

Human Approaches to the Universe. An Interdisciplinary Perspective.

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Panel Discussion 27.9.2003, 15.45-17.30:

Universal Order and the Concept of Time in the Theory of Relativity

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Universal Order in Absolute Time

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Introduction

I like to start my introduction with a practical example of four clocks taken into different environment for one week....

We first have four identical clocks in a laboratory. They are observed to show same time at high accuracy for long periods of time. Then for one week we put one of the clocks to reduced temperature in a refrigerator, one clock into fast motion in a centrifuge, and one clock to an elevated altitude at the top of the laboratory building.

A layman states simply that the clocks in the refrigerator and in fast motion have run slower than the reference clock and the clock kept at an elevated altitude has run faster than the reference clock

...

A physicist's agrees with layman's conclusion regarding the clock in the refrigerator because he knows that temperature affects the ticking frequency of the clock ...

... but there is no recognized physical mechanism for an atomic oscillator to change frequency due to motion — so he has concluded that time slows down for objects moving relative to the observer ...

... there is no recognized mechanism for an oscillator to change frequency due to change in the gravitational potential either, accordingly, the reading of the clock taken to an elevated altitude can be explained if time is assumed to flow faster at a weaker gravitational interaction to a mass centre

...

Regarding the clock in motion, the physicist's interpretation is based on the special theory of relativity originally created to explain the observed constancy of the phase velocity of light in moving frames. Regarding the clock at elevated altitude the physicist's interpretation relies on the general theory of relativity or equivalence principle which extends the conclusions of special relativity to gravitational potential through motion obtained in gravitational acceleration.

Are we unaware of possible physical mechanisms through which motion and gravitational potential affect the frequency of atomic oscillators or are we really obliged to blame time for the changed readings of clocks in motion or in different gravitational states? Does mass in whole space affect clocks in motion like it affects the acceleration of mass objects through inertia?

In his lectures on gravitation Richard Feynman stated:

“If now we compare this number [total gravitational energy $M_{\Sigma}^2 G/R$] to the total rest energy of the universe, $M_{\Sigma} c^2$, lo and behold, we get the amazing result that $GM_{\Sigma}^2/R = M_{\Sigma} c^2$, so that the total energy of the universe is zero. — It is exciting to think that it costs nothing to create a new particle, since we can create it at the center of the universe where it will have a negative gravitational energy equal to $M_{\Sigma} c^2$. — Why this should be so is one of the great mysteries—and therefore one of the important questions of physics. After all, what would be the use of studying physics if the mysteries were not the most important things to investigate”. [Feynman, R., Morinigo, W., Wagner, W., Feynman Lectures on Gravitation (during the academic year 1962-63), Addison-Wesley Publishing Company (1995), p. 10]

and further

“...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.” [Feynman, R., Morinigo, W., Wagner, W., Feynman Lectures on Gravitation (during the academic year 1962-63), Addison-Wesley Publishing Company (1995), p. 164]

A closer study of Feynman’s “intriguing suggestion of spherically closed space” leads to dynamic space described as a spherically closed structure expanding in the direction of the radius in the fourth dimension. Such solution shows the rest energy of matter as the energy of motion mass has due to the expansion of space in the fourth dimension. The dynamics of space is determined by the balance of motion and gravitation in the structure which explains the “the great mystery” of the zero-energy condition between gravitational energy and the rest energy of matter in space. Following the zero energy principle, any motion or gravitational state in space becomes related to the motion and gravitational state of whole space. Clocks in motion and clocks near mass centers run slower due to the linkage between the local energetic environment and contribution of whole space. Contrary to the theory of relativity, in dynamic space time and distance can be handled as absolute coordinate quantities.

Spherically closed dynamic space is studied in detail in the Dynamic Universe theory [1]; predictions derived are supported by experiments equally or better than the corresponding predictions derived from the theory of relativity and standard cosmology model. The Dynamic Universe gives a holistic, highly ordered picture of space and universe. The multitude forms of local expressions of energy originate from and are related to the energy built up in the contraction – expansion process of spherically closed space. Mass appears as the substance for the expression of energy — mass as such is not observable, it becomes observable through momentum when in motion and through gravitation when at finite distance to other mass.

