Fundamental concepts − from force to energy

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Abstract: This paper discusses the nature of reality on the bases of novel fundamental concepts arisen out of the Dynamic Universe theory and the period doubling mechanism presented in papers *The Dynamic Universe – space as a spherically closed energy system* by Tuomo Suntola [1], and *On the Planck scale and properties of matter* by Ari Lehto [2] in this issue. The Dynamic Universe model and the period doubling mechanism open a new perspective on the physical reality and the primary laws of nature. Such a reorientation challenges the bases of the existing theory structures. The fundamental change of paradigm stimulates a deep philosophical study of the basic assumptions and concepts. Antique metaphysics created great principles but met its limits with the lack of empiricism. The triumph of modern physics can be seen in our phenomenal technological progress but the main objective of a scientific theory – to make nature understandable – has not been met. A theory is not inherently correct or wrong but it describes chosen phenomena accurately or less accurately, widely in all circumstances or only in a limited sense. A theory may rely on philosophical ideas of the laws of nature, or it may discern the laws of nature via a mathematical description of observations. A comprehensive theory comprises clear philosophical bases with a minimal number of postulates, without compromising experimental evidence and testable predictions.

Keywords: Laws of Nature, Force, Energy, Matter, Cosmology, Planck Scale

1. Introduction

There was a profound advancement in the conception of reality in antiquity and again at the turn of the modern era. In both cases explicit progress in understanding nature was achieved by new insights in physics and natural philosophy laying down an enduring framework for further research. The conception of reality has once again become blurred. Modern physics has overstepped the boundaries of Newtonian physics but many of the concepts and ideas related to classical physics still prevail. These ideas may be misguiding research and preventing a fresh approach to making reality understandable.

In Kuhnian terms it is not possible to overstep the boundaries of the old paradigm – the habitual methods, approaches and viewpoints – without providing an alternative to the "normal science" built on the Newtonian metaphysics. Such an alternative, the necessary rival, should provide a unified basis for describing relativistic and quantum phenomena which are presently addressed by theories whose basic postulates are incompatible. The DU theory is unique in providing a broad unified basis for describing physical phenomena. DU's holistic approach is indispensable for metaphysical reappraisal and a new picture of the universe. The associated re-evaluation of the fundamental postulates provides a natural context for Period doubling theory. By applying the universal behavior of nonlinear dynamical systems, structures from the elementary particles to cosmological objects can be derived from Planck units by Period doubling thus providing a cause and means to calculate values for basic properties of matter like the rest mass, magnetic moment and the value of the elementary electric charge. This is a unique feature which is missing in the context of the Standard Theory of Particles.

1.1. The Scope of Physical Sciences – Space, Matter, and Motion

In antiquity, the physical sciences were considered to study matter, motion and space (heavens). The classification has essentially survived in modern physics; matter is described in terms of quantum mechanics and electromagnetism, motion in terms of classical mechanics and relativity theory, and space in terms of the standard cosmology model relying both on
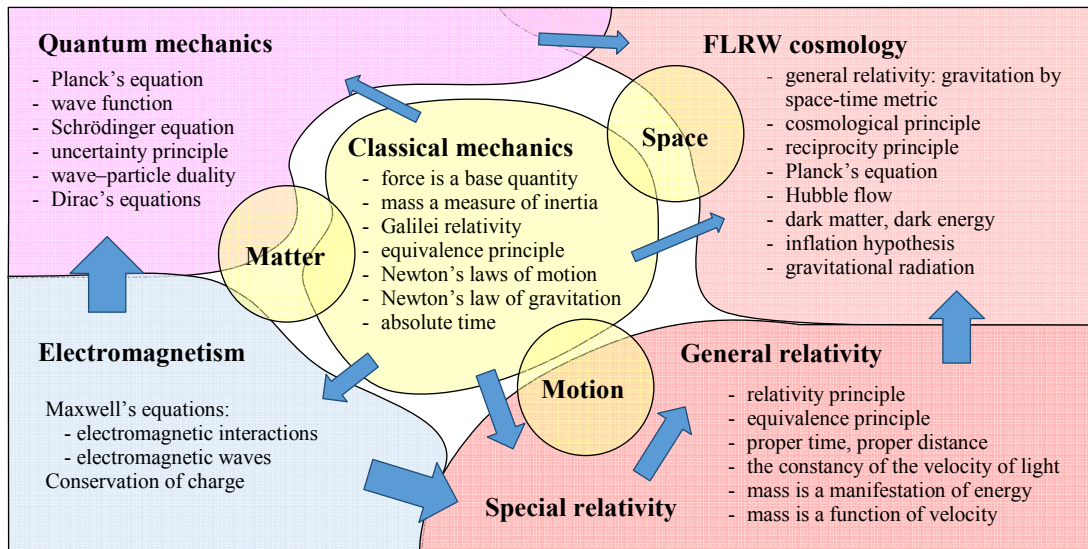
Figure 1. Diversification of prevailing theory structures into sub-theories for the description of matter, motion, and space.

