PHYSICS FOUNDATIONS SOCIETY

THE

DYNAMIC UNIVERSE

TOWARD A UNIFIED PICTURE OF PHYSICAL REALITY

Third edition

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Published by

PHYSICS FOUNDATIONS SOCIETY, Finland

The Physics Foundations Society aims for a deepened understanding of the principles and functions of nature. The Society encourages open-minded, scientifically sound approaches for new perspectives in physics and works for constructive interaction and linkage between individuals, groups, and organizations with the same objectives.

www.physicsfoundations.org

Printed by CreateSpace, USA

ISBN-13: 978-1461027034
ISBN-10: 1461027039

Contents

Preface

The modern view of physical reality is based on the theory of relativity, the related standard cosmology model, and quantum mechanics. The development of these theories was triggered by observations on the velocity and emission/absorption properties of light in late the 19th and early 20th centuries. These theories have attained a high degree of perfection during the last 100 years. When measured with the huge progress in the 20th century, they have been exceedingly successful; not only in increasing our knowledge and understanding of nature but also in bringing the knowledge into practice in technological achievements — in applications ranging from nanostructures to nuclear energy and space travel.

In spite of their major successes, there has also been criticism of the theories since their introduction. The theory of relativity raised lot of confusion not least by redefining the concepts of time and distance, the basic coordinate quantities for human conception. This was quite a shock to the safe and well ordered Newtonian world which had governed scientific thinking for more than two hundred years. Another shock came with the abstraction related to quantum mechanics — particles and waves were interrelated, deterministic preciseness was challenged by probabilities, and continuity was replaced by discrete states. As a consequence, nature was no longer expected to be consistent with human logic; it is not unusual that a lecturer in physics starts his talk by advising the audience not to try to "understand" nature.

In a philosophical sense, neglecting the demand of human comprehension is somewhat alarming, since it is a primary challenge and purpose of a scientific model to make nature understandable. Clearly, it is easier to verify the merits of a scientific theory through its capability of describing and predicting observable phenomena, and that is what the present theories do well in most cases.

As a description of observable physical phenomena a scientific theory is not required to be based on physical assumptions. Ptolemy sky was based on direct description of observations as seen from the Earth. It related the motions of planets to the motion of the Sun across the sky without any physical law, other than continuity, behind the motions. Kepler's laws which still form the basis of celestial mechanics were originally pure mathematical formulations of the observations made by the Danish astronomer Tycho Brahe. Several decades later Newton's law motion and the formulation of gravitational force revealed the physical meaning of Kepler's laws which formed the basis of celestial mechanics for the next centuries.

Newtonian space does not recognize limits 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. Velocities of different observers summed up linearly as described by Galilean transformation. In the theory of relativity the finiteness of velocities is described by linking time to space in four-dimensional spacetime and by postulating the velocity of light to be invariant to all observers. The theory of relativity is a mathematical rather than a physical solution to finiteness of velocities and the transformations between observers in relative motion. In relativistic space, an observer at rest sees a time interval in a moving object approach infinity so that the velocity of light is never exceeded. A clock in a high gravitational field or in fast motion is thought to conserve local proper time but lose coordinate time related to time measured by a clock at rest or in a zero gravitational field.

Newtonian physics, as well as the theory of relativity are local theories. As an alternative approach, the Dynamic Universe provides a holistic perspective to reality. In the DU framework, finiteness of physical quantities results from the finiteness of total energy in space. Space is postulated as a three dimensional structure closed through a fourth dimension. In such a structure, finiteness of velocities in space appears as a consequence of the zero-energy balance of motion and gravitation in whole space. Such a balance does not allow velocities *in* space higher than the velocity *of* space in the fourth dimension. The velocity of space in the fourth dimension – in the direction of the 4-radius of spherically closed space – serves as the reference for all velocities in space. In the DU framework, the velocity of light is not a constant, although it is observed as being constant in most experimental setups. The velocity of light depends on the gravitational environment – and it decreases in the course of the expansion of space. Many physical processes, such as oscillations between energy states in atomic objects are proportional to the local velocity of light, which makes the detection of the actual velocity of light difficult.

Hypothetical homogeneous space, where all mass is uniformly distributed, serves as a universal frame of reference in the Dynamic Universe. Time is absolute and equal everywhere in space. As a consequence of the conservation of total energy in space, the rates of physical processes are dependent of the local gravitational state and the motion of the object studied.

Atomic clocks in fast motion or in a high gravitational field in DU space do not lose time because of slower flow of time but because they use part of their energy for motion and local gravitation in space.

In the DU framework mass has a specific role as wavelike substance for the expression of energy – both in matter and electromagnetic radiation. Localized mass objects in space are described as resonant mass wave structures. In the DU framework, "quantum states" appear as energy minima occurring at resonance states of mass waves describing localized objects – without a need to rely on the specific postulates behind quantum mechanics.

As a basic feature of scientific thinking, the reality behind natural phenomena shall be understood to be independent of the models we use to describe it. The best a scientific model can give is a description that makes the reality understandable. The model should rely on sound basic assumptions and inherently coherent logic, and, specifically in physics and cosmology, give precise predictions to phenomena observed and to be observed.

We can identify three kinds of principles a physical model should be based on:

1. Basic laws of nature, fundamental quantities and natural constants

The identification of the laws of nature is based on experience and recognition of the general "rules" by which nature is found to express itself.

2. Phenomena to be described as consequences of the basic laws

A successful description of a phenomenon generates predictions for observations made or to be made.

3. Coordinate quantities used as measures in describing phenomena

Coordinate quantities, the basic measures, allow quantitative expressions of physical phenomena in a form consistent with human perception.

We are not free to choose the laws of nature but we have considerable freedom in choosing the coordinate quantities. Time and distance are the most fundamental coordinate quantities. For human perception and logic, time and distance should be universal for all physical phenomena described. It is a basic rule in all measurements not to change measures for a phenomenon in different environments or circumstances.

Expression of energy in the Dynamic Universe is complementary. The energy of motion is obtained against release of a potential energy. The released potential energy serves as the negative counterpart of the positive energy of motion resulting in a zero-energy balance. The rest energy of matter is the local expression of energy which is counterbalanced by the global energy of gravitation due to the rest of mass in space.

The Dynamic Universe model is a holistic approach to the universe. The whole is not composed as a sum of elementary units, but multiplicity of elementary units results from diversification of whole. Relativity in the Dynamic Universe means relativity of local to the whole. There are no independent objects in space — everything is linked to the rest of space and thereby to each other.

The zero-energy approach in the Dynamic Universe allows the derivation of local and cosmological predictions with a minimum number of postulates – by honoring universal time and distance as the basic coordinate quantities. The Dynamic Universe offers a unified framework for phenomena currently described in terms of classical physics, electromagnetism, relativistic physics, standard cosmology and quantum mechanics. This unification allows theory structures and the mathematics needed to be greatly simplified.

The origin of the Dynamic Universe concept lies in the continuing interest I have had in the basic laws of nature and the human conception of reality since my student time in the 1960s. I can recognize my friend and former colleague Heikki Kanerva as an important early inspirer in the thinking that paved the way for the Dynamic Universe theory. After many years of maturing, the active development of the theory was triggered by stimulus from my late colleague Jaakko Kajamaa in the early 1990s. I express my sincere gratitude to my early inspirers.

The breakthrough in the development of the Dynamic Universe concept occurred in 1995 once I replaced the time-like fourth dimension with a fourth dimension of a metric nature – thereby revealing the physical meaning of the quantity mc, the rest momentum, the momentum of mass m in a fourth dimension orthogonal to the three space directions. Momentum and the related energy of motion against the energy of gravitation in spherically closed space showed the dynamics of space as that of a spherical pendulum in the fourth dimension — showing the buildup and release of the rest energy of matter as a continuous process in a contraction and expansion period of the structure. Mass can be understood as a wavelike substance for the expression of energy. The rest energy of matter becomes balanced with the global gravitational energy due to all mass in space. By assuming conservation of the total energy in interactions in space, the overall energy structure of space appears as a system of nested energy frames, proceeding from large scale gravitational structures down to atoms and elementary particles. In the DU perspective, the Planck equation is seen consistent with Maxwell's equations, thereby revealing the nature of a quantum as the energy emitted into a cycle of electromagnetic radiation by a single electron transition in the emitter.

The development of the Dynamic Universe model has been documented in annually updated monographs titled *"The Dynamic Universe"* in 1996-99, *"The Dynamic Universe, A New Perspective on Space and Relativity"* in 2000-2003, *"Theoretical Bases of the Dynamic Universe"* in 2004, and *"The Dynamic Universe, Toward a Unified Picture of Physical Reality",* editions 1 and 2 in 2009-2010. The first peer reviewed papers on the Dynamic Universe were published in Apeiron in 2001. Since 2004 my main channel for scientific discussions and publications has been the PIRT (Physical Interpretations of Relativity Theory) conference, biannually organized in London and occasionally in Moscow, Calcutta and Budapest. I would like to express my respect to the organizers of PIRT for keeping up critical discussion on the basis of physics, and pass my sincere gratitude to Michael Duffy, Peter Rowlands, and many conference participants. At the national level, The Finnish Society for Natural Philosophy has organized seminars and lectures on the Dynamic Universe concept. I express my gratitude to the Society and many members of the Society for the encouragement and inspiring discussions. I am exceedingly grateful to the co-founders of the Physics Foundations Society, Ari Lehto, Heikki Sipilä, and Tarja Kallio-Tamminen for their initiatives in promoting the search for the fundamentals of physics and the essence of the philosophy of science, and for providing a forum for insightful discussions on the Dynamic Universe theory. I

also like to express my sincere thanks to Bob Day for his activity in finding and analyzing experimental data for testing DU predictions and for polishing my English language. My many good friends and colleagues are thanked for their encouragement during the years of my treatise. The unfailing support of my wife Soilikki and my daughter Silja and her family has been of special importance and I am deeply grateful to them.

In this book, the Dynamic Universe theory is presented in 8 Chapters. The introduction in Chapter 1 gives an overview of the theory with comparisons to prevailing theories. The Dynamic Universe theory is presented in detail in Chapters 2 to 6, beginning with postulates and definitions, proceeding to predictions, and gradually, to the picture of reality opened by the Dynamic Universe. Chapter 7 demonstrates the use of DU predictions in explaining observations and experiments. Chapter 8 summarizes the results.

The presentation of the Dynamic Universe theory in this book unifies the terms and notations taken into use in the course of the development of the Dynamic Universe theory. The choice of the terms used is an attempt to maintain consistency with the traditional meaning of the each term. For example, energy in the DU framework is presented as a complex quantity; the absolute value of the complex energy is equal to the corresponding traditional notation of energy.

1. Introduction

1.1 From the local to a holistic perspective

1.1.1 From Newtonian space to Einsteinian space

In antiquity, the center of the universe was unequivocally the Earth, surrounded by skies inhabiting the sun, planets and stars. After the scientific revolution trigged by the works of Copernicus, Kepler, Galilei and Newton the center of the universe was moved to the sun, but physics remained built on an observer centered space where anyone in linear motion could consider his state as the state of rest. The Newtonian world was based on absolute time and distance as coordinate quantities. Space was infinite and Euclidean, and velocities grew linearly as long as there was constant force acting on an object.

Newtonian physics is local by its nature. No local frame is in a special position in space, although Newton assumed the existence of a center of space (The Principia, Book 3 [1]). Velocities between observers in Newtonian space are summed up linearly and Galilean relativity applies between observers anywhere in space.

