obtaining the velocity.

There are several important conclusions to be drawn from the analysis of the total energy of motion and the kinetic energy as complex functions (Figure 1.2.2-4):

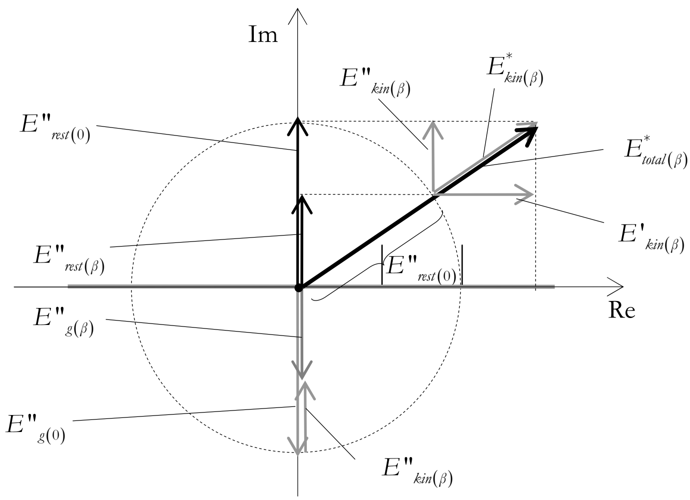


Figure 1.2.2-4. The components of the kinetic energy, E_{kin} of an object moving at velocity βc in a local energy frame. The effect of the imaginary part of the kinetic energy E''_{kin} is a reduction of the global energy of gravitation E''_{g} of the moving object; it is the inertial work done against the global gravitation via central acceleration relative to the equivalence M'' at the center of spherically closed space.

- As a consequence of the conservation of total energy, the rest energy of an object moving at velocity βc in space is reduced.
- The reduction of the rest energy means a reduction of the rest mass available for the rest momentum in the fourth dimension.
- The reduction of the rest mass means an equal reduction in the rest energy and the global gravitational energy of the moving object, thus maintaining the zero-energy balance in the imaginary direction.
- The work done in reducing the rest energy and the global gravitational energy is the imaginary component of the complex kinetic energy.

Reduction of the global gravitational energy due to velocity in space means a quantitative explanation of Mach's principle.

There is no mystery in the "immediate interaction" between an object accelerated in space and all the rest of mass in space. The lightening of a moving object (the reduction of the rest mass) is a local event and results the change in the global gravitation immediately.

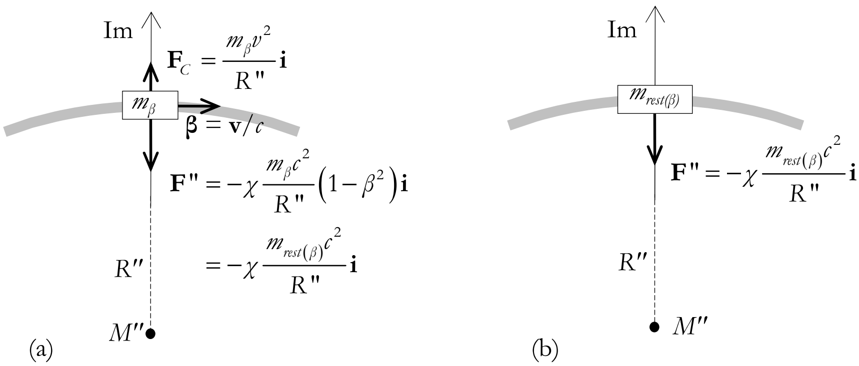


Figure 1.2.2-5. (a) The gravitational force of mass equivalence *M"* on mass m_β moving at velocity $v = \beta c$ within a local frame is reduced by the central force F_C, which makes it equal to the gravitational force of mass equivalence *M"* on mass $m_{rest(\beta)}$ at rest in the local frame as illustrated in figure (b).

The reduction of the rest mass of a moving object can be derived from the conservation of the zero-energy balance by analyzing the components of the energy of motion as complex functions, Figure 1.2.2-4. It can also be deduced by studying the motion in space as central motion relative to the center of the 4-sphere defining space, Figure 1.2.2-5 (Sections 4.3 and 4.1.8).

The zero-energy balance of motion and gravitation in the fourth dimension is obtained equally

for mass $m_\beta \left(= m\big/\sqrt{1-\beta^2}\right)$ moving at velocity β in space

and

for mass $m_{rest(\beta)} \left(= m\sqrt{1-\beta^2}\right)$ at rest in space,

which means that mass $m_{rest(\beta)}$ serves as the rest mass for phenomena within a frame moving at velocity $v = \beta c$.

The energies of motion of mass *m* moving in frame *B* which is moving in frame *A*, is illustrated in Figure 1.2.2-6.

In a general form we can express the rest energy of *n*:th sub-frame in a system of nested systems of motion as

$$E_{rest(\beta_n)} = c_0 m_{rest(\beta_n)} c = c_0 m_0 c \prod_{i=0}^{n} \sqrt{1-\beta_i^2} \qquad (1.2.2{:}12)$$