Dynamic space has generated the rest energy of matter against a release of gravitational energy in a contraction phase from infinity in the past to singularity turning the contraction to expansion. In the expansion phase the rest energy of matter is released back until zero at infinity. At infinity in the future, all motion gained from gravity in the contraction will have been returned back. Mass is conserved but it will no longer be observable because the rest energy of matter will have vanished along with the cessation of motion. The energy of gravitation will also become zero owing to the infinite distances. The cycle of observable physical existence begins at cessation in emptiness and ends at cessation in emptiness.

Gravitation and dynamics in spherically closed space

The concept of space as a 4-sphere was first time suggested by Ludwig Schläfli and Georg Riemann in the mid-nineteenth century. In a writing on cosmology in 1917 Albert Einstein proposed spherical space as a part of relativistic cosmology. By that time, however, the general theory of relativity had just linked time to space as the fourth dimension, ruling out the possibility of the fourth dimension as the purely geometrical dimension required by an orthodox 4-sphere. Also, Einstein was looking for a static solution for space. Gravitation of mass within a 4-sphere would cause a shrinkage force, which would immediately throw the whole structure into a contracting motion along the radius in the fourth dimension. The reason for Einstein to suggest a cosmological constant was just to prevent such collapse. At that time understanding of distant space was vague, galactic structures were unknown; the recession of galaxies and expansion of space were discovered by Edwin Hubble about ten years after Einstein's concept of closed static space.

In spherically closed space a natural solution is not static space but space subject to contraction and expansion. Dynamics based on a zero-energy principle shows the rest energy of matter as the energy of motion mass has due to the contraction or expansion of space in the fourth dimension, in the direction of the 4-radius which also means that the velocity light is determined by and is equal to the velocity of space. In such solution the velocity of light appears as the maximum velocity in space due to the energy balance in the system. In contraction started from the state of rest at infinity in the past motion is gained against release of gravitational energy. In expansion motion works against gravitation resulting in gradual deceleration of expansion until rest at infinity, Figure 1. Motion of space in the direction of the 4-radius is undetectable for observers moving with the structure, indirectly it is observed as uniform expansion of space, the enlarging of all distances in space as the "three-dimensional surface" of the 4-sphere.

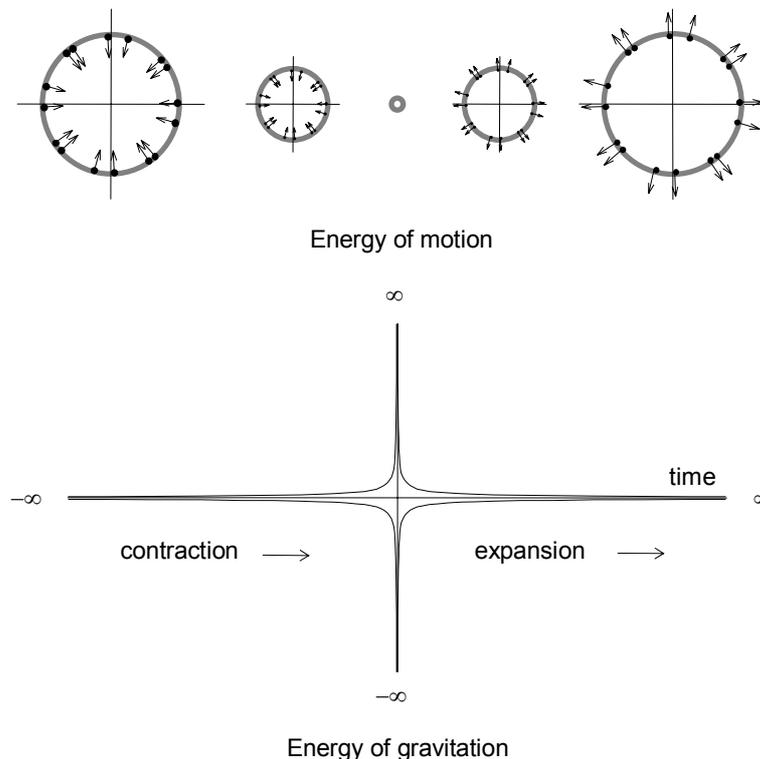


Figure 1. Contraction and expansion of space and the corresponding evolution of the energies of motion and gravitation. In the contraction phase, the 4-radius of space goes from infinity to zero. In the expansion phase, after singularity, the radius increases from zero back to infinity. Zero total energy is preserved through the entire process.