relativity theory and quantum mechanics. Each branch of physics has its unique development path and a set of postulates and principles. In search for a unified theory the different specific postulates in the sub-areas form an obstacle. Figure 1 illustrates the separate puzzle pieces of prevailing theories.

1.2. From Newtonian Physics to Relativity Theory

The bases of modern mathematical physics were settled in classical mechanics by the works of Isaac Newton and his contemporaries. Newton's work on the laws of motion was triggered by the challenge to unravel the centripetal force resulting in Kepler's planetary orbits. The solution was built on Galilei's relativity, a balance of opposite forces, and the equality of inertial and gravitational accelerations. Newton's world relied on absolute time and distance as intuitive natural choices. The Sun, or the barycenter of the Solar system was the center of the universe, fixed stars were far enough not to be drawn together due to their mutual gravitational interaction. Motion in Newtonian space has no limits – the velocity of an object increases without limits as long as there is a nonzero force affecting the object.

Newtonian physics fixed the picture of reality for two hundred years – until observations on electromagnetism, the velocity of light, and the momentum of accelerated electrons in the 1800s. An explanation of the new phenomena was given by the special theory of relativity; the velocity of light was postulated to be a universal physical constant, and the finiteness of velocities was described in terms of modified coordinate quantities, which mathematically limited any observed velocity to the velocity of light as maximum. Special relativity re-established Galilei's relativity principle. Newtonian inertial mass was complemented with the concept of relativistic mass needed to explain the increased momentums of objects accelerated to high velocities. As an unparalleled entity, special relativity introduced the concept of rest energy, which described mass as a manifestation of energy.

In general, the concept of energy as work and integrated force matured in the 1800s, finally as a part of thermodynamics. Energetics, as the distinctive study of energy conversions, had an essential role in the formulation of Maxwell's equations, which are better known as equations describing electromagnetic interactions.

1.3. From Quantum to Atomic Model

Maxwell's equations explained the emission of electromagnetic radiation by moving charges. An alternate approach to the emission of electromagnetic radiation was given by Planck's equation and the quantum concept. Originally, Planck's equation was introduced for solving the spectrum of blackbody radiation; the concept of quantum as an elementary "package" of electromagnetic radiation was presented by Albert Einstein in 1905 in his explanation of the photoelectric effect.

Until the 1800s, theories on mass, matter and material were mainly restricted to the effects of inertia and gravitation. Atomic theory was reawakened by observations showing that different elements combine in simple whole-number ratios to form chemical compounds – work that gradually led to the buildup of the periodic table of elements by Mendeleev. Many physicists were sceptical about atoms still in the late 1800s when Ludwig Boltzmann introduced his statistical thermodynamics based on the kinetic energy of discrete atoms in an ideal gas.

Combining the ideas on electrons as possible structural parts of an atom, and the Planck equation, finally led to the early atomic model by Niels Bohr in 1913. Elaboration of the description of atomic phenomena led to an exhaustive reconsideration of the postulates and the deterministic principles in classical mechanics. The resulting doctrine, quantum mechanics, became the core of physics with an excellent power for predicting physical phenomena, however, at the price of obscuring human comprehension of the reality behind the theory.