The success of Newtonian physics led to a well-ordered mechanistic picture of physical reality. The neat Newtonian picture dominated until the development of the theories of electromagnetism and experiments on accelerated electrons and the velocity of light in 19th century. Maxwell's equations suggested constant velocity of electromagnetic radiation, which in Newtonian space requires an assumption of the presence of absolute world ether. All experiments carried out for finding such world ether failed thus creating an urgent need for reconsideration of the theoretical basis.

According to the electromagnetic theory presented by James Clerk Maxwell in 1865, electromagnetic radiation, including light, propagates in a medium independent of the motion of the source or the receiver [2]. Orthodox Maxwellian world-ether meant strict conflict with Newtonian – Galilean frames of reference, which allowed the local definition of a state of rest for any observer in linear motion. A kind of compromise between world ether and local luminiferous ether had been successfully studied by Francois Arago and Augustin-Jean Fresnel in the early 1800's in experiments on light propagation in optically dense media like glass and water. An important result of the study was Fresnel's frame dragging formula, which predicted partial frame dragging by optically dense (with refractive index $n > 1$) moving media. Fresnel's frame dragging coefficient was confirmed experimentally by Hippolyte Fizeau in his experiments on the effect of moving water on the velocity of light in 1851. Fresnel's frame dragging did not, however, predict frame dragging of "observer's frames" where the refractive index of the light propagation medium is equal to one ($n = 1$).

Maxwell's theory of electromagnetic waves was widely accepted after Heinrich Hertz's experiments in 1886-88. Hertz shared George Stokes' idea (1845) of local ether adhered to moving matter. Anyway, Hertz's experiments trigged an active search for the Maxwellian world-ether and a search for determining our velocity with respect the ether. The most famous of these experiments was the Michelson–Morley experiment (1889) that was interpreted as confirming the local ether hypothesis. The local ether interpretation led to intensive mathematical efforts for finding a satisfactory explanation for the transformation from one ether domain to another by conserving the validity of Maxwell's equations, and the related constancy of the velocity of light. Such a transformation led to modification of the Galilean transformation for the location of a moving system, and to abandoning of the Newtonian absolute coordinate quantities, time and distance. Consequently, time and distance became functions of the relative velocity between the observer and the object.

The transformation, proposed by Woldemar Voigt in 1887, left the wave equation unchanged by applying the Galilean transformation $x' = x - vt$ in the direction of the relative velocity v of a moving frame, the factor $1\big/\sqrt{1-(v/c)^2}$ for y- and z-coordinates perpendicular to velocity v, and factor $1\big/\left[1-(v/c)^2\right]$ for *local time* in the frame moving at velocity v relative to the observer.

In the ether theory of Hendrik Lorentz in 1892–1895, ether was assumed staying at absolute rest, and the speed of light was assumed to be constant in all directions. In Lorentz ether theory, the coordinate transformations were – independent of Voigt's work – equal to Voigt transformations multiplied by factor $1\big/\sqrt{1-(v/c)^2}$. In his later works in 1899 – 1904 Lorentz, following the conclusions by Larmor, concluded that the dilated time in the moving frame is also valid to physical processes like oscillating electrons [3]. The concept of local time was strengthened by Henri Poincaré, who extended the concept of time dilation to synchronization of clocks. Henri Poincaré completed the concepts of the constancy of the velocity of light, the relativity principle and the relativity of simultaneity, and finalized the form of Lorentz transformation [4-6].

Special relativity

The introduction of the special theory of relativity by Albert Einstein in his publication of September 26, 1905 [7,8] may be seen as a successful synthesis of the analyses and conclusions drawn from the efforts of matching observations between inertial frames in relative motion in such a way that Maxwell's equations remain untouched. In special relativity, the constancy of the velocity of light, concluded from Maxwell's equations, got the status of a primary postulate, and the principle of relativity and the Lorentz transformation obtained the status of the laws of nature. Einstein's formulation of the Lorentz transformation implied interpretation of time dilation and length contraction as observer related effects. In his formulation, all relative velocities were limited to the velocity of light, also in the case of the addition of velocities. As an important encouragement to Einstein, the formula for the addition of velocities produced Fresnel's frame dragging formula when applied to low velocities of optically dense media in Fresnel's equation.

Further, Einstein generalized the concept of electromagnetic mass, $m = E/c^2$, developed by several physicist, like Joseph John Thomson, George FitzGerald, Oliver Heaviside, George Searle, Walter Kaufman [9], Wilhelm Wien, Max Abraham, and Henri Poincaré. The generalization established the concepts of rest mass and rest energy, and linked the concept of rest energy to kinetic energy as

$$E_{kin} = E_{tot} - E_{rest} = \frac{mc^2}{\sqrt{1-\beta^2}} - mc^2 = \left(m_{rel} - m\right)c^2 = \Delta m\, c^2 \qquad (1.1.3:1)$$

where $\beta = v/c$, and m_{rel} is *the relativistic mass* increased by the motion. The concept of relativistic mass appears as a postulate in special relativity, justified by the observed mass increase of accelerated electrons, first demonstrated by Joseph John Thompson in 1881.

The special theory of relativity does not deal with the overall structure of space; it is a local theory describing phenomena between an object and a local observer in the absence of gravitational interactions. As in Newtonian space, any inertial observer in SR space may consider his state as the state of rest.

General relativity

Extension of special relativity to gravitational interactions combines Newtonian gravitation with the velocity dependent mass and acceleration of special relativity. Such an approach relies on the equivalence principle that allows acceleration in free fall to be expressed in terms of velocity dependent time and distance in a four-dimensional space-time manifold. In general relativity (GR), gravitational force and acceleration are seen as consequences of space-time geometry, which is determined by mass distribution in space [10].

The theory of general relativity extends the relativistic effects of velocity in special relativity to relativistic effects of the curvature of spacetime due to mass distribution. In the case of a local mass center in space, it means that at a fixed distance from the mass center local time and distance are modified in the same way as they would be modified by the hypothetical velocity obtained in free fall from infinity to the specified distance from the mass center. An analysis of GR space in the vicinity of a local mass center is known as the Schwarzschild solution, presented by Karl Schwarzschild in 1915 [11], just a month after Einstein's first paper on general relativity. Schwarzschild's solution can be seen as a relativistic correction to Newtonian gravitation – in the same way as special relativity is a correction to the Newtonian equations of motion. Schwarzschild's solution allows the derivation of important predictions used for tests of general relativity –such as the bending of light path close to a mass center, the perihelion advance of planet Mercury, and the gravitational blueshift.

Einstein's original view of the cosmological appearance of GR space was that of a Riemannian 4-sphere, a three-dimensional "surface" of a four-dimensional sphere [12]. Following the generally adopted conception at his time, Einstein assumed that space as whole is static. In order to prevent the collapse of spherically closed space, Einstein added the famous cosmological constant to the field equations of general relativity.

Thorough mathematical analyses of the cosmological aspects of the GR field equations were triggered by the work of Russian mathematician Alexander Friedman in 1922–1924 and independently, by the work of Georges Lemaître in 1927 [13]. Lemaître saw the possibility of expanding space and derived a prediction of a linear relationship between the distance and the observed redshift from distant objects – confirmed two years later by Edwin Hubble. Lemaître's prediction became known as the Hubble law. Lemaître's work can be seen as the basis for the Standard Model of relativistic cosmology or the "Big Bang" model.

Relativistic cosmology

The standard model of modern cosmology is based on the Friedman–Lemaître–Robertson–Walker (FLRW) metric, which is a refined form of the works of Friedman and Lemaître. The FLRW metric is derived for homogeneous space. The expansion of relativistic space is explained as occurring via the "Hubble flow" in empty space between local systems like galaxies and quasars, which are assumed to conserve their dimensions in the course of expansion. This means that the gravitational energy of local systems is conserved, but on the cosmological scale, space looses gravitational energy due to the expansion. Predictions for cosmological observables like the dependence of observed angular size on the redshift, and the magnitude/redshift relationship were formulated by several scientists in 1930's. The derivation involved combining the redshift and the dilution of the power density of radiation in accordance with the theory of general relativity and the Planck equation.

In its present form, the Big Bang model describes the general evolution of the universe since the birth of the universe that is estimated to have occurred around 13.7 billion years ago. An essential part of the Big Bang theory deals with the period of the first minutes of expansion, which is assumed to have produced atomic nuclei in a nucleosynthesis process fed by protons and neutrons formed from quark-gluon plasma after a short inflationary expansion epoch.

1.1.2 The holistic perspective

Space as a spherically closed entity

The Dynamic Universe is a holistic approach to physical reality. In the DU, space is studied as a closed energy system; a spherical three-dimensional Riemann "surface", i.e. the three-dimensional "surface" of a four-dimensional sphere, which is basically the structure Einstein first proposed as the cosmological appearance of relativistic space in 1917 [12].

Einstein was looking for a static solution — it was just to prevent the collapse of spherically closed space that made Einstein to add the famous cosmological constant to the theory. Einstein abandoned the concept of the cosmological constant about 10 years later, when Hubble's observations on redshift confirmed the predictions on expanding space presented by Lemaître in 1927 [13]. Accepting spherically closed non-static space had led Einstein close to the Dynamic Universe in his 1917 reasoning. However, a problem had arisen from the nature of the fourth dimension that appears in the direction of the 4-radius of spherically closed space. General relativity assumed a temporal fourth dimension, but an orthodox Riemann sphere assumes a fourth dimension of a metric nature, which allows contraction and expansion of the sphere, i.e. the dynamics of spherically closed space as spherically a symmetric pendulum in the fourth dimension.

For calculating the overall energy balance and the dynamics of spherically closed space, the initial condition is characterized as "hypothetical homogeneous space" where all mass is uniformly distributed in a spherically closed volume. In a contraction phase, the energy of motion is gained against release of gravitational energy. In an expansion phase the energy of motion is paid back to gravitation. In the contraction, space loses volume but gains motion; in the expansion phase space loses motion and gains back volume, Figure 1.1.2-1

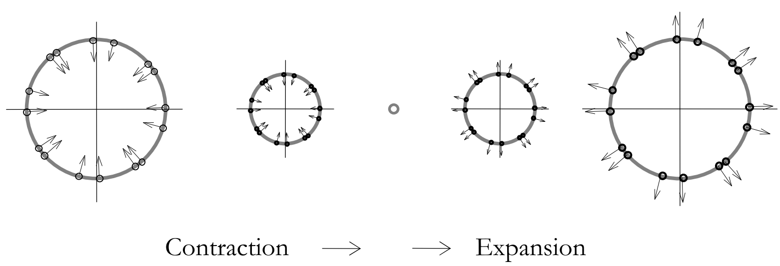


Figure 1.1.2-1. Energy buildup and release in spherical space. In the contraction phase, the velocity of motion increases due to the energy gained from the release of gravitational energy. In the expansion phase, the velocity of motion gradually decreases, while the energy of motion gained in contraction is returned to the energy of gravitation.

The contraction–expansion of space as the surface of a 4-sphere is regarded as the primary energy buildup in space. The energy of motion due to the motion of space in the direction of the 4-radius of the structure is observed as the rest energy of matter. Mass in the DU is not a form of energy but the substance for the expression of energy. The rest energy of matter is not a property of mass but the energy of motion mass possesses due to the motion of space in the fourth dimension.

DU space, the 3-dimentional surface of a four-dimensional sphere has its center in the fourth dimension, in the center of the Riemannian 4-sphere. DU space has finite volume. The total mass in space is the primary conservable in DU space. Hypothetical homogeneous space, with all mass uniformly distributed in the volume, serves as the universal frame of reference to all local frames in space. In the DU, time and distance are universal coordinate quantities.