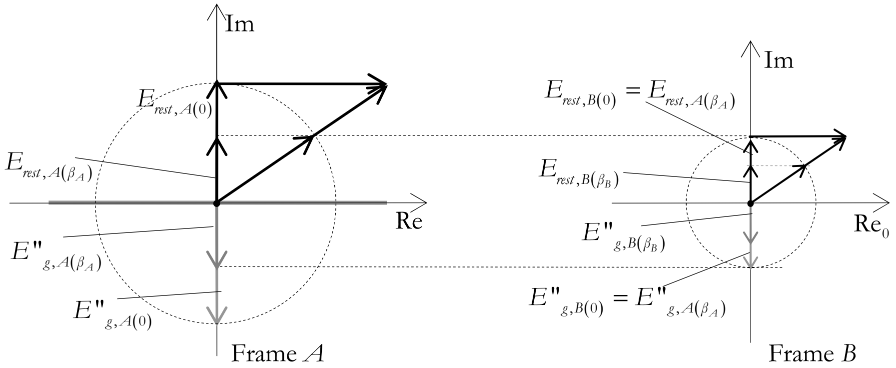


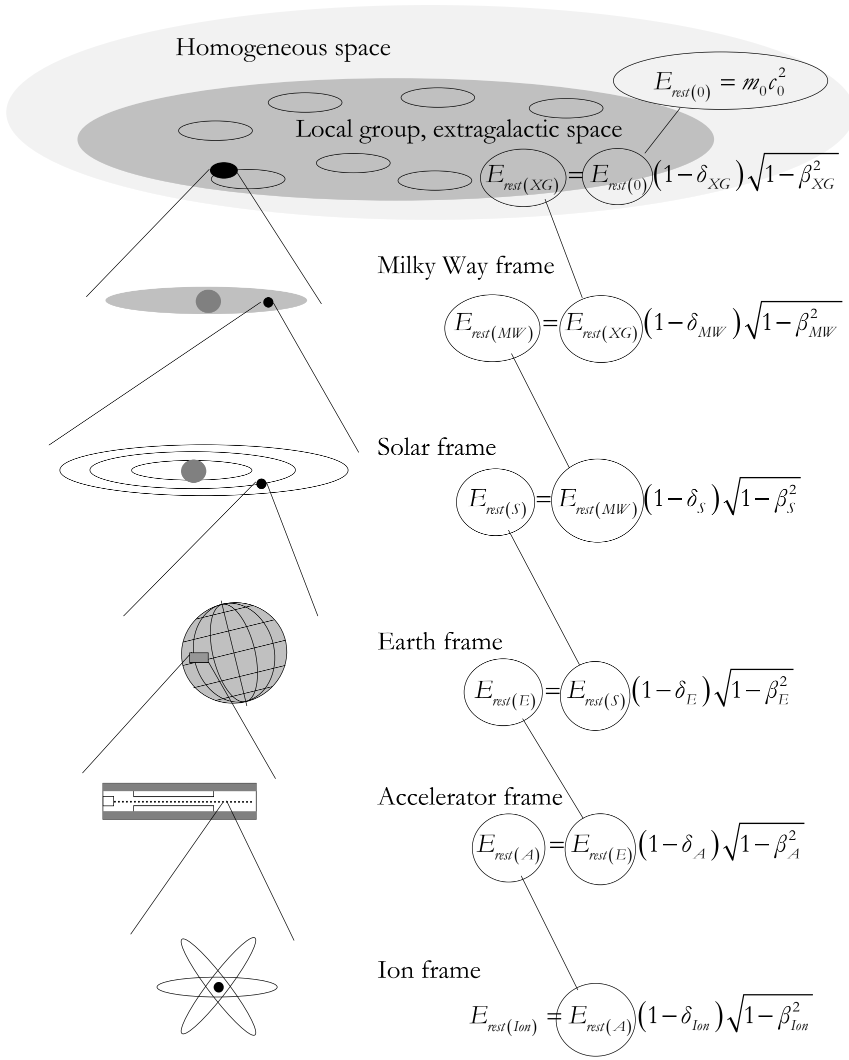
Figure 1.2.2-6. The motion of mass m at velocity β_B in the local frame B, which is moving at velocity β_A in its parent frame A.

and further by including the effect of gravitation on the velocity of light in each frame (1.2.2:6) as

$$E_{rest(\beta_n)} = c_0 m_{rest(\beta_n)} c = m_0 c_0^2 \prod_{i=0}^{n} \left[\left(1-\delta_i\right) \sqrt{1-\beta_i^2} \right] \tag{1.2.2:13}$$

Equation (1.2.2:13) is a central result of the Dynamic Universe theory [see also equation (4.1.4:7)]. It shows the effect of local gravitation and motion on the rest energy of an object in the system of nested energy frames starting from large scale structures and galaxy groups in hypothetical homogeneous space and ending in local systems, and finally in elementary particles and molecular structures in their local environment. Mass m_0 in (1.2.2:13) is the mass of the object as it would be at rest in hypothetical homogeneous space and c_0 is the velocity of light in hypothetical homogeneous space.

Figure 1.2.2-7 illustrates the structure of nested energy frames in space. On the Earth in the Earth gravitational frame, we are subject to the effects of the gravitation and rotation of the Earth, the gravitational state and velocity of the Earth in the solar frame, the gravitational state and velocity of the solar system in the Milky Way frame, the gravitational state and velocity of the Milky Way galaxy in the Local Group, and the gravitational state and velocity of the local group in hypothetical homogeneous space which may be represented by the Cosmic Microwave Background frame as the universal reference at rest. On the Earth, we can create local frames in accelerators or any systems with internal motion. Finally – atoms, molecules, and elementary particles can be considered as energy frames with their internal energy structures.



$$E_{rest(n)} = c_0 m_0 c = m_0 c_0^2 \prod_{i=1}^{n} \left[\left(1-\delta_i\right)\sqrt{1-\beta_i^2} \right]$$

Figure 1.2.2-7. The rest energy of an object in a local frame is linked to the rest energy of the local frame in its parent frame. The system of nested energy frames relates the rest energy of an object in a local frame to the rest energy of the object in homogeneous space.

1.2.3 DU space versus Schwarzschild space

DU space is tilted in the vicinity of mass centers. It is related to the space-time geometry in Schwarzschild space obtained from the field equations of general relativity. Table 1.2.3-I summarizes some predictions of celestial mechanics in Schwarzschild space and in DU space.

At a low gravitational field, far from a mass center, the velocities of free fall as well as the orbital velocities in Schwarzschild space and in DU space are essentially the same as the corresponding Newtonian velocities. Close to the critical radius, however, differences become meaningful.

In Schwarzschild space the critical radius is the radius where Newtonian free fall from infinity achieves the velocity of light

$$r_{c(Schwd)} = \frac{2GM}{c^2} \tag{1.2.3:1}$$

The critical radius in DU space is

$$r_{c(DU)} = \frac{GM}{c_0 c_{0\delta}} \approx \frac{GM}{c^2} \tag{1.2.3:2}$$

	Schwarzschild space	**DU space**
1) Velocity of free fall $\delta = GM/rc^2$	$\beta_{ff} = \sqrt{2\delta}\left(1-2\delta\right)$ (coordinate velocity)	$\beta_{ff} = \sqrt{1/\left(1-\delta\right)^2 - 1}$
2) Orbital velocity at circular orbits	$\beta_{orb} = \dfrac{1-2\delta}{\sqrt{1/\delta - 3}}$ (coordinate velocity)	$\beta_{orb} = \sqrt{\delta\left(1-\delta\right)^3}$
3) Orbital period in Schwarzschild space (coordinate period) and in DU space	$P = \dfrac{2\pi r}{c}\sqrt{\dfrac{2}{\delta}}$, $r > 3 \cdot r_{c(Schwd)}$	$P = \dfrac{2\pi r_c}{c_{0\delta}}\left[\delta\left(1-\delta\right)\right]^{-3/2}$
4) Perihelion advance for a full revolution	$\Delta\psi\left(2\pi\right) = \dfrac{6\pi G\left(M+m\right)}{c^2 a\left(1-e^2\right)}$	$\Delta\psi\left(2\pi\right) = \dfrac{6\pi G\left(M+m\right)}{c^2 a\left(1-e^2\right)}$

Table 1.2.3-I. Predictions related to celestial mechanics in Schwarzschild space [6] and in DU space. In DU space velocity β is the velocity relative to the velocity of light in the apparent homogeneous space of the local singularity, which corresponds to the coordinate velocity in Schwarzschild space.

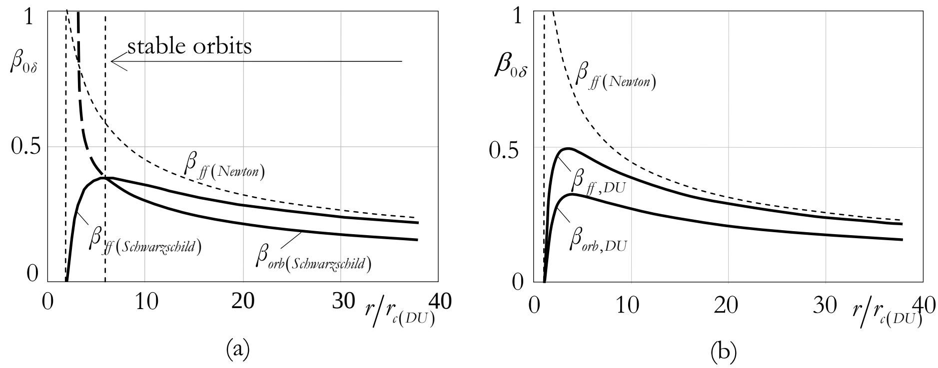


Figure 1.2.3-1. a) The velocity of free fall and the orbital velocity at circular orbits in Schwarzschild space. b) The velocity of free fall and the orbital velocity at circular orbits in DU space. The velocity of free fall in Newtonian space is given as a reference. Slow orbits between $0 < r < 2 \cdot r_{c(DU)}$ in DU space maintain the mass of the black hole.

which is half of the critical radius in Schwarzschild space. The two different velocities c_0 and $c_{0\delta}$ in (1.2.3:2) are the velocity of light in hypothetical homogeneous space and the velocity of light apparent homogeneous space in the fourth dimension.