The kinetic energy related to the motion of space in the direction of the 4-radius appears as the rest energy of matter in space — being in balance with the gravitation of the structure, it discloses the mystery of the equality of the rest energy and the gravitational energy of all mass in space. The rest energy of any mass object is balanced by the gravitational energy of all the mass in space, i.e. the energetic state of a mass object is characterized as an excited state of the energies of motion and gravitation. The linkage of the rest energy to the gravitational energy of all mass in space also results in the inertial behavior of mass known as the Mach's principle.

Mass obtains the character of a substance for the expression of energy. Mass as such is not detectable, mass becomes detectable as matter with rest energy through motion and gravitational interaction with other mass at finite distance.

Motion in four dimensions

When the fourth dimension is interpreted as a geometrical dimension, as it should in a spherically closed dynamic space, a line element in the fourth dimension $|ds_4| = c \cdot dt$ means the distance traveled by space due to expansion in time interval dt . As a consequence, the momentum of mass m due to expansion is $\mathbf{p}_4 = m\mathbf{c}_4$ and the energy of motion, when expressed like the energy of electromagnetic radiation propagating at velocity c , obtains the form $E_{m4} = c \cdot |\mathbf{p}_4| = c \cdot |m\mathbf{c}_4|$ or $E_{m4} = mc^2$, which shows the rest energy of matter as the “energy equivalence” of momentum in the fourth dimension. The total momentum of an object can now be expressed as the orthogonal sum of the momentum in space, in one of the three space directions, and momentum in the fourth dimension due to the motion of space as

$$\mathbf{p}_{tot} = \mathbf{p} + \mathbf{p}_4 \quad (1)$$

and the corresponding energy as

$$E_{tot} = c |\mathbf{p}_{tot}| = c \sqrt{|m\mathbf{c}_4|^2 + |\mathbf{p}|^2} \quad (2)$$

which is the well known expression of the total energy introduced by the theory of special relativity through a completely different reasoning.

The unavoidable momentum mass has in the fourth dimension due to the motion of space turns out to be the reason to the increase of the *effective mass* when mass objects are accelerated in space. As the counterpart of the increase of the effective mass of a mass object at motion in space, the *internal mass* working against the gravitation of all mass in space is reduced. Phenomenologically, this can be understood as an effect of the central acceleration created by motion in spherical space. For objects moving in space the energetic excitation (motion against gravitation) in the fourth dimension is reduced. It can be shown that the reduction of the internal excitation reduces internal processes in the moving objects. *Characteristic oscillation frequencies of atomic oscillators are directly proportional to the internal momentum of the oscillating object.* The internal momentum and the corresponding internal energy are

$$|\mathbf{p}_I| = m_I c = mc \sqrt{1 - \beta^2} \quad E_I = c |\mathbf{p}_I| = m_I c^2 = mc^2 \sqrt{1 - \beta^2} \quad (3)$$

where $m_I = m \sqrt{1 - \beta^2}$ is referred to as the internal mass of the object.

We stated that mass shall be understood as the substance for the expression of energy. Mass at rest in space expresses energy through motion in the fourth dimension only. In the case of mass in motion in space “the substance” is divided for the expression of energy through motion *with* space in the fourth dimension and through motion *in* space in a space direction.