Buildup of localized mass objects like elementary particles, atoms and macroscopic mass centers in space is assumed to occur by conserving the total energy and the zero-energy balance of motion and gravitation. As a consequence, the velocity of light is determined by the velocity of space in the fourth dimension. As a further consequence, the velocity of light decreases in the course of the expansion, and locally the velocity of light is reduced in the vicinity of local mass centers.

The zero-energy balance of motion and gravitation is seen as a conspiracy of the laws of nature: Local energy frames are linked to their parent frames through a system of nested energy frames with hypothetical homogeneous space as the ultimate frame of reference. The rates of physical processes, for example the ticking frequencies of clocks, are determined by the energy states of the clocks, and the velocity of light is observed as constant in in most experimental setups in space.

The Dynamic Universe follows bookkeeper's logic: In order to obtain energy of motion there must be equal amount of potential energy released. Such a balance occurs in whole space as well as in buildup of local energy structures in space. In general, a debt is paid to the borrower.

The velocity of light is determined by the velocity of space in the fourth dimension. The velocity of light is not constant although it is observed as being constant in most experimental situations. The velocity of light slows down with the expansion of space at the present rate of about $\Delta c/c = 3.6\cdot 10^{-11}$ /year – the frequencies of atomic clocks are directly proportional to the velocity of light, which makes the change undetectable.

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 predict dark energy or accelerating expansion of space, but produces parameter-free predictions to cosmological observables – in an excellent agreement with observations. The Dynamic Universe does not rely on postulated energy quanta, wave function or Schrödinger equation, but allows a wave description of localized energy objects as resonant mass wave structures.

Predictions for local phenomena in DU space are essentially the same as the corresponding predictions given by the special and general theories of relativity and quantum mechanics. At the extremes — at cosmological distances and in the vicinity of local singularities in space, differences from the predictions of general relativity and the Friedman-Lemaitre-Robertson-Walker cosmology become meaningful. The DU predictions for cosmological observables can be derived in closed mathematical forms without experimental parameters – with excellent agreement with observations. There is no dark energy in DU space – space expands with a decelerating rate, maintaining the zero-energy balance of motion and gravitation.

Reinterpretation of the Planck equation

The Planck equation originates from the need for solving the wavelength spectrum of blackbody radiation. In about 1900, Max Planck realized that the atoms emitting and absorbing radiation at the walls of a blackbody cavity could be considered as harmonic oscillators able to interact with radiation at the resonant frequency of the oscillator only [14]. As an intuitive view, he proposed, that the energy, which each oscillator emits or absorbs in a single emission/absorption process is proportional to the frequency of the oscillator. He described the energy of such a single interaction with the equation $E = hf$, where h is a constant. The interpretation of the equation was that electromagnetic radiation is emitted or absorbed only in energy quanta proportional to the frequency of the radiation. Planck saw this as contradicting the classical electromagnetism as expressed by Maxwell's equations.

However, once we solve Maxwell's equations for the energy of one cycle of radiation, like the emission from a dipole, we find that the energy injected into a cycle of radiation is proportional to the frequency - just as proposed by Planck's heuristic equation.

In order to find the solution we have to relate the dipole length to the wavelength emitted, and we have to apply vacuum permeability, μ_0, instead of vacuum permittivity, ε_0, as the vacuum electric constant. The solution combines the dipole characteristics (number of oscillating electrons, dipole length/emitted wavelength, radiation geometry) with the Planck constant and the frequency of the radiated electromagnetic wave. It also reveals the Planck constant in terms of fundamental electromagnetic constants, the unit charge e, the vacuum permeability μ_0 – and the velocity of light, which appear as a hidden factors in the Planck constant.

Removal of c from the Planck constant h reveals "the intrinsic Planck constant" $h_0 = h/c$, *with dimensions [kg·m], thus converting the Planck equation into the form* $E = h_0 fc = h_0/\lambda \cdot c^2$, *where, in the latter form, the dimension of the factor* h_0/λ *is that of mass [kg]. The rewritten Planck equation is formally identical with the equation for the rest energy of matter!*

The concept of mass as a wavelike substance for the expression of energy is a fundamental finding for the unified picture of physical reality in the Dynamic Universe.

The inherent form of the energy of motion, defined in hypothetical homogeneous space, is

$$E_m = c_0 \left|\mathbf{p}\right| \tag{1.1.2:1}$$

The rest energy of mass at rest in homogeneous space is the energy of motion due to the expansion of space in the direction of the 4-radius

$$E_m = c_0 \left|\mathbf{p}_4\right| = mc_0^2 = \frac{h_0}{\lambda_m} c_0^2 \tag{1.1.2:2}$$

where λ_m is equal to the Compton wavelength of mass *m*.

The energy carried by an elemental cycle of electromagnetic radiation propagating in hypothetical homogeneous is

$$E_{rad(0)} = c_0 \left|\mathbf{p}_{rad}\right| = \frac{h_0}{\lambda_m} c_0^2 = m_\lambda c_0^2 \tag{1.1.2:3}$$

where m_λ is referred to as the mass equivalence of the cycle of radiation (a quantum of radiation).

Local structures in space

Conservation of the overall zero-energy balance of motion and gravitation in mass center buildup in space requires local tilting of space. As a consequence of the tilting, the velocity of space in the local fourth dimension, and the local velocity of light in tilted space are reduced (see Figure 1.1.2-1)

$$c = c_0 \cos\varphi \tag{1.1.2:4}$$

Mass center buildup occurs in several steps which leads to a system of nested gravitational frames characterized by a dent in space and a reduction of the velocity of light.

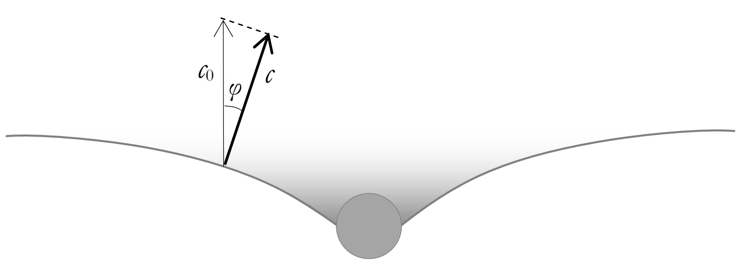


Figure 1.1.2-1. Buildup of a mass center in space results in a local dent in the fourth dimension. The local velocity of light, which is determined by the velocity of space in the local fourth dimension, is reduced. The figure illustrates a dent in hypothetical homogeneous space, where the velocity of light is c_0.

Energy-momentum four-vector

In a local study, motion of space in the fourth dimension creates momentum $\mathbf{p}_4 = m\,\mathbf{c}_4$, which is referred to as the rest momentum of mass m

$$\mathbf{p}_4 = m\mathbf{c}_4 = m\mathbf{c} = \mathbf{p}_{rest} \tag{1.1.2:5}$$

where $\mathbf{c}_4$ is the velocity of space in the local fourth dimension.

The Dynamic Universe favors a complex presentation of energy and momentum. The energy of motion in the DU can be written as

$$E_m^{¤} = c_0 p^{¤} = c_0\left(p + \mathrm{i}\,p''\right) \tag{1.1.2:6}$$

where p is the momentum in a selected space direction and p'' is the momentum in the local fourth dimension. Superscript "¤" is used as a notation for a complex function. Obviously, the total energy of motion is the modulus of the complex function

$$E_m = \mathrm{Mod}\left\{E^{¤}\right\} = c_0\sqrt{p''^2 + p^2} = c_0\sqrt{\left(mc\right)^2 + p^2} \tag{1.1.2:7}$$

In the DU framework the kinetic energy obtains the form

$$E_{kin} = \Delta E_{tot} = c_0 \Delta\left|\mathbf{p}\right| = c_0 \Delta\left(mc\right) = c_0\left(m\,\Delta c + c\,\Delta m\right) \tag{1.1.2:8}$$

An important message of equation (1.1.2:8) is that the kinetic energy in free fall in gravitational field is obtained against reduction of the local velocity of light by Δc, due to local tilting of space, and kinetic energy via acceleration at constant gravitational potential is obtained by insert of excess mass Δm.

The relativistic mass is not a consequence of velocity but the mass contribution needed for obtaining velocity.

Kinetic energy obtained in free fall is obtained against release of global gravitational energy via tilting of space. Kinetic energy in free fall is not associated with increase of mass as it is in the case of acceleration at constant gravitational potential. Gravitational mass is not equivalent to relativistic inertial mass as postulated in the general theory of relativity.

Celestial mechanics derived from the DU assumptions shows same perihelion advance as the corresponding prediction in general relativity. As a major difference to general relativity, orbits in the vicinity of local singularities – black holes – in DU space are stable down to the critical radius. Slow orbits close to the critical radius maintain the mass of the singularity.

The rest energy of a mass object is reduced in the vicinity mass centers in space due to the reduced velocity of light. As a part of the overall energy balance, the rest energy is also affected by motion due to a contribution of rest mass to the momentum of a moving object in DU space, Figure 1.1.2-2.

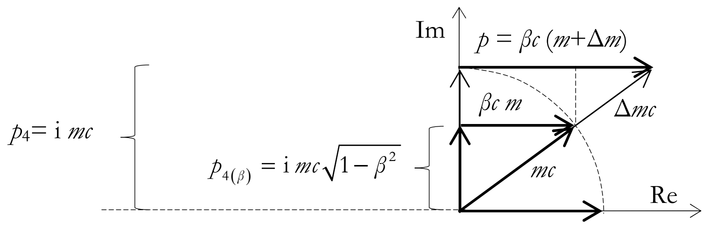


Figure 1.1.2-2. The momentum of an object moving in space at velocity βc consists of the contribution by momentum p_4 that the object has at rest in the fourth dimension (βcm) and the additional contribution due to mass Δm needed to obtain velocity βm. As the result, the rest momentum available in the moving object, $p_{4(\beta)}$ is reduced.

The reduction of the rest energy available for an object in motion, in the frame of the moving object, is responsible for the reduction in the rate of physical processes like the ticking frequencies of atomic clocks in a moving frame. The reduction of the rest energy is also the price paid for the status of a local state of rest in the moving frame.

The Dynamic Universe is an analysis of energy balances of material structures and radiation in spherically closed space.

What is described in terms of distorted metrics in the theory of relativity, appears as the effect of local motion and gravitation on the locally available rest energy in Dynamic Universe.

Clocks in motion or in the vicinity of mass centers in space do not lose time because of slower flow of time, but because part of their energy is bound into motion and local gravitation in space.

What is described in terms of a wave function or a probability wave in quantum mechanics, appears as a resonant mass wave structure in the Dynamic Universe.

The overall zero-energy balance in space leads to a system of nested energy frames with hypothetical homogeneous space as the universal frame of reference. Any local energy state can be related to the state of rest in hypothetical homogeneous space.

Any elementary unit in the Dynamic Universe is related to the rest of space: The whole is not composed of multitude of elementary units but the multitude of elementary units is seen as a result of diversification of the whole.

The Dynamic Universe shows the development of the universe from emptiness in the past – via singularity – to emptiness in the future. The ongoing expansion continues with a decelerating rate, with the diminishing energies of motion and gravitation in balance.

1.1.3 Hierarchy of physical quantities and theory structures

The postulates

Due to the empirically driven evolution in its different areas, and the lack of a holistic metaphysical basis, the development of contemporary physics has led to diversification, with specific postulates in different areas. The postulates behind relativity theory and quantum mechanics are listed in the corresponding boxes in Figure 1.1.3-1. As illustrated in the figure, for example, the Klein-Gordon equation in the quantum mechanic's box rely on special relativity, while the Schrödinger equation is based on Newton's mechanics.

The main postulates in the Dynamic Universe are the spherically closed space, the zero-energy balance of motion and gravitation, and the use of time and distance as universal coordinate quantities. The DU postulates are defined at the base level, and they apply as such in all areas of physics and cosmology.