1.4. Outlining the Cosmological Appearance of Space

The extension of special relativity into general relativity was primarily based on the equivalence principle allowing the interpretation of gravitational acceleration indistinguishable from inertial acceleration. The expression of acceleration in terms of transformed coordinates allowed the description of gravitation as a property of space-time geometry linked to the mass density and distribution in the surrounding space. In practice, the general theory of relativity is mainly applied as Schwarzschildian space, linked to a local mass center.

Outlining of a cosmological picture of general relativity assumes the cosmological principle which claims homogenous mass distribution at the cosmological scale. Einstein's first impression of the cosmological picture of space according to general relativity was a 3-surface of a 4-sphere [3]. Spherically closed space fulfilled ideally the demand of the cosmological principle. Following the general understanding in the 1910s, Einstein assumed a static space. Therefore, for preventing a collapse of the 4-sphere, Einstein postulated the famous cosmological constant, which in the late 1990s was re-established as the dark energy needed to match the cosmological predictions to the observed magnitude versus redshift curves of high-z type Ia supernovae.

The standard cosmology model, the Friedman-Lemaitre-Robertson-Walker cosmology (FLRW-cosmology), was primarily developed in the 1930s. The 1930s cosmologists met an exceptional challenge in putting together the special and general theories of relativity, the Planck equation, the still developing quantum mechanics, and the observations suggesting expanding space. Metrics of space was based on Friedman's and Lemaitre's solutions of general relativity, a demand for reciprocity was based on special relativity, and Planck's equation was interpreted to describe an intrinsic property of radiation propagating in expanding space, which meant loss of energy by the increase of wavelength. The expansion of space was described in terms of "Hubble flow" between galaxies. Galaxies were assumed to conserve their dimensions in the course of the expansion [4]. To reach an agreement with precise observations since the late 1990s, the predictions of the standard model for the magnitudes have been complemented with dark energy, an otherwise unknown entity working like pushing gravitation in the Hubble flow resulting in accelerating expansion.

The standard model explains the birth of the universe as an occurrence of "quantum fluctuation", a sudden local appearance of energy, the start of the flow of time and spreading of space. The early stage of the expansion, an inflation period, is characterized by an extremely high expansion velocity exceeding the present velocity of light. The standard cosmology model does not manage to predict the fate of the universe.

1.5. The Picture of Physical Reality

In a historical perspective, the development of empirical sciences has started from phenomena close to the "human scale", observable without sophisticated instruments. Above the human scale, the cosmology model can be seen as an extrapolation of the originally local relativity theory. Below the human scale, subatomic phenomena could not be placed in the framework of classical physics or the relativity theory. Quantum mechanics meant not only a new postulate basis but also a new, and still unsettled way of looking at physical reality. The discussion related to the interpretation of quantum mechanics has been going on for almost a century implying a profound need to reconsider the conventional approach to reality. It is impossible to understand the holistic quantum phenomena like nonlocality within the conceptual bases employed in contemporary physics. Yet it is not possible to reconsider the accustomed views and principles without an alternative.

2. The Great Principles

It is often stated that energy is the most basic concept in modern physics. Yet no theory is comparable to the DU in its adherence to energy and its overall conservation as the zero-energy balance in space.

2.1. From Force to Energy

2.1.1. The Laws of Conservation

The conservation laws are perhaps the oldest general principles behind conceptions of the laws of nature. The Greek philosopher Heraclitus expresses an early conservation law by stating that *"The amount of rain is equal to the amount of water evaporated"*. Aristotle's cause and effect carried a seed to energetics; Gottfried Leibniz expressed the conservation of energy in his *Essay in Dynamics* [5]: *"There is neither more nor less power in an effect than in its cause"*. At Leibniz's time – and for a long time after that – the concept of energy was still vague and mixed with the concept of force. Leibniz tried to base the laws of motion on the balance between *vis viva* (living force, kinetic energy, mv^2) and *vis mortua* (dead force, potential energy), which served as a precursor to motion and *vis viva*.