Local geometry of space

The picture of regular spherical space is based on homogeneous distribution of mass as we can assume at cosmology level. Locally, mass has cumulated into mass centers. Following the zero-

energy principle, it can be shown that cumulation of mass into mass centers in space result in bending of the 4-surface in the fourth dimension, Figure 2. In bended space the direction of local fourth dimension (local imaginary direction) deviates from the direction of the 4-radius. As a result the local imaginary velocity of space is reduced by factor $\cos\phi$ from the velocity of the expansion in the direction of R_4 , the direction of imaginary axis in homogeneous space, Figure 2. Reduction of the imaginary velocity of space means also reduction in the local velocity of light

$$c_\delta = c = c_{0\delta} (1 - \delta) = c_{0\delta} \left(1 - \frac{GM}{rc_0c} \right) \approx c_{0\delta} \left(1 - \frac{GM}{rc^2} \right) \quad (4)$$

Bending of space together with a reduction in the velocity of light result in bending of light and delay of radio signals (the Shapiro effect) close to mass centers.

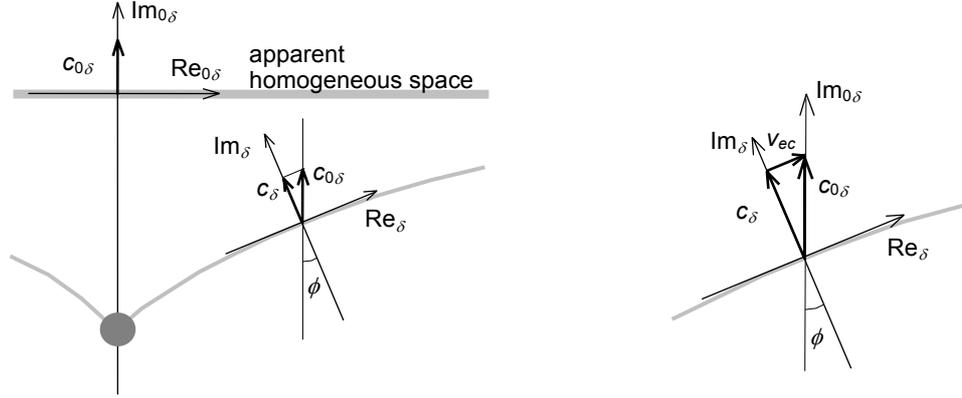


Figure 2. Space is tilted in the fourth dimension close to mass centers in space. Local complex coordinates follow the shape of space, causing the local imaginary axis, Im_δ to deviate from the direction of the imaginary axis in apparent homogeneous space, $Im_{0\delta}$. The imaginary velocity of space in the δ -state, c_δ is reduced according to the formula $c_\delta = c_{0\delta} \cos\phi$, where ϕ is the tilting angle of space in the δ -state. The orthogonal sum of the local imaginary velocity and the escape velocity, v_{ec} , to apparent homogeneous space is equal to the imaginary velocity of the apparent homogeneous space as illustrated in the picture on the right.

Characteristic oscillation frequencies

We found that motion in space reduces the internal momentum of an object by reducing its internal mass. By reducing the imaginary velocity of space near mass centers, also a local mass center results in a reduction in the internal momentum of objects in the tilted space near the center.

It can be shown that the characteristic emission, absorption and oscillation frequencies of atomic objects are directly proportional to the internal momentum. As a result, the ticking frequencies of atomic clocks are reduced in the direct proportion to the internal momentum. Taking into account the effect of each relevant energy frame of an oscillating object (like the gravitational potential and velocity in the Earth gravitational frame, the gravitational potential and velocity of the Earth in the Sun gravitational frame, gravitational potential and velocity of the solar system in the Milky Way, and of course the velocity of the clock in a local centrifuge frame as in our example of the four clocks we started with), the frequency determining the ticking frequency of an atomic clock is

$$f_{1,2} = f_{1,2(0)} \prod_{i=1 \dots n} \left[(1 - \delta_i) \sqrt{1 - \beta_i^2} \right] \quad (5)$$

where $f_{1,2(0)}$ is the frequency of the clock at rest in hypothetical homogeneous space. Equation (5) is in a complete agreement with all experiments made with atomic clocks on Earth, in satellites ect.