The force based perspective

Figure 1.1.3-1 compares the hierarchy of some key quantities and theory structures in contemporary physics and in the Dynamic Universe.

Contemporary physics, as it is today, can be seen as the result of experimentally driven evolutionary development of our understanding of the observable physical reality. The turn from metaphysical conception to systematic scientific progress can be attributed to Isaac Newton who, in the late 1600's, defined the concepts of mass and force and established the mathematical expressions for the primary interactions of gravitation and motion. Implicitly, Newton's equations define time and distance as coordinate quantities common to all events in space. Newton's second law can be seen hiding an assumption of infinite Euclidean space; according to the second law, the velocity of an object increases linearly, without limits, as long as there is constant force acting on an object. Newtonian physics is local by its nature; there is no frame of reference in common to the local frames.

Over time, mismatches began to develop between theory and observations. The relativity was needed to add effects of finiteness to unlimited Newtonian space and to match the contradictions seen in electromagnetism between local frames in relative motion. Finiteness was introduced via modified metrics, which replaced the Newtonian universal coordinate quantities by the concept of spacetime. Like Newtonian physics, relativistic physics is local by its nature. Newtonian empty space is replaced by a continuous field. Energy differences are calculated by integrating the force field.

The ultimate goal of the field concept is a unified field theory combining the four fundamental forces – strong interaction, electromagnetic interaction, weak interaction, and gravitational interaction – identified in contemporary physics.

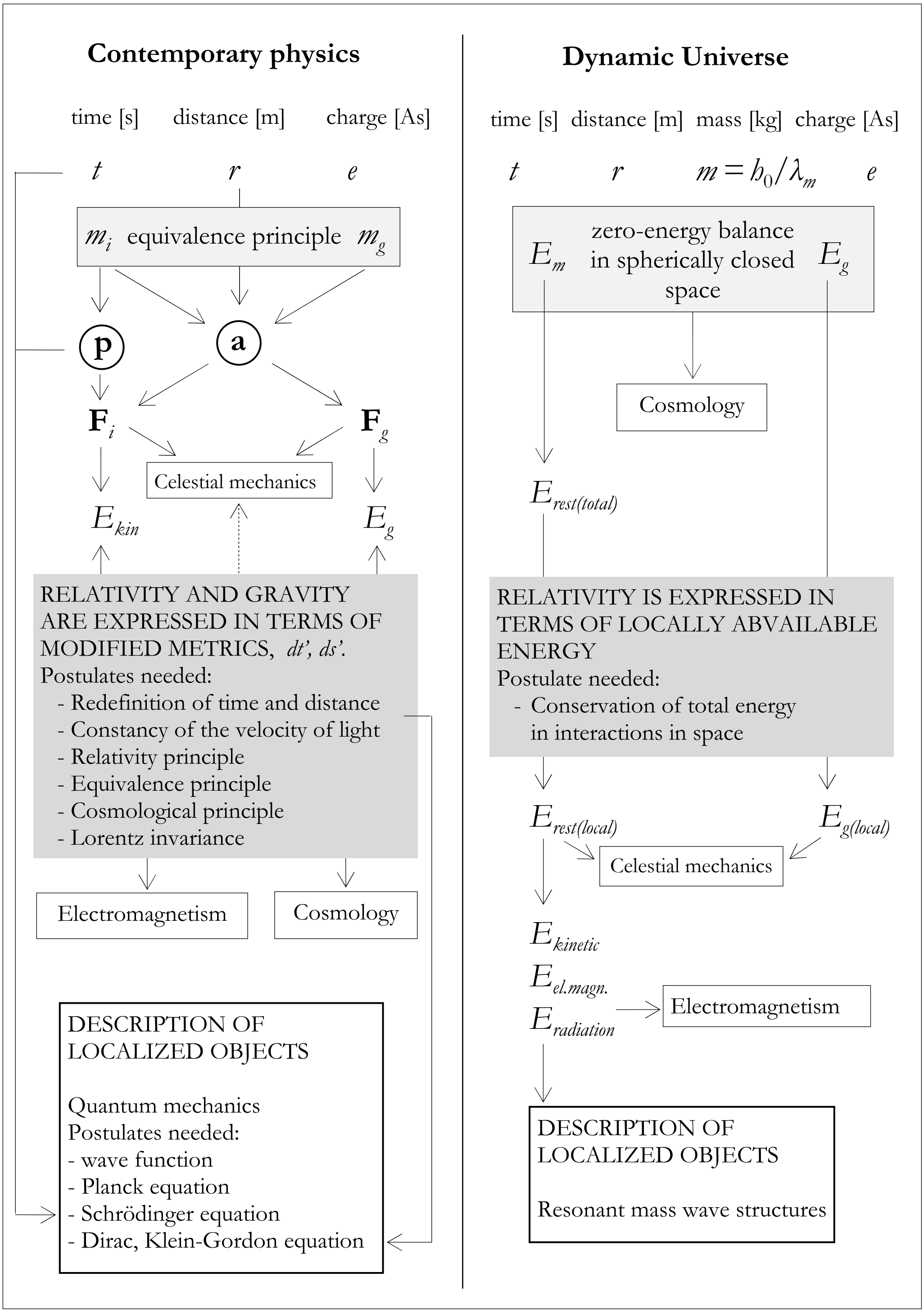


Figure 1.1.3-1. Hierarchy of some central physical quantities and theory structures in contemporary physics and in the Dynamic Universe.

The energy based perspective

In the DU, the hierarchy of force and energy is opposite to that in contemporary physics. Energy is a primary quantity. Force in the DU is defined as the gradient of energy, which shows a tendency toward minimum energy in an energy system.

Force is local and immediate; it simply means detection of the local energy gradient.

In the Dynamic Universe, whole space is studied as an energy system. The base forms of energy, the energy of motion and the energy of gravitation are defined in "idealized" conditions – in hypothetical homogeneous space, which serves as the universal frame reference in the DU.

DU space is characterized as a zero-energy continuum with the energies of motion and structures in balance.

The zero-energy condition in space appears as the excitation of the energy of motion against its complementary counterpart, the energy of gravitation. Such an excitation occurs via the dynamics of whole space as a spherically closed entity. The buildup of structures within space is studied by conserving the overall zero-energy balance in space. Such an approach leads to a system of nested energy frames, and relativity appears as a consequence of the conservation of the total energy is the system.

Starting from energy, instead of force, is essential for the holistic approach in the Dynamic Universe. The energy due to the motion of space in the fourth dimension, in the direction of the 4-radius of spherically closed space, is observed as the rest energy of matter. It serves as the source of energy for all local structures and expressions of energy. The buildup of elementary particles and mass centers in space means that certain part of the momentum in the fourth dimension is turned toward space directions. As a consequence, the rest energy available in local structures becomes a function of the local gravitational environment and the local motion in space. The reduced rest energy reduces the rate of physical processes, for example, the characteristic emission and absorption frequencies of atomic objects appear as functions of the gravitational state and motion of the object.

Relativity in the DU is expressed in terms of locally available energy. Relativity does not need additional postulates; it is a direct consequence of the conservation of total energy in space, and an indivisible part of the overall energy balance in space. Relativity in the DU means relativity between the local and the whole. Any local state is related, via a system of nested energy frames, to the state of rest in hypothetical homogeneous space, which serves as the universal frame of reference.

All local expressions of energy, like kinetic energy, Coulomb energy, and the energy of electromagnetic radiation are derivatives of the local rest energy. The energy of a quantum of radiation is derived from Maxwell's equations as the energy injected into a cycle of electromagnetic radiation by a single electron transition in a dipole. All localized mass objects in space can be described as resonant mass wave structures. Mass itself appears as a wavelike substance for the expression of energy.

Base units and quantities

Space and time are basic attributes for human conception. The concept and nature of time has been under philosophical deliberation since the Greek philosophers, and even before in the eastern cultures. As a rational choice, Newton assumed absolute time and space for defining physical quantities like velocity, momentum and acceleration. In Newtonian physics, absolute time and distance are measures in infinite Euclidean space. Newton's space does not have a defined center or a fixed reference to distances. An object is considered as staying at rest or in uniform motion if there is no net force acting on it.

The theory of relativity meant a radical redefining of the concepts of time and distance. In order to explain the properties of electromagnetic radiation and the observations between observers in relative motion, time and distance were postulated to be functions of velocity in the special theory of relativity. In the next step, to extend the concept of special relativity to motion due to gravitation, time and distance became functions of the mass distribution in the four-dimensional space-time manifold.

Time and distance are basic quantities for human conception and orientation. Human conception relies on the ideas of definite time and distance – in the Dynamic Universe framework time and distance are referred to as coordinate quantities and are the same for all observers, at any location at any moment. The rates of physical events and processes as well as the dimensions of physical structures, however, are dependent on their energetic environment in space.

1.1.4 Dynamic Universe and contemporary physics

In spite of the very different theory structures and postulates, predictions for most local observables in the DU and in contemporary physics are essentially the same. The cosmological appearance of space in the DU is quite different from that in standard Big Bang cosmology. In the DU, there is no instant start of physical existence or a "turn on" of the laws of nature. The laws of nature and the substance for the expression of energy are understood as eternal qualities. The buildup and release of the rest energy needed for the expression of physical existence and all material structures in space appears as a continuous process from infinity in the past to infinity in the future. Space is characterized as a zero-energy continuum with the energies of motion and structures in balance.

The picture of "quantum reality" in the DU is a direct derivative of the properties of mass as a wavelike substance – and the linkage of mass waves and electromagnetic radiation. A quantum of radiation in the DU is the energy injected into a cycle of electromagnetic radiation by a single oscillation cycle of a unit charge in a dipole. A point emitter, such as an atom, can be regarded as a one-wavelength dipole in the fourth dimension.

Localized mass objects are described as resonant mass wave structures in the DU. In spherically closed space, locally closed structures enclosing the momentum of a mass wave, can be described as mass wave with momentum in the fourth dimension. There are no point-like particles in the DU. The wave description of localized objects in the DU does not rely on the Schrödinger equation or the wave function.

Table 1.1.4-I summarizes some basic properties of special relativity, general relativity, FLRW cosmology, quantum mechanics – and the Dynamic Universe.

	Contemporary physics	**The Dynamic Universe**
Birth of the universe	Big Bang turning on time and the laws of nature and producing the energy for physical existence.	Buildup of the rest energy of matter in a contraction phase before singularity of spherically closed space.
Equality of the total gravitational energy and total rest energy in space	Coincidence	Expression of the overall zero-energy balance of motion and gravitation in space.
The velocity of light	Postulated to be the same (constant) for any observer.	Determined by the velocity of space in the fourth dimension.
Rest energy of matter	Property of mass.	The energy of motion mass possesses due to the velocity of space in the fourth dimension.
Geometry of space	Undefined as a whole. Defined locally by spacetime metrics as an attribute of mass distribution in space.	Space is described as the 3-surface of a 4-sphere. Mass centers in space result in local dents in the fourth dimension.
Relativity	Consequence of spacetime metrics.	Consequence of the conservation of total energy in space.
Effect of motion and local gravitation on clock readings	The effect of motion and gravitation on clocks is due to dilated time.	The effect of motion and gravitation on clocks is a consequence of the conservation of total energy in space.
The Planck equation	Postulated as $E=hf$, where h is the Planck constant [Js].	Derived from Maxwell's equations into form $E_\lambda=h_0/\lambda\, c_0 c$, where h_0 [kgm] is the intrinsic Planck constant, and the quantity h_0/λ [kg] is the elementary mass equivalence of a cycle of radiation.
Quantum objects	Structures described in terms of wave functions.	Resonant mass wave structures.
Approach to unified theory	Field theory for unifying primary interactions.	Unified expressions of energies.