In Schwarzschild space the predicted orbital velocity at circular orbit exceeds the velocity of free fall when r is smaller than 3 times the Schwarzschild critical radius, which makes stable orbits impossible. In DU space the orbital velocity decreases smoothly towards zero at $r = r_{c(DU)}$, which means that there are stable slow velocity orbits between $0 < r < 4 \cdot r_{c(DU)}$, Fig. 1.2.3-1.

The importance of the slow orbits near the critical radius is that they maintain the mass of the black hole.

The instability of orbits in Schwarzschild space can be traced back to the effect of the equivalence principle behind the field equations in general relativity, which assumes buildup of effective mass in free fall in gravitational field.

According to the DU analysis there is no source of mass to result in an increase of mass in free fall in a gravitational field – the velocity and momentum of free fall are obtained against a reduction of the local velocity of light and rest momentum.

The prediction for the orbital period at circular orbits in Schwarzschild space apply only for radii $r > 3 \cdot r_{c(Schwd)}$. Due to the decreasing orbital velocity close to the critical radius in DU space the orbital period has a minimum at $r = 2 \cdot r_C$.

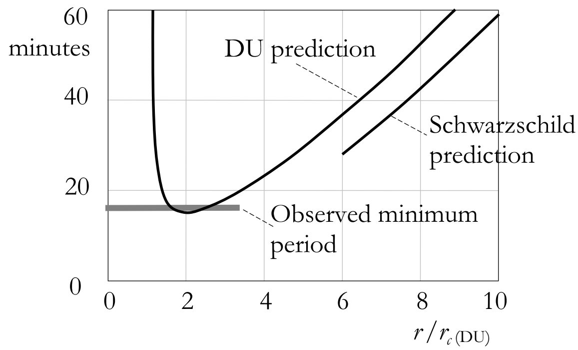


Figure. 1.2.3-2. The predictions in Schwarzschild space and in DU space for the period (in minutes) of circular orbits around Sgr A* in the center of Milky Way. The shortest observed period is 16.8 ± 2 min [7] which is very close to the minimum period of 14.8 minutes predicted by the DU. The minimum period predicted for orbits for a Schwarzschild black hole is about 28 minutes, which occurs at $r = 3{\cdot}r_{c(Schwd)} = 6{\cdot}r_{c(DU)}$. A suggested explanation for the "too fast" period is a rotating black hole (Kerr black hole) in Schwarzschild space.

The black hole at the center of the Milky Way, the compact radio source Sgr A*, has an estimated mass of about 3.6 times the solar mass which means $M_{black\ hole} \approx 7.2{\cdot}10^{36}$ kg, which in turn means a period of 28 minutes as the minimum for stable orbits in Schwarzschild space. The shortest observed period at Sgr A* is 16.8 ± 2 min [7] which is very close to the prediction for the minimum period 14.8 min in DU space at $r = 2{\cdot}r_{c(DU)}$, Fig. 1.2.3-2.

In DU space the velocity of free fall reaches the local velocity of light when the tilting angle of space is $\phi = 45°$, which occurs at distance at $r_{0\delta} \approx 3.414 \cdot r_c$. We may assume that such a condition is favorable for matter to radiation and elementary particle conversions.

As shown in Table 1.2.3-I, the prediction for perihelion advance in elliptic orbits is essentially the same in Schwarzschild space and in DU space. In DU space the prediction can be derived in a closed mathematical form.

The linkage of local and the whole

In DU space all velocities in space are related to the velocity of space in the fourth dimension, which also determines the local velocity of light. The orbital radii of all gravitational systems in DU space are related to the 4-radius of spherically closed space.

According to the DU analysis, out of the observed 3.82 ± 0.007 cm/year increase [8] of the Earth to Moon distance, about 2.8 cm comes from the expansion of space and the rest, ≈ 1 cm, from other reasons like the tidal interactions (see Section 7.3.3).

A dynamic balance between local gravitational systems can be seen in the interactions between a local orbiting system and its hosting gravitational system. The Earth–Moon system is a subsystem in the solar system. The eccentricity of Earth–Moon orbit around the Sun is about 0.0167 which means that the Earth to Sun distance varies about 5 million km between perihelion and aphelion. It also means that the orbital velocity of the Earth–Moon system varies between perihelion and aphelion. According to the DU analysis, the changes in the gravitational state and velocity of the Earth–Moon system in the solar system result in an annual variation of about 12.6 cm in the Earth to Moon distance. It turns out that the effects of the changes in the gravitational state and velocity of the Earth–Moon system in the solar system on the velocity of light and clocks on the Earth are such the variation in the Earth to Moon distance when measured by laser ranging is cancelled (see Section 7.3.3).

Topography of the fourth dimension

The curvature of space near local mass centers is a consequence of the conservation of the energy balance created in the primary energy buildup of space. Because the fourth dimension is a geometrical dimension, the shape of space can be solved in distance units, including the topography in the fourth dimension. Dents in space are associated with a reduced velocity of light. Figure 1.2.3-3 illustrates the "depth" profile of the planetary system and the profile of the velocity of light in the vicinity of the Earth.

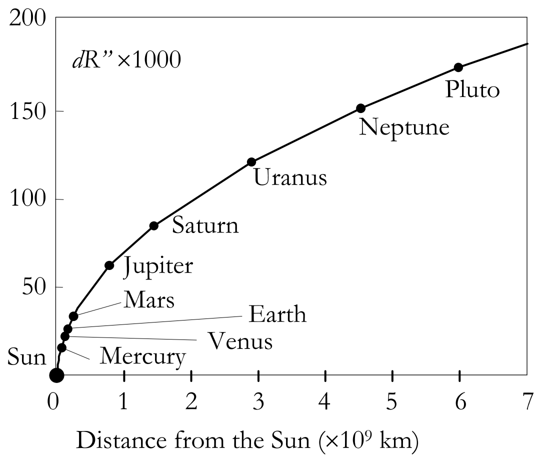


Figure 1.2.3-3. Topography of the solar System in the fourth dimension. Earth is about 26 000 km higher than the Sun, Pluto is about 180 000 km higher than the Sun in the fourth dimension.

Propagation of light through the dents around mass centers in space is subject to delay (the Shapiro delay) and the path of light is bent. A comparison of the predictions of the Shapiro delay and the bending of light in general relativity and in the DU is given in Table 1.2.3-II. The Shapiro delay is affected both by the lengthening of the path and the reduction of the velocity of light in the vicinity of mass centers as illustrated on the first row of Table 1.2.3-II.

In the GR prediction the effects of the lengthening of the path is equal to the effect of slower velocity (delayed time). In the DU prediction the lengthening of the path comes only from the radial component of the path (the direction towards the mass center). The tangential component of the path is not subject to lengthening (see Figure 5.3.1-2).

The effect of the difference in the GR and DU predictions for the Shapiro delay is not detectable in the experiments that have been performed (see Section 7.3.4).