The system of cascaded energy frames applied in equation (5) is a consequence of the zero energy principle: The energy of motion shall be paid back to the potential energy system it has been

obtained from (or excited with); the kinetic energy of an object, the work done in achieving a velocity in space, is reversible, it is released when an object is returned to *the state of rest in the energy frame the motion has been obtained*. The rest energy of the object can be characterized as the intrinsic energy of the object, it is released only in billions and billions of years through the work the expansion of space does against the gravitation in the direction of the 4-radius of space.

The linkage of kinetic and structural energies through zero energy principle gives an energy frame the character of an energy object with dualistic expression energy. Any local energy frame can be regarded as an energy object in its parent frame. Ultimate parent frame is hypothetical homogeneous space. The state of rest in hypothetical homogeneous space serves as a universal reference for any energy state in space.

A quantum of radiation

We can find that the velocity of light is a hidden factor in Planck constant, accordingly, a proper way of writing the Planck constant is

$$h = h_0 c \quad (6)$$

where h_0 is referred to as the *intrinsic Planck constant* independent of the expansion of space. Applying the intrinsic Planck constant the energy of a quantum gets a unifying form

$$E_\lambda = \frac{h_0}{\lambda} c^2 = h_0 f \cdot c = p \cdot c = \frac{h_0}{\lambda} c \cdot c = m_\lambda c^2 \quad (7)$$

where h_0/λ has the unit mass [kg] and can be characterized as the mass equivalence of an energy quantum (of radiation).

A point emitter like atom travels with space a distance of one wavelength in a cycle. When such emitter is described a dipole of one wavelength in the fourth dimension we find, just by applying Maxwell's equations, that the energy emitted in one cycle with only one unit charge oscillating in a dipole, is equal to

$$E_{\lambda 0} = 1.11 \cdot 2\pi^3 e^2 \mu_0 c \cdot f = h \cdot f = h_0 f \cdot c = \frac{h_0}{\lambda} c \cdot c = p \cdot c \quad (8)$$

Equation (8) give a physical meaning to energy quantum: *Quantum of electromagnetic radiation is the energy of one cycle of radiation emitted by one oscillation cycle of a unit charge in a quantum emitter*. The Heisenberg uncertainty principle turns into a clear message: *In order to obtain full information about the substance available in an energy quantum for the expression of momentum, we need to observe the full wavelength of the wave*.

Cosmological consequences

Spherically closed space gives a more ordered picture of the universe than that suggested by cosmology models based on the theory of relativity. The buildup and release of the rest energy of matter can be understood as a continuous process from infinity in the past through singularity to infinity in the future. The instantaneous singularity is not a "hot Big Bang" but an ultimate excitation of the rest energy of matter.

The contraction and expansion of space is considered as the primary energy buildup and release. As the initial condition the total mass of the universe is considered as being uniformly distributed throughout space. Condensation of matter into clusters in space is considered as a process of secondary energy buildup. The secondary energy buildup creates conditions, local singularities, "black holes", where the formless matter energized in the primary energy buildup is converted into electromagnetic radiation, elementary particles, and atomic structures.

In the preset state of expansion the 4-radius of the universe can be estimated to be about 14 billion light years (corresponding to Hubble constant $H_0 = 70$ (km/s)/Mpc). Since the expansion velocity has been faster in the past the corresponding time from singularity is 9.3 billion years. The

expansion of space slows down gradually, present decrease in the expansion velocity (and the velocity of light) is $\Delta c/c \approx -3.6 \cdot 10^{-11}$ /year.

The expansion of space occurs uniformly everywhere in space, not only between galaxies or galaxy groups as taught by the standard model. The dimensions of galaxies and the radii of orbiting stellar systems are subject to expansion. Atomic radii, however, are conserved. The precise geometry, dynamics and energetic development of space allow the derivation of precise mathematical expressions for redshifts, optical distances, angular sizes, and apparent magnitudes of cosmological objects throughout the development of the Universe. The background radiation obtains a precise expression as the radiation propagated 360 degrees around expanding spherical space. What we see in the background radiation is the light emitted by the location of our own galaxy about 750 000 years after the singularity. The redshift of background radiation is $z = e^{2\pi} - 1 \approx 534.5$.