Table 1.1.4-I. Comparison of some fundamental features in contemporary physics and in the Dynamic Universe.

1.2 The Dynamic Universe

1.2.1 Hypothetical homogeneous space

The Riemann 4-sphere

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 referred to as "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 [12]. 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 [15] 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 [16] 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 constant velocity of light, and time as the fourth dimension.

The Dynamic Universe can be seen as 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 space as spherically closed structure.

The Dynamic Universe gives a holistic view of physical reality starting from whole space as 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 wavelike substance for the expression of energies in localized mass objects, in electromagnetic radiation and in Coulomb systems.

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, which is 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.

In free fall in space, gravitational energy is converted into kinetic energy. In the conversion, the velocity of free fall is gained against reduction of the velocity of space in the local fourth dimension. Mass in free fall is conserved. Buildup of kinetic energy at constant gravitational potential requires a supply of extra mass, which is observed as an increase of the mass of the mass object that was put in motion.

The "relativistic mass" is not a consequence of velocity, but the mass contribution needed to obtain the velocity.

Buildup of kinetic energy via gravitational acceleration in free fall in space *is not equivalent* to the buildup of kinetic energy at constant gravitational potential, which means that there is no basis for equivalence principle. 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.

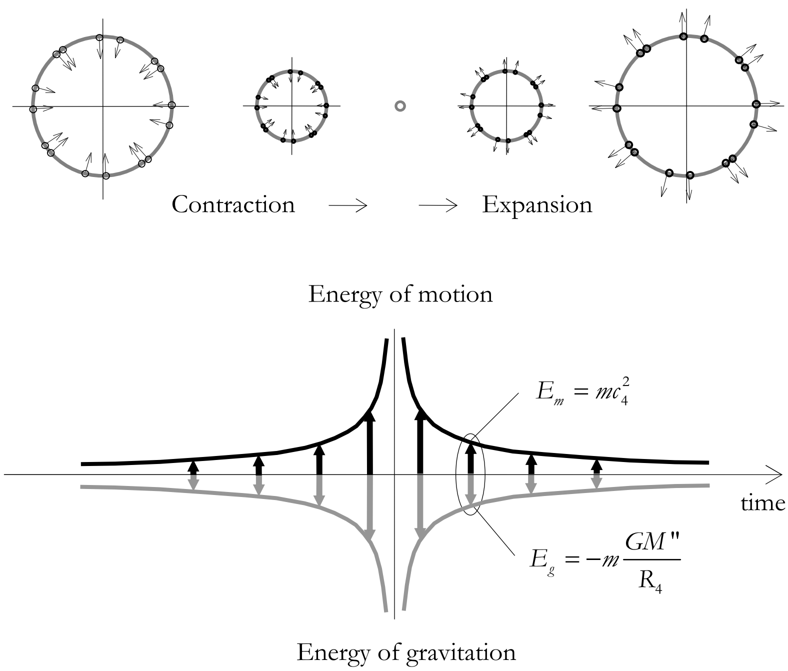


Figure 1.2.1-1. Energy buildup and release in spherical space. In the contraction phase, the velocity of motion increases due to the energy gained from the release of gravitational energy. In the expansion phase, the velocity of motion gradually decreases, while the energy of motion gained in contraction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

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

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

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, $R_4 = R_H \approx 14$ billion light years, the present velocity of the expansion, c_4, in (1.2.1:1) is

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

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.

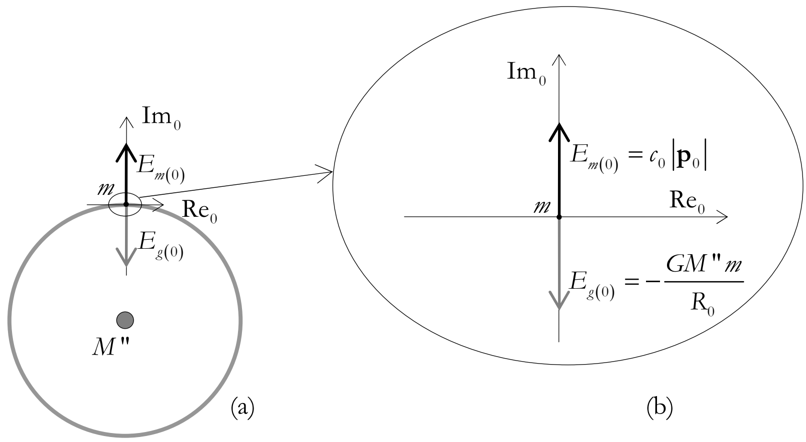


Figure 1.2.1-2. (a) Hypothetical homogeneous space has the shape of the 3-dimensional "surface" of a perfect 4-dimensional sphere. Mass is uniformly distributed in the structure and the barycenter of mass in space is in the center of the 4-sphere. Mass m is a test mass in hypothetical homogeneous space. (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 by 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 loses velocity and gains back volume.

The basis of the zero-energy concept was first time expressed, at least indirectly, 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 [17].

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

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

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.

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.

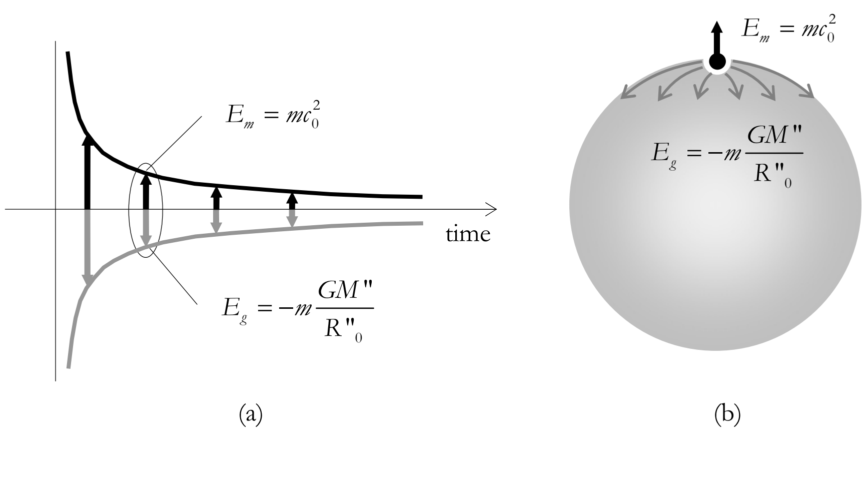


Figure 1.2.1-3(a) The twofold nature of matter at rest in space is manifested by the energies of motion and gravitation. The intensity of the energies of motion and gravitation declines as space expands along the 4-radius. (b). Complementarity of local and whole can be seen in the complementarity of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

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 the Dynamic Universe. There is no need to expect antimatter 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

$$E_m = c_0 \left|\mathbf{p}\right| \tag{1.2.1:4}$$

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

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

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 $\mathbf{p_r}$ in a space direction has the energy of motion comprising the momentum both in the fourth dimension and in space

$$E_m = c_0 \left|\mathbf{p}_4 + \mathbf{p_r}\right| \tag{1.2.1:6}$$

or

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

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 of 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. As a consequence, 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

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

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

Applying the *intrinsic Planck constant,* $h_0 = h/c$, the unit energy of a cycle of electromagnetic radiation 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

Coulomb energy

$$E_c = N^2 \frac{e^2 \mu_0}{4\pi r} c_0 c = N^2 a \frac{h_0}{2\pi r} c_0 c = c_0 m_c c$$

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

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

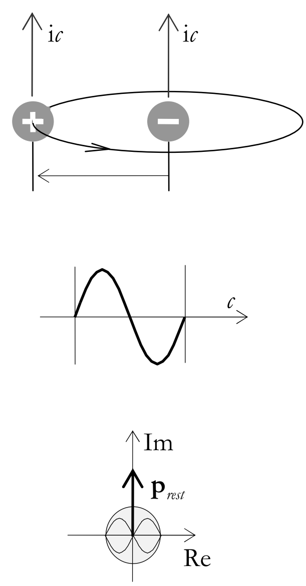


Figure 1.2.1-4. Unified expressions for the Coulomb energy, the unit energy of a cycle of electromagnetic radiation, and the rest energy of a localized mass object.

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

where λ_m is equal to the Compton wavelength. 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 5.3.4). 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

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

where the wavelength λ_β is the wavelength equivalence of the relativistic 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 in parallel with the moving object at velocity βc, or a wave with the de Broglie wavelength propagating at the velocity of light, c. The concept of a mass wave can be seen as a replacement to the wave packet description of a moving particle in the quantum mechanical context. The wave front expression of momentum is illustrative, for example, in the description of the double slit experiment [18] (see Section 5.3.5).

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 in tilted space

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

where ψ is the tilting angle of local space and $\mathbf{p}_{rest(0)}$ is the rest momentum in non-tilted space. The scalar value of the rest momentum $\mathbf{p}_{rest(\psi)}$ is

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

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.

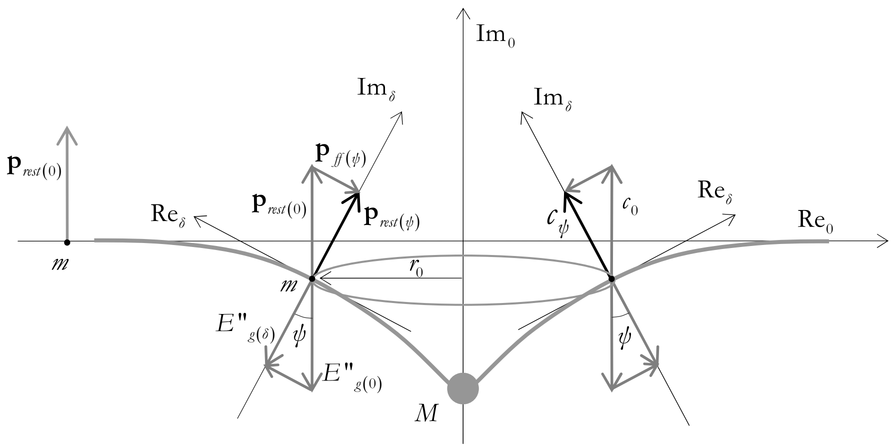


Figure 1.2.2-1. Free fall of mass *m* towards mass center *M* in space. The velocity and momentum of free fall is obtained against a reduction of the local rest momentum in tilted space.