	General relativity	**Dynamic Universe**
1) Shapiro delay, general expression $\Delta T = \Delta T_{path} + \Delta T_{path}$	$\Delta T_{(path)} = \frac{GM}{c_{0\delta}^3}\ln\left[\frac{x_B + r_B}{x_A + r_A}\right]$ $\Delta T_{(velocity)} = \frac{GM}{c_{0\delta}^3}\ln\left[\frac{x_B + r_B}{x_A + r_A}\right]$	$\Delta T_{(path)} = \frac{GM}{c_{0\delta}^3}\ln\left\{\left[\frac{x_B + r_B}{x_A + r_A}\right] - \left[\frac{x_B}{r_B} - \frac{x_A}{r_A}\right]\right\}$ $\Delta T_{(velocity)} = \frac{GM}{c_{0\delta}^3}\ln\left[\frac{x_B + r_B}{x_A + r_A}\right]$
2) Shapiro delay of radar signal (in radial direction to and from a mass center)	$\Delta T_{(A-B)} = \frac{2GM}{c^3}\ln\frac{r_B}{r_A}$ (coordinate velocity)	$\Delta T_{(A-B)} = \frac{2GM}{c^3}\ln\frac{r_B}{r_A}$
3) Shapiro delay $(D_1, D_2 \gg d)$	$\Delta T = \frac{2GM}{c^3}\ln\left[\frac{4D_1D_2}{d^2}\right]$	$\Delta T = \frac{2GM}{c^3}\ln\left\{\left[\frac{4D_1D_2}{d^2}\right] - 1\right\}$
4) Bending of light path	$\phi = \frac{4GM}{c^2 d}$	$\phi = \frac{4GM}{c^2 d}$

Table 1.2.3-II. The Shapiro delay and the bending of the light path in the vicinity of a mass center. Distances r_A and r_B in the table are the distances of the source and the receiver from the mass center. Distance x_A and x_B are the distance from the source and the receiver to the point of shortest distance from the path to the mass center (denoted as d at row 3 (see Figure 5.3.1-4).

1.2.4 Clock frequencies and the propagation of light

Characteristic emission and absorption frequencies

The expression of relativity as the locally available rest energy in space means that all energy states in atomic systems are functions of the gravitational state and velocity of the system in the local energy frame, and the gravitational state and velocity of the local energy frame in all its parent frames as given in equation (1.2.2:13). When substituted for the rest energy of electron, the energy states of electrons in the standard solution of hydrogen-like atoms become functions of the gravitational state and velocity (see Section 5.1.3)

$$E_{Z,n} = \frac{Z^2}{n^2}\frac{a^2}{2} m_{e(0)} c_0^2 \prod_{i=1}^{n} \left(1-\delta_i\right)\sqrt{1-\beta_i^2} \qquad (1.2.4:1)$$

where a is the fine structure constant.

The characteristic emission and absorption frequency, corresponding to an energy transition $\Delta E_{(n1,n2)}$, can be expressed as

$$f_{(n1,n2)} = \frac{\Delta E_{(n1,n2)}}{h_0 c_0} = Z^2 \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] \frac{a^2}{2h_0} m_{e(0)} c_0 \prod_{i=1}^{n} \left(1-\delta_i\right)\sqrt{1-\beta_i^2} \qquad (1.2.4:2)$$

or

$$f_{(n1,n2)} = f_{0(n1,n2)} \prod_{i=1}^{n} \left(1-\delta_i\right)\sqrt{1-\beta_i^2} \qquad (1.2.4:3)$$

where $f_{0(n1,n2)}$ is the characteristic frequency the atom would have at rest in hypothetical homogeneous space. As shown by equation (1.2.4:2) the characteristic frequency is not only a function of local gravitation and motion but also a function of the velocity of light in hypothetical homogeneous space, which means that the frequency of atomic oscillators deceases in direct proportion to the decrease of the velocity of light in expanding space.

There is no time dilation in the DU. The characteristic emission and absorption frequencies of atomic oscillators are functions of the state of the expansion of space, and the gravitational state, and velocity of the oscillator in space.

The characteristic wavelength is a function of the motion of the atom in space, but not a function of the gravitational state or the state of the expansion of space

$$\lambda_{(n1,n2)} = \frac{c}{f_{(n1,n2)}} = \frac{2h_0}{Z^2\left[1/n_1^2 - 1/n_2^2\right]a^2 m_{e(0)}} \frac{1}{\prod_{i=1}^{n}\sqrt{1-\beta_i^2}} \qquad (1.2.4:4)$$

The characteristic wavelength is directly proportional to the Bohr radius

$$\lambda_{(n1,n2)} = \frac{4\pi a_0}{aZ^2\left[1/n_1^2 - 1/n_2^2\right]} \qquad (1.2.4:5)$$

which means that also the Bohr radius a_0 is independent of the local gravitational state and the state of the expansion of space. However, the Bohr radius increases with the velocity of the atom in space.

In a local gravitational frame equation (1.2.4:3) for the frequency of atomic clocks reduces into

$$f_{\delta,\beta} = f_{0\delta,0}\left(1-\delta\right)\sqrt{1-\beta^2} \qquad (1.2.4:6)$$

where $f_{0,\delta 0}$ is the frequency of the clock at rest in the apparent homogeneous space of the local gravitational frame. Equation (1.2.4:6) is the DU replacement of the equation for proper frequency in Schwarzschild space

$$f_{\delta,\beta} = f_{0,0}\sqrt{1-2\delta-\beta^2} \qquad (1.2.4:7)$$

Where δ is the DU gravitational factor $\delta = GM/rc^2$.

There is no length contraction in the DU. Sizes of objects bound by Coulomb energy increase with the velocity of the object in space.

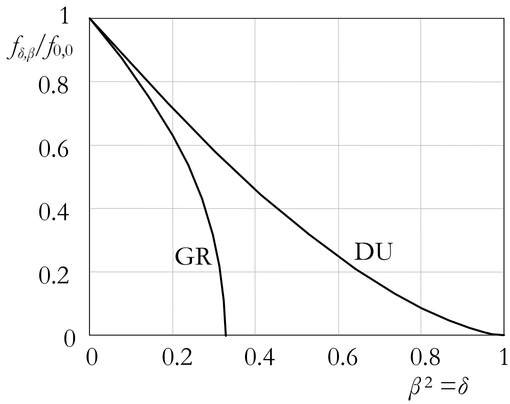


Figure 1.2.4-1. The difference in the DU and GR predictions of the frequency of atomic oscillators at extreme conditions when $\delta = \beta^2 \rightarrow 1$. Such condition may appear close to a black hole in space. The GR and DU predictions in the figure are based on equations (1.2.4:7) and (1.2.4:6), respectively.

On the Earth and in near space, the difference between the DU and GR predictions for clock frequencies in (1.2.4:6) and (1.2.4:7) is undetectable, $\Delta f/f \approx 10^{-18}$. The difference, however, is essential at extreme conditions, close to local singularities in space, where δ and β approach unity, Figure 1.2.4-1.

The curves in figure 1.2.4-1 correspond to the frequencies of clocks in circular orbits in the vicinity of a local singularity in space. The GR clock stops at $r = 3 \cdot r_{c(DU)}$ whereas the frequency of the DU clock approaches softly to zero at critical radius.

Gravitational shift of clocks and electromagnetic radiation

The DU model makes a clear distinction between the gravitational effects on the frequency and wavelength of atomic oscillators and the gravitational effects on the frequency and wavelength of electromagnetic radiation (see Section 5.2.2).