2.1.2. The Balance of Opposite Forces

Newton chose force as the base quantity and postulated the balance of opposite forces. Also, he postulated the equality of gravitational force and inertial force, which led to the breakthrough in celestial mechanics thereby establishing the status of Newton's equations of motion as fundamental laws in physics. The status of force as a primary quantity in physics has survived since Newton's breakthrough – today, the main efforts towards a unifying theory are directed to the unification of forces, or the four fundamental interactions: gravitational, electromagnetic, strong nuclear, and weak nuclear. On the other hand, chemical bonds are characterized by their bonding energy rather than bonding forces. Also, thermodynamics emphasizes the role of energy – in a closed system, the main conservable is the sum of the kinetic and potential energy in the system.

2.2. The Concept of Energetics

The concept of energy was recognized as work and integrated force only as recently as the 1800s. The principles of energetics were outlined as a part of thermodynamics, in its most definite form by Herman von Helmholtz [6] in the mid-1800s. A key feature in energetics is the interaction of the two complementary expressions of energy: potential energy and kinetic energy.

Hermann von Helmholtz also stated the overall conservation of energy: *"The quantity of force (amount of work) which can be brought into action in the whole of Nature is unchangeable, and can neither be increased nor diminished"*. In fact, the statement was already given by Gottfried Leibniz in his Essays in Dynamics: *"The total amount of force in the world is conserved both locally and globally with the result that there is always as much force in a cause as in its effect"*. In modern terms Helmholz's and Leibniz's "force" means energy. Vis viva (living force) means kinetic energy and vis mortua (dead force) potential energy.

In the introduction of his paper *"A Dynamical Theory of the Electromagnetic Field"* [7] James Clerk Maxwell describes the basis of his famous equations on electromagnetism as a manifestation of energetics: *"The medium is therefore capable of receiving and storing up two kinds of energy, namely, the "actual" energy depending on the motions of its parts, and "potential" energy, consisting of the work which the medium will do in recovering from displacement in virtue of its elasticity"*.

In Chapter VIII in his book *"Science and Hypothesis"* [8], 1905, Henri Poincaré states: *"We begin by defining two quantities which play a fundamental part in this theory (energetics). They are kinetic energy, or vis viva, and potential energy. Every change that the bodies of nature can undergo is regulated by two experimental laws. First, the sum of the kinetic and potential energies is constant. This is the principle of the conservation of energy... Second ... is Hamilton's principle, and is one of the forms of the principle of least action."*

The second fundamental law of nature Poincaré refers to, the principle of least action, can be seen as a manifestation of Aristotle's *entelecheia*, the natural trend to actualize potentiality – the least action occurs when, at each position of a path, the available potential energy is optimally converted into the energy of motion.

2.3. Extension of Energetics to Space as a Whole

The Dynamic Universe re-establishes the principles of energetics to cover space as a whole and extends the application of energetics from the micro-world to the cosmological structure of space. The DU-extensions to energetics come from:

1. structured space, which allows the calculation of the total gravitational energy and the dynamics of space, and
2. from the unified, complex function presentation of energy.

The complex energy links the effect of the motion of space as the rest energy and the imaginary part, to the energy related to motion in space as the real part. Correspondence to conventional notation of energy comes from the absolute value of the complex total energy.

Also, the complex function notation links the effect of whole space on the energy of gravitation balancing the rest energy. Helmholtz's definition of the state of rest – *"in a closed system an object is at rest when its kinetic energy is zero"* – applies in DU's nested energy frames which link any energy state in space to the state of rest in hypothetical homogeneous space which serves as the universal reference to all energy states in space.

There is nothing intrinsically separate in DU space, any mass object is linked to the mass in the rest of space. Any velocity or kinetic energy carried by a moving object in space has its history which links it to the state of rest in hypothetical homogeneous space.

In the "energy physics" of the DU, the conventional equations of motion for force and acceleration are derived from the overall zero energy balance in space. Newtonian physics and the relativity theory can be seen as approximations of the DU:

By neglecting the revealed holistic effects resulting from the rest of space, the DU laws of motion in local frames become essentially equal to those derived in special relativity, and by further neglecting the effects of velocities approaching the velocity of light, the laws can be approximated with Newtonian laws of motion.