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

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

where δ is referred to as the gravitational factor

$$\delta = \frac{MR"}{M"r_0} = \frac{GM}{r_0 c_0^2} \qquad (1.2.2:4)$$

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

$$\begin{aligned} E"_{g(n)} &= E"_{g(0)}\prod_{i=1}^{n}\cos\psi_i = -\frac{GM"m}{R"_0}\prod_{i=1}^{n}\cos\psi_i \\ &= -\frac{GM"m}{R"_0}\prod_{i=1}^{n}\left(1-\delta_i\right) = -\frac{GM"m}{R"} \end{aligned} \qquad (1.2.2:5)$$

where the local, apparent 4-radius *R"* is

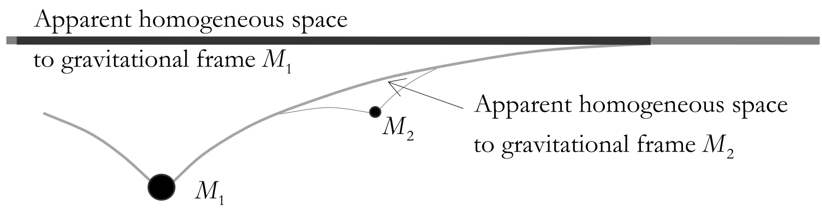


Figure 1.2.2-2. Space in the vicinity of a local frame, as it would be without the mass center, is referred to as apparent homogeneous space to a gravitational frame. Accumulation of mass into mass centers to form local gravitational frames occurs in several steps. Starting from hypothetical homogeneous 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.

$$R'' = R''_n = R''_0 \Big/ \prod_{i=1}^{n} \left(1-\delta_i\right) \tag{1.2.2:6}$$

The local velocity of light at gravitational state δ_n in the *n*:th frame is

$$c = c_n = c_0 \prod_{i=1}^{n} \left(1-\delta_i\right) \tag{1.2.2:7}$$

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

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} and the corresponding energy

$$\Delta E_C = c_0 \Delta m_{EM} c \tag{1.2.2:8}$$

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

$$E_{m(tot)} = E_{rest} + E_{kin} = c_0 mc + c_0 \Delta m \cdot c = c_0 c\left(m + \Delta m\right) \tag{1.2.2:9}$$

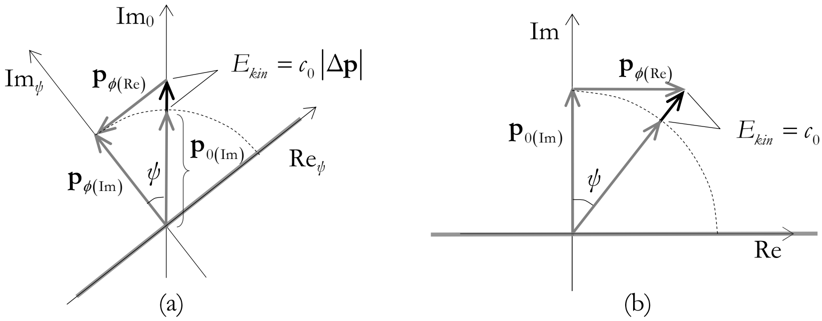


Figure 1.2.2-3. (a) Kinetic energy in free fall is obtained against reduction of the local rest momentum via tilting of space. (b) At constant gravitational potential kinetic energy is obtained by insertion of excess mass.

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

$$E_{kin} = c_0\Delta\left|\mathbf{p}\right| = c_0\left(\left|m\Delta c\right| + \left|c\Delta m\right|\right) \tag{1.2.2:10}$$

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.

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

$$\begin{aligned} E_{m(tot)} &= c_0\left|\mathbf{p}^*\right| = c_0\left|\mathbf{p}' + \mathrm{i}\,\mathbf{p}_0''\right| = c_0\left|\left(m+\Delta m\right)\mathbf{v} + \mathbf{i}\ mc\right| \\ &= c_0\sqrt{\left(mc\right)^2 + \left(m+\Delta m\right)^2\left(\beta c\right)^2} \end{aligned} \tag{1.2.2:11}$$

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

$$m_\beta = m + \Delta m = \frac{m}{\sqrt{1-\beta^2}} = m_{rel} \tag{1.2.2:12}$$

which is equal to the expression of the relativistic mass, m_{rel}, in the theory of special relativity.

The increase of relativistic mass is not a consequence of the velocity but the extra substance needed to obtain 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):

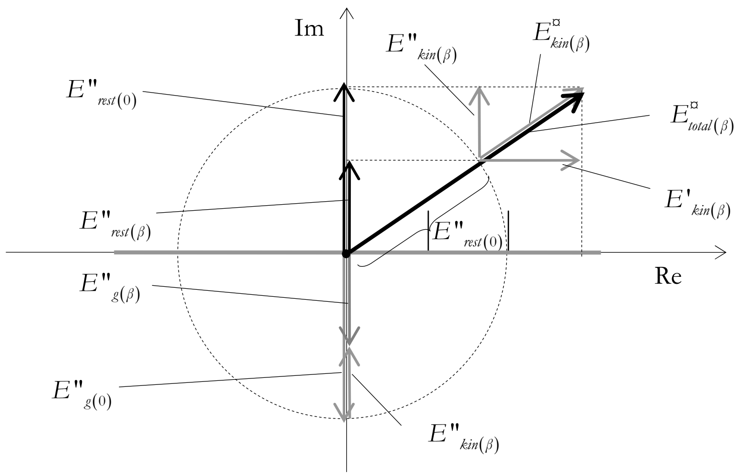


Figure 1.2.2-4. The components of the kinetic energy, E_{kin} of an object moving at velocity βc in a local energy frame. The effect of the imaginary part of the kinetic energy E''_{kin} is a reduction of the global energy of gravitation E''_g of the moving object; it is the inertial work done against the global gravitation via central acceleration relative to the mass 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 it results in an immediate change in the global gravitation.

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 4.1.3 and 4.1.8).

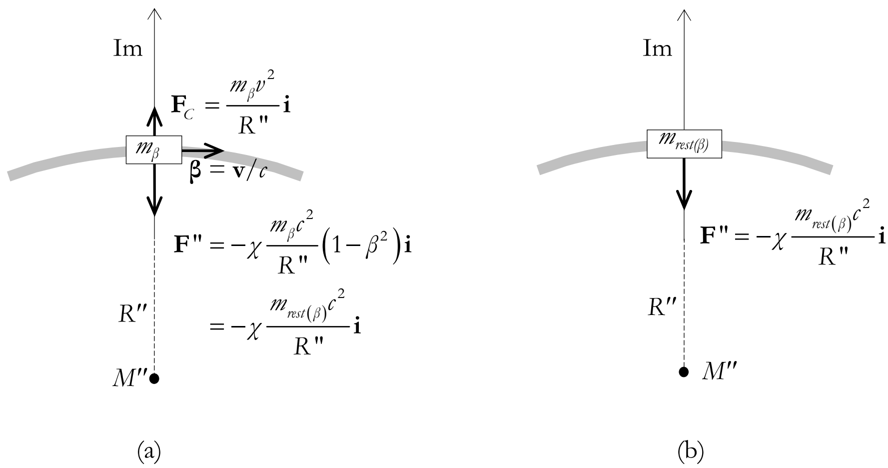


Figure 1.2.2-5. (a) The gravitational force of mass equivalence M'' on mass m_β moving at velocity $v = \beta c$ within a local frame is reduced by the central force F_C, which makes it equal to the gravitational force of mass equivalence M'' on mass $m_{rest(\beta)}$ at rest in the local frame as illustrated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

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

for mass m_β $\left(= m\big/\sqrt{1-\beta^2}\right)$ 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 the n:th sub-frame in a system of nested systems of motion as

$$E_{rest(n)} = c_0 m_{rest(n)} c = c_0 mc = c_0 m_0 c \prod_{i=1}^{n} \sqrt{1-\beta_i^2} \tag{1.2.2:13}$$

where the rest mass m in the n:th frame is related to the rest mass m_0 at rest in hypothetical homogeneous space

$$m = m_0 \prod_{i=1}^{n} \sqrt{1-\beta_i^2} \tag{1.2.2:14}$$

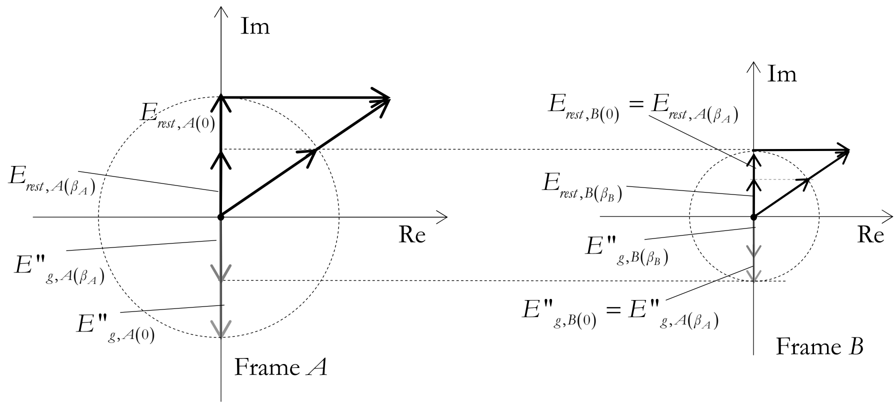


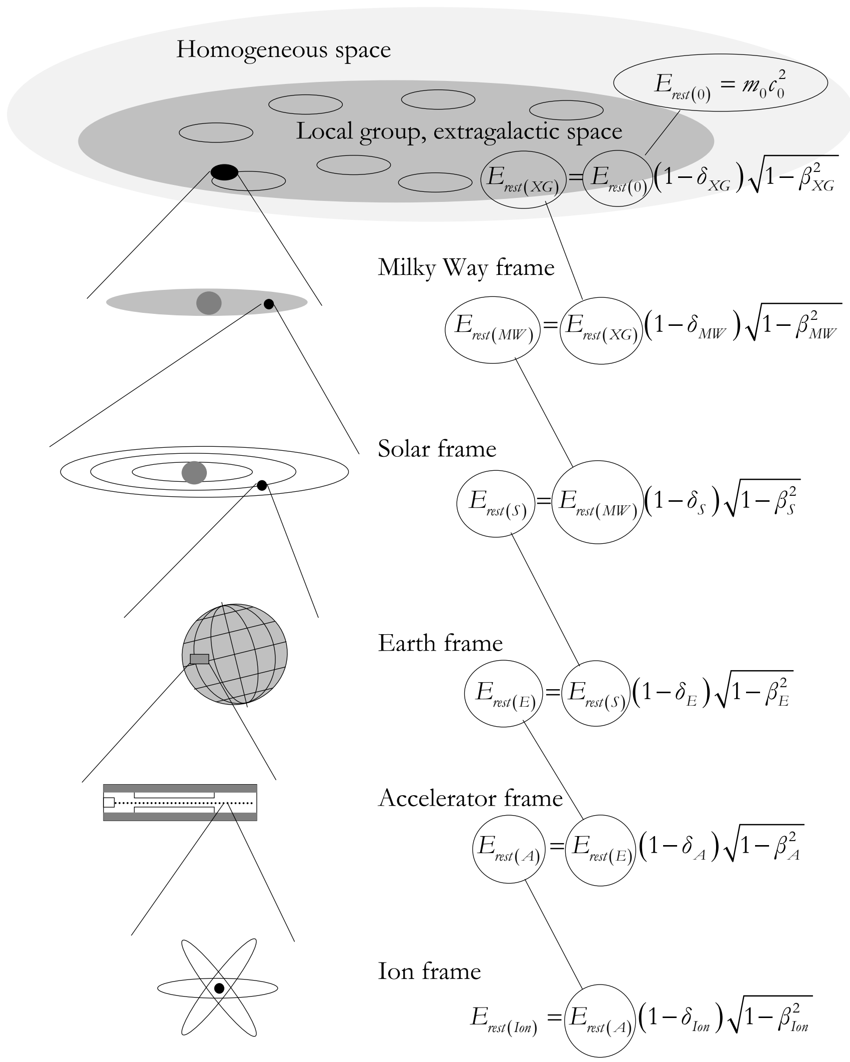
Figure 1.2.2-6. The motion of mass m at velocity β_B in the local frame B, which is moving at velocity β_A in its parent frame A.

By including the effect of gravitation on the local velocity of light in the n:th frame (1.2.2:7) equation (1.2.2:13) obtains the form

$$E_{rest(n)} = c_0 mc = m_0 c_0^2 \prod_{i=1}^{n} \left[\left(1-\delta_i\right)\sqrt{1-\beta_i^2} \right] \tag{1.2.2:15}$$

Equation (1.2.2:15) 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. Equation (1.2.2:15) relates the locally available rest energy of mass m to the rest energy mass m would have at rest in hypothetical homogeneous space. *Mass* m_0 in (1.2.2:15) 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.