The clock frequency is a function of the gravitational state of the clock. A clock at a higher altitude (A) runs faster than an identical clock at a lower altitude (B)

$$f_A = \frac{1-\delta_A}{1-\delta_B} f_B = C \cdot f_B \qquad ; \qquad (C > 1) \tag{1.2.4:8}$$

The velocity of light at altitude (A) is higher than the velocity of light at altitude (B)

$$c_A = C \cdot c_B \; ; \qquad \frac{c_A}{c_B} = \frac{f_A}{f_B} = C \tag{1.2.4:9}$$

The wavelength of electromagnetic radiation emitted by a transmitter driven by the clock at (A) is equal to the wavelength emitted by a transmitter driven by the clock at (B)

$$\lambda_A = \frac{c_A}{f_A} = \lambda_B = \frac{c_B}{f_B} \tag{1.2.4:10}$$

The frequency of radiation transmitted from (A) to (B), is conserved — same number of cycles is received as sent in a time interval. The frequency from (A), observed at (B), as compared to the frequency of the local clock at (B) is

$$f_{A(B)} = f_A = C \cdot f_B \tag{1.2.4:11}$$

i.e. the frequency of radiation from (A), when received at (B) is higher by the factor C than the frequency of the reference clock at (B).

The wavelength of the radiation received at (B) is

$$\lambda_{A(B)} = \frac{c_B}{f_A} = \frac{c_B}{C \cdot f_B} = \frac{\lambda_B}{C} \qquad (1.2.4:12)$$

i.e. the wavelength of radiation from (A), when received at (B) is shorter by factor C than the wavelength emitted by a transmitter driven by the clock at (B).

An important message of the short analysis above is that the frequency of radiation and, accordingly, the momentum of radiation are not affected by the propagation from one gravitational state to another — the effect of the reduced velocity of light on the momentum at a lower altitude is compensated by the shortening of the wavelength

$$\mathbf{p}_{rad(f)} = \frac{\hbar_0}{\lambda} c \cdot \hat{\mathbf{r}} = f \cdot \hat{\mathbf{r}} = f_A \cdot \hat{\mathbf{r}} = f_{A(B)} \cdot \hat{\mathbf{r}} \qquad (1.2.4:13)$$

- *The characteristic frequency of an oscillator is directly proportional to the local velocity of light in the gravitational state of the oscillator.*
- *The characteristic wavelength of electromagnetic radiation sent by an oscillator is independent of the gravitational state in which the oscillator is located.*
- *The gravitational red or blue shift of electromagnetic radiation is the shift of the wavelength of the radiation due to difference in the velocity of light at different gravitational states. No change in the frequency of the radiation occurs during propagation.*

The Doppler effect of electromagnetic radiation

In the DU framework the Doppler effect of electromagnetic radiation is derived in a classical way by taking into account separately the motion of the transmitter and the receiver. Accordingly, the Doppler shifted frequency of radiation sent from a source A to a receiver B is observed at B as

$$f_{A(B)} = f_A \frac{\left(1-\beta_{B(\mathbf{r})}\right)}{\left(1-\beta_{A(\mathbf{r})}\right)} = f_0\left(1-\delta_A\right)\sqrt{1-\beta_A}\,\frac{\left(1-\beta_{B(\mathbf{r})}\right)}{\left(1-\beta_{A(\mathbf{r})}\right)} \qquad (1.2.4:14)$$

where $\beta_{A(\mathbf{r})}$ and $\beta_{B(\mathbf{r})}$ are the velocities of A and B in the direction of the propagation of the radiation in the frame in common to the source and the receiver.

In the last form, the effect of gravitation and motion of the source at A is included according to equation (1.2.4:14). When compared to the frequency of a reference oscillator at B

$$f_B = f_0\left(1-\delta_B\right)\sqrt{1-\beta_B} \tag{1.2.4:15}$$

the Doppler shifted of frequency is

$$f_{A(B)} = f_B \frac{\left(1-\delta_A\right)\sqrt{1-\beta_A^2}}{\left(1-\delta_B\right)\sqrt{1-\beta_B^2}} \frac{\left(1-\beta_{B(\mathbf{r})}\right)}{\left(1-\beta_{A(\mathbf{r})}\right)} \tag{1.2.4:16}$$

Equation (1.2.4:16) is essentially the same as the prediction for Doppler shifted frequency in the general theory of relativity. Importantly, however, the square root terms in the DU equation (1.2.4:16) are not a part of the Doppler effect, or "transversal Doppler" as referred to in special relativity, but the effect of the local motions on the characteristic frequencies of the oscillators at A and B.

A complete form of the Doppler effect, taking into account the system of nested energy frames is given in equation (5.2.3:23) in Section 5.2.3.

1.2.5 The Dynamic Cosmology

Basic quantities

The Dynamic Universe is a holistic model starting from whole space as a zero-energy system of motion and gravitation. Instead of extrapolating the cosmological appearance of space from locally defined field equations, locally observed phenomena are derived from the conservation of the zero-energy balance of motion and gravitation in whole space.

The precise geometry and the overall zero-energy balance in DU space allow the derivation of cosmological predictions using simple mathematics, essentially free of additional parameters.

The physical distance between locations in spherically closed space can be expressed in terms of the separation angle seen from the 4-center of space, Figure 1.2.5-1(a)

$$D_{phys} = \theta \cdot R_0 \tag{1.2.5:1}$$

As the 4-radius increases at velocity $c_4 = c_0$, objects at physical distance D_{phys} from each other have a relative recession velocity

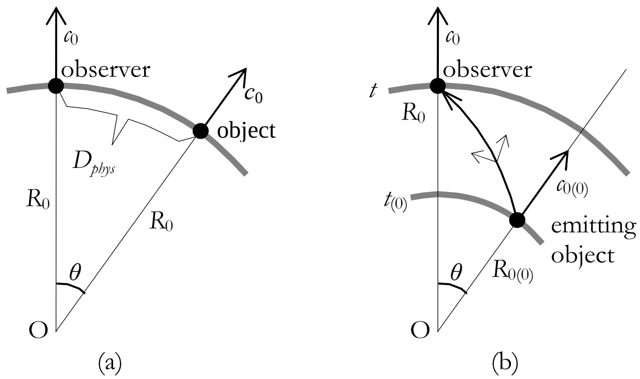


Figure 1.2.5-1. (a) A linear Hubble law corresponds to Euclidean space where the distance of the object is equal to the physical distance, the arc D_{phys}, at the time of the observation.

(b) When the propagation time of light from the object is taken into account, the optical distance is the length of the integrated path over which light propagates in space in the tangential direction in the 4-sphere $D_{opt} = D = \int dD_{\perp}$. Because the velocity of light in space is equal to the expansion of space in the direction of R_4, the optical distance is $D = R_0 - R_{0(0)}$, the lengthening of the 4-radius during the propagation.

$$v_{rec} = \theta \cdot c_0 \tag{1.2.5:2}$$

Observation of distant objects occurs via propagation of light or radio signals from the objects. Taking into account the light propagation time and the expansion of space during the propagation of light, the physical distance converts into optical distance, and the relative recession velocity into optical recession velocity, Figure 1.2.5-1(b).