A state of motion is characterized as an energy state rather than a state characterized by the velocity relative to an arbitrary reference. Primarily, the energy of motion is obtained against release of potential energy – the energy of motion can be seen as a debt to the potential energy which paid it out in the energy conversion creating the motion.

The "energy physics" allows a holistic, from the whole to the local approach of space and phenomena in space. The Dynamic Universe theory provides a new comprehensible framework for outlining reality. It is no more a clockwork or a formless spacetime entity but a spherically closed dynamic whole. The dynamics of space as a spherically closed structure relies on the energy balance of whole space, which allows solving first the dynamics of whole space, and then the energy conversions within space by conserving the overall energy balance. In the DU, cosmological predictions can be derived from the primary energy balances in space. Such an approach eliminates the need for a sudden appearance of physical existence in a BigBang, but instead, explains the energizing of space via the dynamics of whole space in a contraction-expansion process. Interactions within space are described in terms of energy conversions conserving the overall energy balance of space. In the DU, the unification of the subareas in physics is obtained by unified expressions of energy; force can be seen as a local quantity, the gradient of energy.

2.4. Gravitational Potential and the Immediate Gravitational Force

The DU describes gravitational interaction in terms of a scalar potential field, which is understood as a primary physical entity. Any localized mass object contributes to the gravitational potential field around it – and any mass object is subject to the gravitational potential created by all other mass in space. Any location in space is characterized by the gravitational potential arising from all mass in space. Gravitational potential is sensed as gravitational energy by a mass object. Mathematically, the amount of gravitational energy is the product of the local gravitational potential and the mass of the sensing object. The concept of gravitational potential corresponds to Laplace's mathematical approach, which led to overwhelming accuracy in the celestial mechanics of the planetary system [9]. In his mathematical procedure Laplace did not, however, consider the role the scalar potential field as a primary physical entity.

In the DU framework, gravitational force on a mass object can be seen as a direct consequence of the universal trend towards minimum potential energy. This occurs when a mass object senses the local gradient of the scalar gravitational field. Gravitational force is local and immediate – it does not require force carriers from the sources of the potential field.

DU's immediate gravitation and the overall zero-energy balance are in a full agreement with Mach's principle, which suggests that inertia originates from the gravitational interaction of all the mass in space. Mach's principle requires immediate gravitational interaction in order to result in immediate inertia. In fact, the complex function presentation of energy in the DU shows the imaginary component of the kinetic energy as the work done against the gravitation due to the rest of mass in space – which is a quantitative explanation of Mach's principle.

2.5. The Dynamics of Space and the Dynamics in Space

For applying the principles of energetics in whole space, space shall be studied as a closed energy system. In the DU, space is described as the 3-surface of a 4-sphere free to contract and expand in a four-dimensional universe. For space as a whole, the primary dynamics is a process of contraction and expansion of the 4-sphere like a spherical pendulum pulsating in the 4-dimensional universe – a primary transcendent emptiness. In the contraction phase space gains motion from its own gravitation, and in the expansion phase the energy of motion gained in the contraction is paid back to the energy of gravitation. Accordingly, all mass in space is in motion in the fourth dimension, in the direction of the 4-radius of the structure. The energy of motion mass possesses due to the motion of space is observed as the rest energy of mass, the quantity first revealed by the theory of relativity and often equalized with mass. The distinctive differentiation of mass and energy given by the DU is an essential factor in the buildup of a unified theory structure and the associated comprehensible picture of reality.
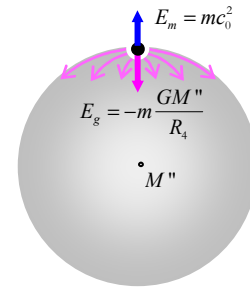

Figure 1. Spherically closed space as the 3-surface of a 4-sphere. The rest energy of a local object is counterbalanced by the gravitational energy arising from the rest of space.

2.6. The Symmetry of the Energies of Motion and Gravitation

The rest energy of any localized object, given by its transcendent motion is counterbalanced by the gravitational energy due to all other mass in space. Via the balance of the two expressions of energy, locality is inherently linked to the rest of space. There is nothing intrinsically separate in space. The non-localized presence of a mass object appears as the gravitational potential the mass object contributes to the total gravitational potential in space. Linkage of local to the rest of space means that there are no intrinsically separate objects or particles in space, Fig.1.