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

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. The tilting of DU space is the counterpart of the curvature of 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, the 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

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

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.

	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 [19] 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.

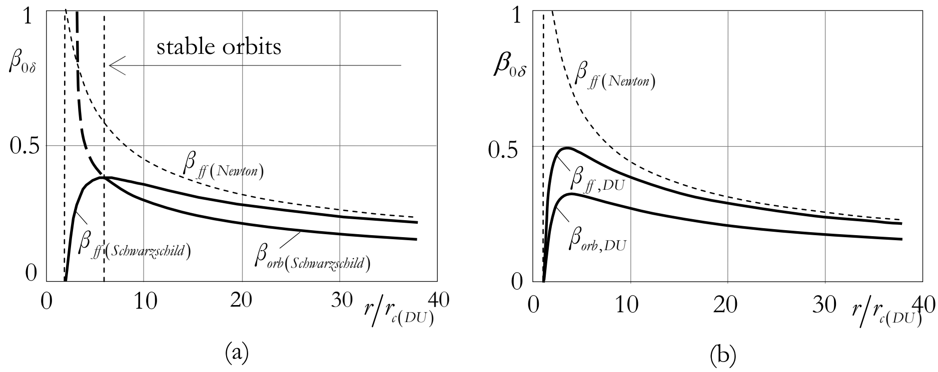


Figure 1.2.3-1. a) The velocity of free fall and the orbital velocity at circular orbits in Schwarzschild space. b) The velocity of free fall and the orbital velocity at circular orbits in DU space. The velocity of free fall in Newtonian space is given as a reference. Slow orbits between $0 < r < 2 \cdot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

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 relativistic 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 $r = 2 \cdot r_C$.

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 [20] 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.

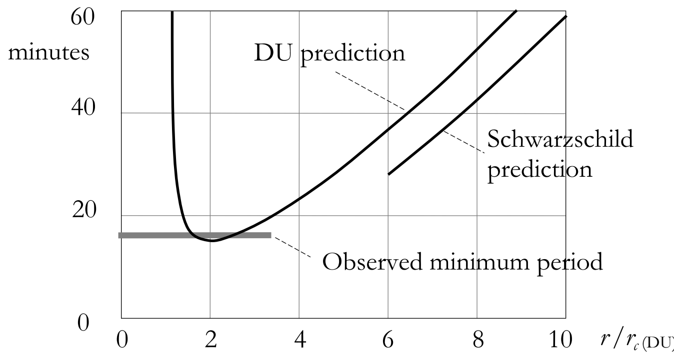


Figure. 1.2.3-2. The predictions in Schwarzschild space and in DU space for the period (in minutes) of circular orbits around Sgr A* in the center of Milky Way. The shortest observed period is 16.8 ± 2 min [20] which is very close to the minimum period of 14.8 minutes predicted by the DU. The minimum 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.

In DU space the velocity of free fall reaches the local velocity of light when the tilting angle of space is 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.

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 [21] 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 expressed 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.

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 5.4.1-2).

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).

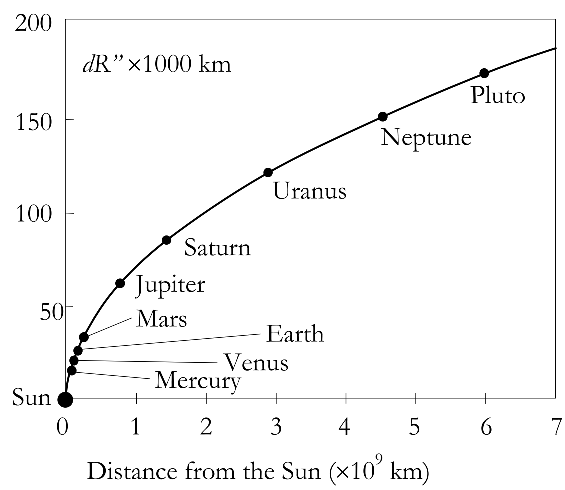


Figure 1.2.3-3. Topography of the solar System in the fourth dimension. Earth is about 26 000 km higher than the Sun, Pluto is about 180 000 km higher than the Sun in the fourth dimension.

	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 ($D_1, D_2 \gg d$)	$\Delta T = \frac{2GM}{c^3} \ln\left[\frac{4D_1 D_2}{d^2}\right]$	$\Delta T = \frac{2GM}{c^3} \ln\left\{\left[\frac{4D_1 D_2}{d^2}\right] - 1\right\}$
4) Bending of light path	$\psi = \frac{4GM}{c^2 d}$	$\psi = \frac{4GM}{c^2 d}$

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_1, D_2 at row 3, see Figure 5.4.1-4).

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 (1.2.2:15).

In the DU framework, the energy states of hydrogen like atoms can be solved by assuming that the mass wave of an electron creates a resonance condition in the Coulomb potential energy environment around the nucleus (see Section 5.1.4). The resulting solution is "relativistic". The standard non-relativistic solution of quantum mechanics appears as the approximate

$$E_{Z,n} = -c_0 mc\left[1-\sqrt{1-\left(\frac{Za}{n}\right)^2}\right] \approx -\left(\frac{Z}{n}\right)^2 \frac{a^2}{2} mc^2 \tag{1.2.4:1}$$

where a is the fine structure constant and mc^2 is the rest energy of electron in the local energy environment characterized by the velocity and gravitational state of the atom in the local energy frame and in the parent frames (see Section 5.1.3). Expression of (1.2.4:1) in terms of the nested energy frames gives

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

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

$$f_{(n1,n2)} = \frac{\Delta E_{(n1,n2)}}{h_0 c_0} = Z^2\left[\frac{1}{n_1^2}-\frac{1}{n_2^2}\right]\frac{a^2}{2}\frac{m_{0(e)}c_0}{h_0}\prod_{i=1}^{n}\left(1-\delta_i\right)\sqrt{1-\beta_i^2} \tag{1.2.4:3}$$

or

$$f_{(n1,n2)} = f_{0(n1,n2)}\prod_{i=1}^{n}\left(1-\delta_i\right)\sqrt{1-\beta_i^2} \tag{1.2.4:4}$$

where $f_{0(n1,n2)}$ is the characteristic frequency the atom would have at rest in hypothetical homogeneous space. As shown by equation (1.2.4:3) 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

$$\lambda_{(n1,n2)} = \frac{c}{f_{(n1,n2)}} = \frac{2h_0}{Z^2\left[1/n_1^2 - 1/n_2^2\right]a^2 m_{e(0)}}\frac{1}{\prod_{i=1}^{n}\sqrt{1-\beta_i^2}} \tag{1.2.4:5}$$

The characteristic wavelength is directly proportional to the Bohr radius

$$\lambda_{(n1,n2)} = \frac{4\pi a_0}{aZ^2\left[1/n_1^2 - 1/n_2^2\right]} \tag{1.2.4:6}$$

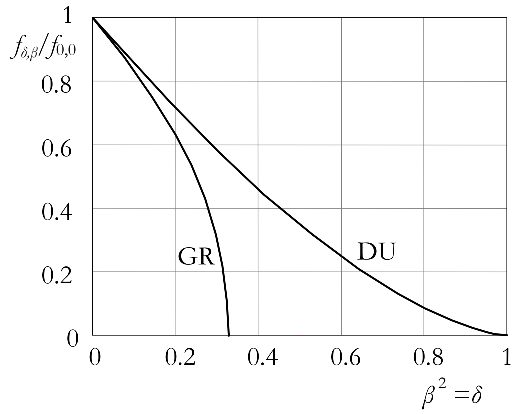


Figure 1.2.4-1. The difference in the DU and GR predictions of the frequency of atomic oscillators at extreme conditions when $\delta = \beta^2 \rightarrow 1$. Such condition may appear close to a black hole in space. The GR and DU predictions in the figure are based on equations (1.2.4:8) and (1.2.4:7), respectively.

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 (1.2.4:4) for the frequency of atomic clocks reduces to

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

where $f_{\delta 0}$ is the frequency of the clock at rest in the apparent homogeneous space of the local gravitational frame. Equation (1.2.4:7) is the DU replacement of the equation for "proper frequency" in Schwarzschild space

$$f_{\delta,\beta} = f_{0,0}\sqrt{1-2\delta-\beta^2} \qquad (1.2.4:8)$$

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.

On the Earth and in near space, the difference between the DU and GR predictions for clock frequencies in (1.2.4:7) and (1.2.4:8) 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)

$$f_A = \frac{1-\delta_A}{1-\delta_B} f_B = C \cdot f_B \qquad ; \qquad (C > 1) \tag{1.2.4:9}$$

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

$$c_A = C \cdot c_B \; ; \qquad \frac{c_A}{c_B} = \frac{f_A}{f_B} = C \tag{1.2.4:10}$$

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)

$$\lambda_A = \frac{c_A}{f_A} = \lambda_B = \frac{c_B}{f_B} \tag{1.2.4:11}$$

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

$$f_{A(B)} = f_A = C \cdot f_B \tag{1.2.4:12}$$

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

$$\lambda_{A(B)} = \frac{c_B}{f_A} = \frac{c_B}{C \cdot f_B} = \frac{\lambda_B}{C} \tag{1.2.4:13}$$

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

$$\mathbf{p}_{rad(f)} = \frac{\hbar_0}{\lambda} c \cdot \hat{\mathbf{r}} = f \cdot \hat{\mathbf{r}} = f_A \cdot \hat{\mathbf{r}} = f_{A(B)} \cdot \hat{\mathbf{r}} \tag{1.2.4:14}$$

Summary of clock frequencies and the propagation of radiation in a local gravitational frame:

- *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

$$f_{A(B)} = f_A \frac{\left(1-\beta_{B(\mathbf{r})}\right)}{\left(1-\beta_{A(\mathbf{r})}\right)} = f_0 \left(1-\delta_A\right)\sqrt{1-\beta_A} \frac{\left(1-\beta_{B(\mathbf{r})}\right)}{\left(1-\beta_{A(\mathbf{r})}\right)} \tag{1.2.4:15}$$

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 (1.2.4:15). When compared to the frequency of a reference oscillator at *B*

$$f_B = f_0 \left(1-\delta_B\right)\sqrt{1-\beta_B} \tag{1.2.4:16}$$

the Doppler shifted of frequency is

$$f_{A(B)} = f_B \frac{\left(1-\delta_A\right)\sqrt{1-\beta_A^2}}{\left(1-\delta_B\right)\sqrt{1-\beta_B^2}} \frac{\left(1-\beta_{B(\mathbf{r})}\right)}{\left(1-\beta_{A(\mathbf{r})}\right)} \tag{1.2.4:17}$$

Equation (1.2.4:17) 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 (1.2.4:17) 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

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

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, 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

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

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

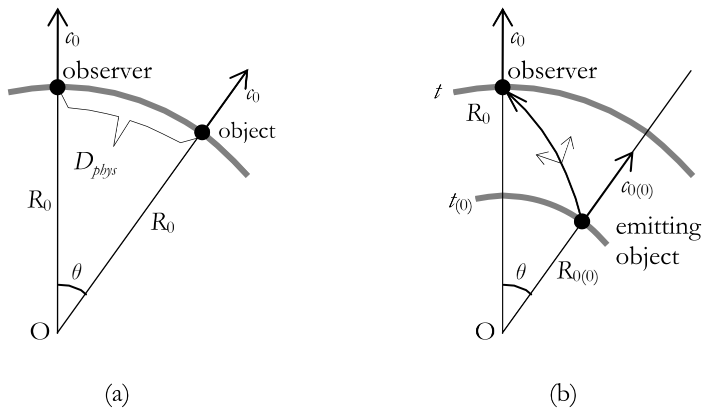


Figure 1.2.5-1. (a) A linear Hubble law corresponds to Euclidean space where the distance of the object is equal to the physical distance, the arc D_{phys}, at the time of the observation.