All along the path the velocity of light in space is equal to the expansion velocity of space as the 4-sphere, which reduces the optical distance into

$$D = R_0\left(1 - e^{-\theta}\right) \tag{1.2.5:3}$$

and the optical recession velocity into

$$v_{rec(optical)} = \frac{dD}{dt} = c_0\left(1 - e^{-\theta}\right) = \frac{D}{R_0} c_0 \tag{1.2.5:4}$$

Redshift, or the lengthening of the wavelength of radiation propagating in space, is assumed to be directly proportional to the expansion of space, which defines redshift z as

$$z = \frac{\lambda - \lambda_0}{\lambda_0} = \frac{R_0 - R_{0(0)}}{R_{0(0)}} = \frac{D/R_0}{1 - D/R_0} = e^{\theta} - 1 \qquad (1.2.5:5)$$

Applying the concept of redshift, the optical distance can be expressed

$$D = R_0 \frac{z}{1+z} \qquad (1.2.5:6)$$

As shown in Chapter 5.1.3, the characteristic emission wavelengths of atomic objects are conserved in the course of expansion of space. Accordingly, comparison of a received emission spectrum to the corresponding in situ spectrum gives directly the redshift.

Angular size of cosmological objects

Radiation from an object *A(z)* at a distance angle θ from the observer is seen at its apparent location *A'(z)*, at distance *D* (Fig. 1.2.5-2), redshifted by

$$z = e^{\theta} - 1 = \frac{D/R_0}{1 - D/R_0} \qquad (1.2.5:7)$$

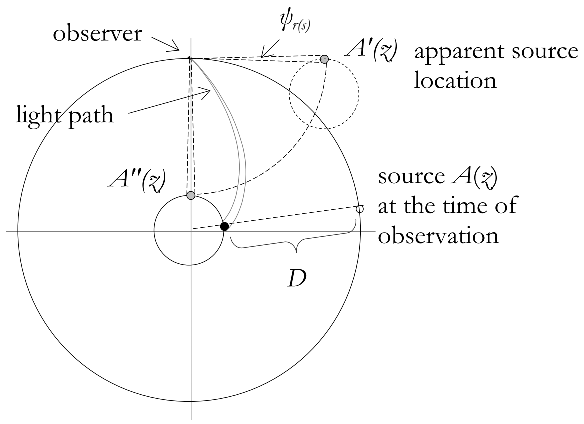


Figure 1.2.5-2. Propagation of light in expanding spherically closed space. The apparent line of sight is the straight tangential line. The distance to the apparent source location *A'(z)* is at the optical distance $D = R_{(observation)} - R_{(emission)}$ along the apparent line of sight. The symmetry of expansion in three space dimensions and in the fourth dimension makes the observed optical angle $\psi_{r(s)}$ of the apparent source *A'(z)* equal to the optical angle of a hypothetical image *A''(z)* at distance *D* in the direction of the R_0 radius.

For a non-expanding object with a fixed diameter, d_s the observed angular diameter is

$$\frac{\psi_{r(s)}}{d_s/R_0} = \frac{z+1}{z} \tag{1.2.5:8}$$

and for expanding objects with diameter $d = d_0/(1+z)$, like galaxies and quasars

$$\frac{\psi}{\theta_d} = \frac{\psi}{\left[d_0/(1+z)\right]/R_0} = \frac{1}{z} \tag{1.2.5:9}$$

where θ_d is the angular diameter of the object, as seen from the 4-center of space. Equation (1.2.5:9) means Euclidean appearance of galactic objects, which is very well supported by observations (see Figure 6.2.3-2).

Predictions given by equations (1.2.5:8) and (1.2.5:9) are essentially different from the corresponding predictions in the standard FLRW cosmology. First, the prediction for optical distance in DU space is different from the angular diameter distance in standard cosmology; second, equations (1.2.5:8) and (1.2.5:9) are free from additional parameters like the mass density, or dark energy, and third, unlike in FLRW space, the gravitationally bound objects in DU space expand in direct proportion to the expansion of space.

The DU prediction for magnitude

The dilution of the power density of radiation from an object results from the areal spreading proportional to the distance squared, and from the effect of the redshift.

In DU space the areal spreading is related to square of the optical distance. As a demand of the conservation of the mass equivalence carried by a cycle of radiation, the dilution of power density received comes from the increased time in which, due to the redshift, a cycle is received.

It should be noted that the effect of the declining velocity of light affects equally the energy of the radiation observed, and the energy of radiation emitted by an in situ reference source.

Combining the areal dilution and the redshift dilution, the prediction for the energy flux, or power density, from an object at optical distance D relates to the energy flux from a reference source at distance d_0 (d_0 is small enough to result negligible redshift) as

$$F_{(D,z)} = F_{e(ref)} \cdot \frac{d_0^2}{D^2} \frac{1}{(1+z)} \tag{1.2.5:10}$$

Substitution of (1.2.5:6) for the optical distance equation (1.2.5:10) yields the form

$$F_{(D,z)} = F_{e(ref)} \cdot \frac{d_0^2}{R_0^2} \frac{(1+z)}{z^2} \quad (1.2.5:11)$$

which corresponds to the apparent magnitude (see Section 6.3.2)

$$m = M + 5\log\frac{R_0}{d_0} + 5\log z - 2.5\log(1+z) + K_{instr} \quad (1.2.5:12)$$

Equation (1.2.5:12) applies to the *bolometric energy flux* observed. For converting the prediction of equation (1.2.5:12) comparable with the FLRW prediction for *K*-corrected magnitudes, the magnitudes converted to emitters rest frame, the prediction (1.2.5:12) converts into

$$m_{K(DU)} = M + 5\log\frac{R_0}{d_0} + 5\log z + 2.5\log(1+z) + K_{instr} \quad (1.2.5:13)$$

(see Section 6.3.2) where K_{instr} stands for possible effects of galactic extinction, spectral distortion in Earth atmosphere, and instrumental corrections. The prediction (1.2.5:13) does not include effects due to the local motion and gravitational environment of the observed object and the receiver. Both the prediction (1.2.5:12) for direct bolometric observations, and (1.2.5:13) for *K*-corrected observations are in an excellent agreement with observations (see Sections 6.3.3 and 6.3.4).

The FLRW predictions

There is a major difference between the concepts of distances, and the observed angular diameter and magnitude of distant objects in the DU and in the FLRW cosmology. In the early work of Tolman [9] the observed angular diameter of an object at "coordinate distance" r_C is related to the angular diameter of a reference object of the same size at distance r_s (with $z_s \approx 0$) as

$$\frac{\theta}{\theta_s} = \frac{r_s}{r_C/(1+z)} \quad (1.2.5:14)$$

where z is the redshift observed in the radiation from the object. The energy flow F of the redshifted radiation from the object at coordinate distance r_C is related to the energy flow (power density) F_s from a reference source at distance r_s (with $z_s \approx 0$) as {see equation (26) in [9]}

$$F = \frac{r_s^2}{r_C^2} \frac{F_s}{(1+z)^2} \tag{1.2.5:15}$$

Combining (1.2.5:14) and (1.2.5:15) gives the *Tolman test* of the surface brightness

$$\frac{F/\theta^2}{F_s/\theta_s^2} = \frac{1}{(1+z)^4} \tag{1.2.5:16}$$

where θ^2 and θ_s^2 are the angular areas of the object and the reference, respectively. Equation (1.2.5:16) states that the surface brightness of an object decreases in proportion to $(1+z)^4$ with its redshift.