3. Re-Evaluation of Central Concepts

3.1. The Velocity of Light and Atomic Clocks

It is often stated that the constancy of the velocity of light is an experimental fact. In order to describe the constancy, the velocity of light was *defined* constant. Such a solution passes the question: why is the velocity of light *observed* as constant, or what gives the velocity of light such a unique property and a specific value?

The DU answers the question: the velocity of light is equal to the velocity of space in the fourth dimension. The velocity of space in the fourth dimension is determined by the balance between the energy of gravitation and motion in space. The velocity of space is not a constant but slows down gradually in the course of the expansion, which means that also the velocity of light decreases, the present rate of slowing is $\Delta c/c$ $\approx$ $3.6 \cdot 10^{-11}$ in a year which, however, is not directly observable.

As a consequence of the overall energy balance in DU-space, local space is tilted in the vicinity of mass centers, which means that the velocity of space in the local fourth dimension and the local velocity of light are reduced. Ticking frequencies of atomic oscillators are proportional to the rest momentum of the oscillating electrons, i.e. the frequencies are proportional to the local 4-velocity of space and, accordingly, to the local velocity of light. As a result, when measured with an atomic clock, the velocity of light is observed constant anywhere in space. The local tilting of space and the reduced
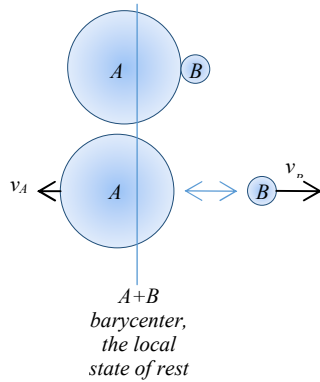
$\Delta E = E_A + E_B$ = Energy for separating B from A (no binding energy assumed)

$E_A = \frac{1}{2} \cdot m_A v_A^2$ = Kinetic energy of A after separation

$E_B = \frac{1}{2} \cdot m_B v_B^2$ = Kinetic energy of B after separation

$\mathbf{p}_A + \mathbf{p}_B = m_A v_A + m_B v_B = 0 \quad \Rightarrow \quad v_B = -\frac{m_A}{m_B} v_A$

$\frac{E_B}{E_A} = \frac{\frac{1}{2} m_B v_B^2}{\frac{1}{2} m_A v_A^2} = \frac{m_B v_A^2}{m_A v_A^2} \cdot \frac{m_A^2}{m_B^2} = \frac{m_A}{m_B} \quad \Rightarrow \quad E_B = \frac{m_A}{m_B} E_A$

$E_A = \frac{\Delta E}{1 + m_A / m_B}, \qquad E_B = \frac{\Delta E}{1 + m_B / m_A}$

Figure 2. In the initial state, mass objects A and B are supposed to be in touch with each other in the state of rest in a local energy frame. When A and B are separated from each other by applying energy ΔE, the velocities of the two objects, are determined by the conservation of total zero momentum, i.e. the two objects obtain equal but opposite momentums relative to the barycenter of the A-B system. The velocities obtained by the objects are related as the inverse of the ratio of the masses. If no binding energy between A and B is assumed in the initial state, the energy used for removal is fully converted into the kinetic energies of A and B. If the mass m_A is much larger than the mass m_B, the removal energy ΔE appears mainly as the kinetic energy of the lighter object B, $E_B = ΔE/(1 + m_B/m_A)$ ≈ΔE, while the velocity $v_A ≈ 0$ and $v_B ≈ \sqrt{2\Delta E / m_B}$.

After the separation, the two objects are in linear motion relative to each other. In a dynamic sense, it is not possible, however, to redefine the state of rest to either one of the moving objects as suggested by the relativity principle. Identical atomic oscillators attached to objects A and B sense their energy state, i.e. the effect of the changed kinetic energy on the rest energy determining the frequencies of the oscillators.

velocity of light near mass centers are observed as the Shapiro-delay of radio signals, the bending of light paths passing a mass center, and the gravitational shift of the frequencies of atomic clocks – observations, which general relativity explains in terms of the modified space-time coordinates.