Predictions derived from the spherical, dynamic space in absolute time pass key cosmology tests equally or better than the corresponding predictions derived from the theory of general relativity and standard cosmology model [magnitude/redshift (Appendix 1), Euclidean appearance of the angular size of distant objects, perihelion advance of elliptic orbits, bending of light and delay of radio signals near mass centers].

Conclusions

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

We can identify three kinds of qualities or factors a physical model is based on

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

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

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

A successful description of a phenomenon generate 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 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 shall be universal for all physical phenomena described. It's a basic rule in all measurements not to change measures for a phenomenon in different environments or circumstances; adjusting the measures is a shortcut, a false way out hiding the problem.

There is no need to sacrifice the constancy and universality of the basic coordinate quantities, distance and time, for right predictions of the frequencies of atomic oscillators and the seeming constancy of the velocity of light.

In space described as spherically closed entity with dynamics determined by zero-energy balance between motion and gravitation, absolute time and universal distance unit can be applied for all phenomena in space.

The choice is this:

If we fix the velocity of light and make it the maximum speed in space by applying Lorentz transformation as a law of nature, we have to use time and distance as parameters in describing the behavior of atomic oscillators and measurements of the phase velocity of light in moving frames. We have to postulate the rest energy of matter as a property of mass and accept a relative state of rest as our reference for motion. We are not able to conclude either the overall geometry of space or the development of the geometry with the expansion of space.

If we describe space as a dynamic zero-energy surface of a 4-dimensional sphere, time and distance can be used as absolute coordinate quantities and we understand the dependence of the velocity of light on the development of the universe and on local gravitational state. We can relate the value of the velocity of light to the total mass and dimensions of space, we understand why and when the velocity of light is observed as being constant, and also why the velocity of light is the maximum speed achievable in space. Further, we can define the state of rest in any local energy frame and relate that to the absolute state of rest in space. We can identify a quantitative expression to Mach's principle, to the nature of mass, and a quantum of energy.

Describing space as structured dynamic entity in absolute time gives simple and logical explanation to the mystery of the four clocks we started with; the clock in a centrifuge lost time because it was running slower due to its velocity in the centrifuge frame and the clock at elevated altitude gained time because it was running faster due to higher gravitational potential in the Earth gravitational frame.

The curious concept of time in theory of relativity was originally justified with and based on the relative velocity between the observer and the object. We know for sure, that the reading cumulated in the counter of a clock is unambiguously determined by the gravitational and motional state of the clock, it is not related to any particular observer. In fact, this was first time demonstrated in practice as late as in the 70's when atomic clocks were taken into airplanes and satellites. Until that time all experiments on the frequencies of atomic oscillators were based on observation of the frequency or wavelength of electromagnetic signal sent by the oscillators. Such experiments combine the inherent frequency of the transmitting oscillator, propagation of the electromagnetic radiation transferring the frequency, receiving of the radiation and the state of a reference oscillator at observer's location, which all can be handled in absolute time in dynamic space.

Reference

1. T. Suntola, "The Dynamic Universe, A New Perspective on Space and Relativity", ISBN 951-97938-8-7, 300 pages, Suntola Consulting Ltd., 2003; www.sci.fi/~suntola .

Appendix 1.

Magnitude of distant supernovas (used as standard candelas)

For a satisfactory fit with observations, the interpretation of recent supernova observations (magnitude/redshift) with standard model requires an assumption of “dark energy” with gravitational “push” at cosmological distances. Mathematically this can be demonstrated by re-introducing a cosmology constant rejected by Einstein after Hubble’s findings of expanding space in late 1920’s. Such solution means that the expansion of space is accelerating instead of decelerating as predicted by the “classical” Einstein - deSitter model.

The prediction derived from Dynamic Universe (DU) gives an excellent fit with observations without any free parameter or new assumption. The expansion of space continues forever with a decreasing velocity until zero at infinity.

In the figure below the DU prediction is compared to observations and the predictions of the standard model with different mass- and energy-density parameters. As shown by a precise numerical comparison, the DU-fit without any free parameters is better than any of the fits by the standard model with several optimized parameters.