In later literature the coordinate distance r_C is generally referred to as the comoving distance d_C and distance $r_C/(1+z)$ in equation (1.2.5:14) as the angular diameter distance d_A

$$d_A \equiv d_C/(1+z) \tag{1.2.5:17}$$

As the effective distance in equation (1.2.5:15), the luminosity distance d_L is defined

$$d_L \equiv d_C(1+z) = d_A(1+z)^2 \tag{1.2.5:18}$$

Obviously, using these concepts of angular diameter distance and the luminosity distance, the expressions of angular diameter and the power density of radiation [W/m^2] obtain the classical forms

$$\frac{\theta}{\theta_s} = \frac{d_s}{d_A} \tag{1.2.5:19}$$

and

$$\frac{F}{F_s} = \frac{d_s^2}{d_L^2} \tag{1.2.5:20}$$

In Tolman's derivation of (1.2.5:15) the effect of redshift on the observed power density, the $1/(1+z)^2$ factor comes from two mechanisms:

1. First, from the "evident" reduction of the energy of a quantum of radiation as suggested by the Planck equation as $1/(1+z)$.
2. Second, from the reduction of the arrival rate of quanta to the observer as $1/(1+z)$.

The discussion of the two factors was continued in several papers in 1930's [10-14]. In the DU framework only the second mechanism applies.

The predictions for the power density F in (1.2.5:15), (1.2.5:16) and (1.2.5:20) mean bolometric power free of spectral distortion in observation instruments, atmospheric attenuation, and other sources of disturbances. At Tolman's time the observation instrument was generally a photographic plate and the K-correction used to convert the observed luminosities to bolometric power density came primarily from the spectral correction of the sensitivity of the photographic plates used.

In today's FLRW cosmology the luminosity distance D_L is expressed in terms of redshift, mass density, and dark energy density as [15]

$$\begin{aligned} D_L &= D_A\left(1+z\right)^2 \\ &= R_H\left(1+z\right)\int_0^z \frac{1}{\sqrt{\left(1+z\right)^2\left(1+\Omega_m z\right)-z\left(2+z\right)\Omega_\Lambda}}\,dz \end{aligned} \qquad (1.2.5:21)$$

where D_A is the angular diameter distance, Ω_m is the mass density relative to the Friedman critical mass, Ω_Λ is the relative dark energy density, and R_H is the Hubble radius, related to the Hubble constant H_0 as

$$R_H = \frac{c}{H_0} \qquad (1.2.5:22)$$

The prediction for the magnitude of standard candles in FLRW cosmology is based on luminosity distance D_L in (1.2.5:21). The prediction is applied to K-corrected observations, where the K-correction, in addition to instrumental factors, includes conversion of the observed magnitudes to the "emitter's rest frame" [16].

In today's multichannel photometry it is possible to follow a redshifted spectrum by bandpass filters matched to the wavelength of the maximum intensity in the spectrum. With bolometric detectors and filters with same relative width, such a measurement gives essentially the bolometric power density at all redshifts in the range of the bandpass filters (see Figure 6.3.3-1).

As shown in Section 6.3.4 the presently applied K-correction in multichannel detection with filters matched to the redshifted spectrum results in a z dependent correction that in magnitude units is

$$K\left(z\right)_{z-match} \approx 5\log\left(1+z\right) \qquad (1.2.5:23)$$

which is the correction used for converting the DU prediction for direct bolometric magnitude into a prediction applicable to K-corrected observations.

In the DU perspective, the effect of the redshift on the power density of radiation comes only from the reduced arrival rate of cycle, i.e. the reduced frequency observed. Accordingly, the dilution of the power density due to the redshift is $1/(1+z)$, not $1/(1+z)^2$ as assumed in the FLRW prediction. Another difference between the DU and the FLRW predictions comes from the distance applied in the prediction for observed power density. In the DU equation (1.2.5:10) the distance is the DU optical distance; in the Tolman equation (1.2.5:15), the distance is the co-ordinate distance. The total effect of these differences on the predicted power density in the redshift range ($0 < z < 3$) is such that the observed power density, according to the FLRW prediction, is lower by a factor of $(1+z)^2$ than the power density given by the DU prediction. The FLRW prediction is applied to observations corrected with a *K*-correction, which in bolometric multi-bandpass photometry results in an $(1+z)^2$ reduction in the power densities, which is equal to $5\log(1+z)$ increase in magnitude units (see Sections 6.3.2-6.3.4).

Surface brightness of expanding objects

In DU space, gravitationally bound systems expand in direct proportion to the expansion of space in the direction of the 4-radius. As a result, galaxies and quasars are observed in Euclidean geometry, which means that the diameters decrease in direct proportion to the optical distance. Euclidean appearance means also that the surface brightness of distant objects is reduced by the amount of the redshift only, Section 6.3.6.

The spherically closed space

The spherically closed space in the DU necessitates a major re-evaluation of the cosmological picture of space. DU space is far more ordered than the FLRW space. Space has a well defined overall geometry, and all local systems in space are linked to space as whole.

Space, and the energy of matter did not come into existence in a sudden BigBang but the excitation of the rest energy of matter was build up gradually against release of gravitational energy in a contraction phase preceding the singularity that turned the contraction into the ongoing expansion.

1.3 Experimental

The DU analyses of important experiments are collected into Chapter 7. DU predictions for local and near space phenomena are essentially equal to the corresponding predictions given by the theory of relativity. At the extremes, at cosmological distances and in the vicinity of local singularities in space the DU predictions differ from the predictions relying on the theory of relativity. DU predictions can be generally presented in closed mathematical forms without free parameters — with excellent agreement with observations.

1.3.1 Key elements for predictions

Moving frames and the state of rest

The universal frame of reference in the Dynamic Universe is hypothetical homogeneous space. Any state of motion and gravitation in space can be linked to the state of rest in hypothetical homogeneous space. A local state of rest can be understood via the zero-energy balance of an object or a local frame. A local state of rest is established against a reduction of the locally available rest energy.

There is no need for specific formulas for the composition of velocities in the DU. In general, the Galilean transformation applies. However, we cannot sum up velocities of mass objects and radiation. What can be summed up are the momentums of mass objects and the momentums of radiation.

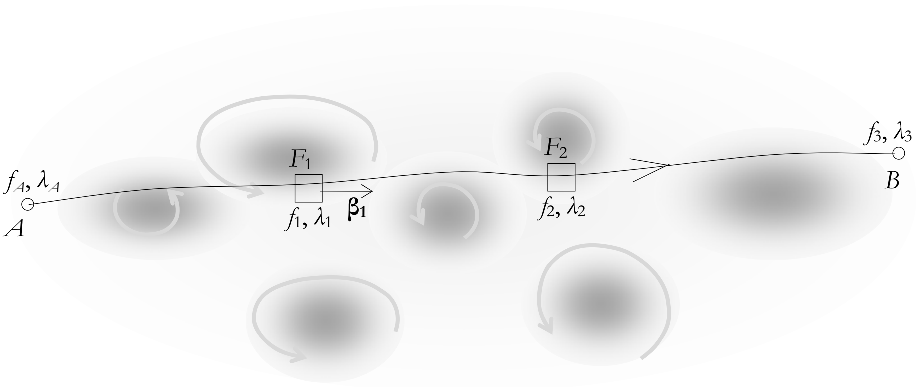


Figure 1.3.1-1. The path of light passing local gravitational systems in space. When detected in a frame F_1 moving at velocity $\beta_1 c$ in the light propagation frame, the observed frequency and the wavelength are Doppler shifted. The phase velocity of the light in the observation frame, as the product of frequency and wavelength, is unchanged but the momentum of the radiation is changed.