(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.

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

As shown in Chapter 5.1.4, 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

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

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

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

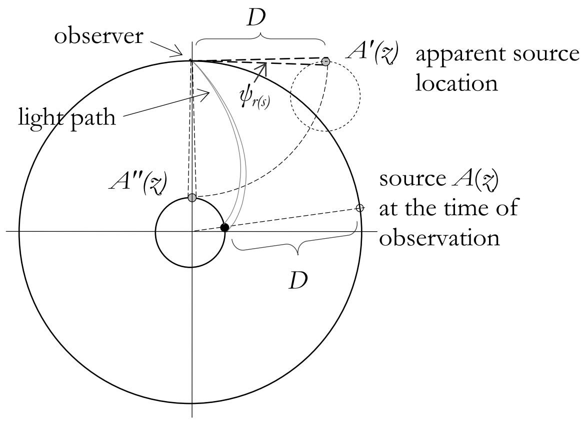


Figure 1.2.5-2. Propagation of light in expanding spherically closed space. The apparent line of sight is the straight tangential line. The distance to the apparent source location *A'(z)* is at the optical distance $D = R_{(observation)} - R_{(emission)}$ along the apparent line of sight. The symmetry 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.

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

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

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

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

which corresponds to the apparent magnitude (see Section 6.3.2)

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

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

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

(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 [22] 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

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

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 [22]}

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

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

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

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 a non-expanding object decreases in proportion to $(1+z)^4$ with its redshift. Unlike in the DU, all celestial objects, including galaxies and quasars, in the FLRW cosmology are non-expanding.

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

$$d_A \equiv d_C/(1+z) \qquad (1.2.5:17)$$

In FLRW cosmology, the luminosity distance d_L is defined

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

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

$$\frac{\theta}{\theta_s} = \frac{d_s}{d_A} \qquad (1.2.5:19)$$

and

$$\frac{F}{F_s} = \frac{d_s^2}{d_L^2} \qquad (1.2.5:20)$$

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 [23–27]. In the DU framework, assuming conservation of the mass equivalence of radiation, 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 [28]

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

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" [29].

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

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

which is the correction used for converting the DU prediction for direct bolometric magnitudes into a prediction applicable to magnitudes "in emitter's rest frame".

In the DU perspective, assuming conservation of the mass equivalence of radiation, the effect of the redshift on the power density of radiation comes 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 coordinate 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 to "emitter's rest frame" 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 for velocities in the kinematic sense. 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.

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, Figure 1.3.1-1.

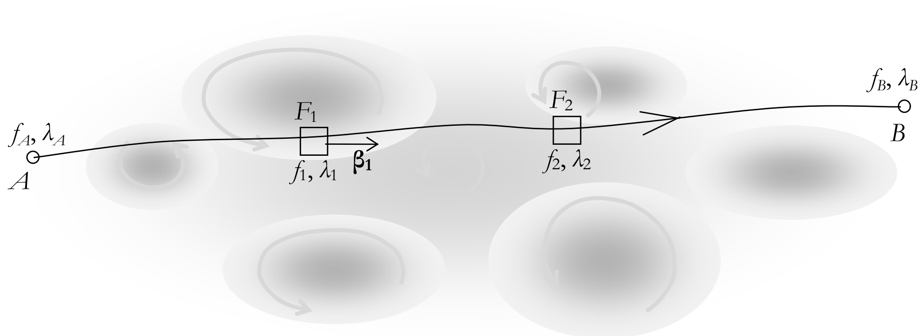


Figure 1.3.1-1. The path of light passing local gravitational systems in space. When detected in a frame F_1 moving at velocity $\beta_1 c$ in the light propagation frame, the observed frequency and the wavelength are Doppler shifted. The phase velocity of the light in the observation frame, as the product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

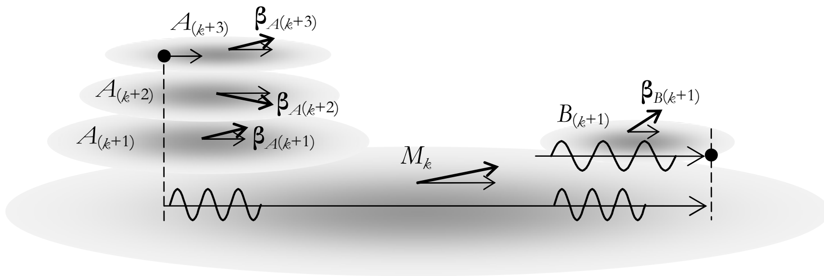


Figure 1.3.1-2. Transmission of electromagnetic radiation from the source at rest in frame $A(k+3)$ to the receiver at rest in frame $B(k+1)$. The motions of frames $A(k+1)$ … $A(k+3)$ result in a change of the wavelength in radiation propagating in the M_k frame.

Due to the opposite changes of the frequency and the wavelength, the phase velocity of radiation, however, is observed unchanged. 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 Sections 5.2.3 and 5.5.1, Figure 1.3.1-2.

Conservation of the phase velocity

In fact, the Doppler effect is enough for understanding the constancy of the phase velocity of light observed by observer B moving in frame A. Observer B moving at velocity $v=\beta c$ in the direction of the radiation received, observes the wavelength increased as

$$\lambda_B = \lambda_A / (1-\beta) \tag{1.3.1:1}$$

and the frequency decreased as

$$f_B = f_A \cdot (1-\beta) \tag{1.3.1:2}$$

The observed phase velocity is

$$c_B = \lambda_B f_B = \lambda_A f_A \frac{1-\beta}{1-\beta} = \lambda_A f_A = c_A \tag{1.3.1:3}$$

Equation (1.3.1:3) means that the phase velocity is independent of the velocity of the observer. The momentum of radiation propagating in frame A is

$$\mathbf{p}_{\lambda(A)} = \frac{h_0}{\lambda_A}\mathbf{c}_A \tag{1.3.1:4}$$

When observed in frame *B* moving in frame *A* at velocity *β*, the momentum is reduced by

$$\mathbf{p}_{\lambda(B)} = (1-\beta)\mathbf{p}_{\lambda(A)} = \frac{h_0}{\lambda_A}(1-\beta)\mathbf{c} \tag{1.3.1:5}$$

In the case of radiation, the change of momentum due to the motion of a receiver is observed as a change in the wavelength and the related mass equivalence – not as a change of velocity.

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 7.3.2). Simultaneity in the DU means simply that the events in question occur at the same time.

In the DU framework, the zero result of the Michelson–Morley experiment can be seen as a consequence of the energy frame structure. An M–M interferometer can be regarded as a moving frame. The simplest form of an M–M interferometer is a one-dimensional resonator. As shown in Section 5.3.2, such a resonator can studied as a frame of its own. In the direction of the velocity of the resonator in the parent frame, the Doppler shifted front- and back waves create a momentum in the parent frame, but conserve the resonance condition and equality of the opposite waves in the resonator frame. Such a mechanism does not apply to rotating circular resonators, and a phase shift between opposite waves appears.

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

Experiments with clocks

The prediction (1.2.4:4) for clock frequencies, derived from conservation of total energy

$$f_{(n1,n2)} = f_{0(n1,n2)} \prod_{i=1}^{n} (1-\delta_i)\sqrt{1-\beta_i^2} \tag{1.3.1:6}$$

applies to all experiments and observations regarding relativistic effects of clocks. Frequency $f_{0(n1,n2)}$ in (1.3.1:6) is the frequency of the clock at rest in hypothetical homogeneous space. Equation (1.3.1:6) 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 (1.3.1:6) 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 (1.3.1:6) allows a comparison of clocks in different energy frames. Equation (1.3.1:6) 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 (1.3.1:6) 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 5.3.4).

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 paleo- anthropological 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).

1.4 Summary

Overall picture of space and matter

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 — 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.

In the Dynamic Universe, mass has an abstract role as wavelike substance for the expression of energy. At the same time, mass appears as the main conservable throughout the contraction and expansion of space.

The system of energy frames and the absolute coordinate quantities

The system of nested energy frames is a characteristic feature of the Dynamic Universe. It allows the usage of time and distance as absolute coordinate quantities, and allows an analytical study of the linkage between the local and the whole, and thereby the linkage between local objects.

We may assume that the actual system of energy frames is more complicated than the simple hierarchical structure presented in this book. As in the case of Newtonian gravitational potential or the spacetime structure in general relativity, all mass objects or mass distribution in space contribute to a local condition. The hierarchical approach, however, is very illustrative and serves most practical needs.

Local and global

A local state of rest is an attribute of energy balances in the system of nested energy frames. The price paid for "the status" a local state of rest is a reduction of the rest energy. As discussed in Section 4.1.3, the imaginary component of kinetic energy is the work done against the imaginary gravitational energy, which is the gravitational energy due to all the rest of mass in space.

Inertia is not a property of mass but a consequence of the zero-energy balance of motion and gravitation in space.

The effect of local motion on the zero-energy balance of motion and gravitation can be illustrated by studying the balance of forces in the fourth dimension. In spherically closed space, any motion in space is central motion relative to the 4-center of space in the fourth dimension, in the center of the 4-sphere defining space. As discussed in Section 4.1.8, a central force in the fourth dimension results in an effective reduction of the gravitational force due to the rest of mass in space. In terms of the energy of motion, it means that the rest energy, the imaginary component of the energy of motion in a moving object is reduced.

The imaginary component of kinetic energy is work done against the gravitational energy due to the rest of mass in space when an object is put into motion. It is exactly what Ernst Mach suggested – inertia is the effect of the rest of mass in space on the object accelerated.

Energy and force, the holistic perspective

A key element for the holistic perspective in the Dynamic Universe is the choice of energy, instead of force, as the primary physical quantity. The Dynamic Universe relies on the overall zero-energy balance of the energies of motion and the energies of structure (potential energies). Force in the DU is a derived quantity as the gradient of energy. Force is local by its nature; it means sensing of the local gradient of energy and a trend toward minimum energy. The unified expressions of energy in the Dynamic Universe allow straightforward analyses of the conservation of energy in different energy conversions.

The destiny of the universe

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 reversal 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 meant conversion of, at least, part of energized mass into electromagnetic radiation in space — turning on the light in space — and triggering elementary particle buildup and 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

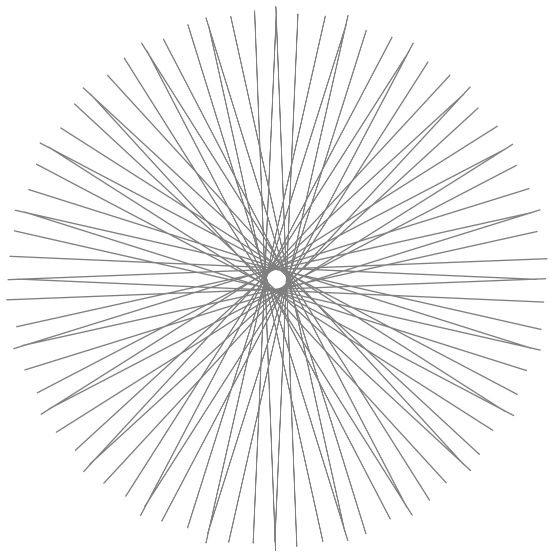


Figure 1.4-1. The turn of the contraction of space to the expansion by passing the singularity point at a finite distance could "turn on the light" in space by converting a share of the energized matter with momentum in the fourth dimension, into electromagnetic radiation with momentum in space.

Planck distance a measuring rod for structured material and mass objects in space (Section 5.3.6).