When received in a frame moving in the direction of radiation received, due to the Doppler shift, the frequency of the radiation is observed reduced, and the wavelength of the radiation is observed increased. The phase velocity of radiation, however, is observed unchanged, Figure 1.3.1-1. The Doppler shift in the system of nested energy frames is discussed in Section 5.2.3.

The propagation velocity of radiation is determined by the local gravitational environment along the propagation path. The propagation velocity is reduced close to mass centers, which together with the topography of the fourth dimension result in bending of the path.

The propagation of radiation can be studied as propagation in the "root parent frame", the frame in common to the source and the receiver. The propagation time of light from an object to an observer is discussed in Section 5.4.1, Figure 1.3.1-2.

In near space experiments and in satellite communication, the root parent frame for communication between satellites, or between a satellite and an Earth station, is the Earth Centered Inertial frame (ECI-frame), in which the Earth is rotating and satellites are orbiting. Propagation of a radio signal in the ECI frame means that the propagation time is calculated for the distance from the location of the satellite at the time of the signal leaves the transmitter to the location of the receiver at the time the signal is received. Such a calculation includes automatically the so called "Sagnac delay" in satellite communication (Section 7.2.7). Simultaneity in the DU means simply that the events in question occur at the same time.

The historically important experiments by Michelson–Morley and Michelson–Gale as are discussed in Sections 7.2.1 and 7.2.3, respectively.

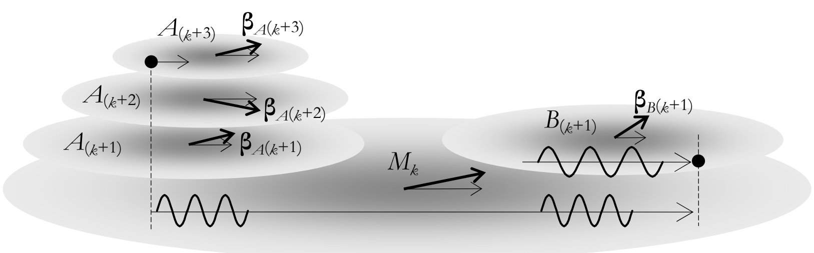


Figure 1.3.1-2. Transmission of electromagnetic radiation from the source at rest in frame $A(k+3)$ to the receiver at rest in frame $B(k+1)$. The motions of frames $A(k+1)$ … $A(k+3)$ result in a change of the wavelength in radiation propagating in the M_k frame.

Experiments with clocks

The prediction (1.2.4:3) for clock frequencies, derived from conservation of total energy

$$f_{(n1,n2)} = f_{0(n1,n2)} \prod_{i=1}^{n} \left(1-\delta_i\right)\sqrt{1-\beta_i^2} \qquad (1.3.1:1)$$

applies to all experiments and observations regarding relativistic effects of clocks. Frequency $f_{0(n1,n2)}$ in (1.3.1:1) is the frequency of the clock at rest in hypothetical homogeneous space. Equation (1.3.1:1) shows the effect of the gravitational state and the velocity of the clock in the local energy frame, and the effects of the gravitational state of the local frame in its parent frames.

Equation (1.3.1:1) is much more than serving a "proper time" equivalence of the relativity theory. It not only makes the laws of nature look the same for a local observer but *shows the law in common to any local observer*. Importantly, equation (1.3.1:1) allows a comparison of clocks in different energy frames. Equation (1.3.1:1) is applicable for all moving clocks in the Earth frame, for satellite clocks as well as for slow transport of clocks on the rotating Earth, Sections 7.2.4 – 7.3.1. Together with the DU predictions for the Doppler effect, and the signal propagation time, equation (1.3.1:1) is also applicable in the analysis of annual variations of the Earth to Moon distance in lunar ranging (Section 7.3.3), and in comparisons of Earth clocks to pulsar frequencies.

Energy conversions, conservation of energy and momentum

The composition of the Planck equation and the uniform expression of the energies of mass objects, Coulomb energy, and the energy of electromagnetic radiation are of major importance in understanding the conservation of energy in local interactions in space. The concept of the mass equivalence of electromagnetic radiation is of crucial importance for understanding the conservation requirements in redshifted radiation.

The introduction of the intrinsic Planck constant opens the perspective to the wave nature of mass and allows the description of mass objects as standing wave structures. Description of the momentum of a mass object in terms of a wave front propagating at the velocity of a moving object opens a new perspective to the wave nature of mass and mass objects (Section 5.6.3).

The overall picture of space as a spherically closed entity, with dynamics determined by a zero-energy balance of motion and gravitation gives new insight to the long term development of space — as it was in the past and as it is expected to be in the future. On the Earth scale, it allows the linkage of paleoanthropological data to the predictions of the development of the orbital parameters of the Earth and Moon in a time scale up to 1 billion years (Section 7.4.2).

1.4 Open questions

The Dynamic Universe theory is primarily an analysis of energy balances in space. It introduces the concept of a fourth dimension closing the three-dimensional space, and the dynamics that describes the development of the zero-energy balance in space — in principle, from infinity in the past to infinity in the future.

The Dynamic Universe shows the complementary nature of the energy of motion and the energy of gravitation, and the complementarity between local and the whole. The complementarity between the local and the whole is characteristic of mass objects; in electromagnetic phenomena complementarity is seen more like local complementarity between positive and negative charges, and between electric and magnetic fields in electromagnetic radiation.

The Dynamic Universe theory, as presented in this book, does not solve or define the ultimate beginning or end of the physical system. Mathematically, the cycle of physical existence and the zero-energy balance extend from infinity in the past to infinity in the future. We cannot exclude the possibility of closing also the fourth dimension, and return to a new contraction and expansion cycle after a finite period of expansion.

The primary energy buildup in Dynamic Universe is described as a process of hypothetical homogeneous space, with motion only in the fourth dimension. There is no answer to what broke the ideal symmetry of homogeneous space to enable the buildup of radiation and material structures in space.

We may think that the turn of the contraction phase of space to the expansion phase did not occur through an ideal single point, but by passing the 4-center at a finite radius, which could convert a certain part of energized mass into electromagnetic radiation in space — turn on the light in space as it were — and trigger the process of nucleosynthesis, Figure 1.4-1. The linkage of the Planck mass and Planck distance to the total mass and the 4-radius of space may be interpreted as a possible turning distance, making the Planck distance a measuring rod for structured material and mass objects in space (Section 5.6.5).

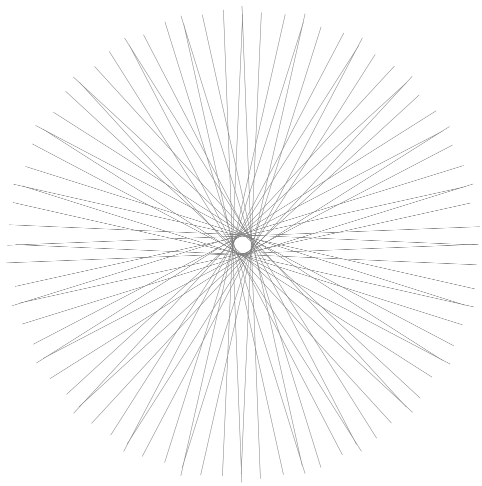


Figure 1.4-1. The turn of the contraction of space to the expansion by passing the singularity point at a finite distance could “turn on the light” in space by converting a share of the energized matter with momentum in the fourth dimension, into electromagnetic radiation with momentum in space.