A detailed study of the observations of the velocity of light requires special attention to the measurement: In the case of satellite communication, like in the case of the Global Positioning System, we apply the signal transmission velocity in the ECI-frame (the Earth Centered Inertial Frame). In interferometric measurements, like in the famous Michelson – Morley experiments in late the 1800s or the less known Michelson – Gale experiment in 1925, the measurement is based on the observation of the phase shift between divided beams; the constancy of the velocity of light, as the phase velocity, was deduced from the phase shifts observed. In the DU framework, the different experimental setups are analyzed applying the system of nested energy frames which allow the determination of the reference at rest from the overall energy balances in each case.

3.2. The Relativistic Mass

One of the first predictions of the special relativity testable in laboratory was the concept of relativistic mass which, in fact, had been observed before the introduction of special relativity by Walter Kaufmann in 1902 [10]. Due to the kinematic bases of special relativity, the relativistic mass is explained as a consequence of the relative velocity and the associated coordinate transformations. In the DU framework, mass is the substance for the expression of energy; the relativistic mass results from the energy contribution needed to obtain the velocity, momentum and the kinetic energy of the

object put in motion – relativistic mass is not a consequence of velocity but the velocity is a consequence of the mass input by the accelerating system.

3.3. The Relativity Principle

The principle of relativity authorizes any observer in a state of rectilinear motion to define his state as the state of rest. The detailed energy structure of space revealed by the DU is less generous. There is a given objective energy state for everybody. In the Dynamic Universe framework a state of motion is primarily characterized in terms of the total energy of the moving object; in a local energy frame a state of rest is characterized as a state with zero kinetic energy in the frame. Buildup of motion within the frame requires certain energy to be released and converted into kinetic energy of the object put into motion. Figure 2 illustrates (as a Newtonian approximation) the separation of two mass objects initially at rest in a local energy frame.

After the separation the two masses, *A* and *B*, are in rectilinear motion with their kinetic energies and velocities inversely proportional to the masses. The kinetic energies are related to the state before the separation, which is the state of rest of the local frame. In spatial sense the state of rest is the barycenter of the *A-B* system, which conserves its position after the separation of the two masses.

In the DU framework, a detailed energy analysis shows that the rest energies of the objects in motion are reduced by quantities $\sqrt{1 - (v_A/c)^2}$ and $\sqrt{1 - (v_B/c)^2}$, respectively, Fig. 3.

Because the frequencies of atomic clocks are proportional to the rest energy of the oscillating electrons, the frequencies of atomic clocks moving with objects *A* and *B* are reduced by the same factors. The reduction of each clock frequency is
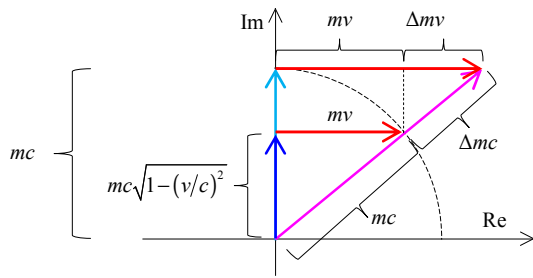
Figure 3. *The components of the momentum of mass object m moving at velocity v in a local energy frame. The rest momentum of an object in motion is reduced due to the contribution of momentum component mv to the momentum in space.*

Figure 4. *Buildup of kinetic energy in free fall (a) and at constant gravitational potential (b). In the case of free fall from non-tilted space to tilted space the kinetic energy is obtained against reduction of the rest energy. At constant gravitational potential the kinetic energy is obtained from the accelerating system.*

related to the velocity the object has relative to the state of rest in the local frame. The frequencies are not related to the relative velocity of the two moving objects as taught by special relativity. *There is no place for the relativity principle in the Dynamic Universe.* Clocks in motion run slower because part of their total energy is used in the motion in space.

3.4. The Equivalence Principle

The theory of general relativity relies strongly on the equivalence principle which equalizes the inertial and gravitational accelerations. The DU is more restricting here, too. There is a definite difference in the mechanism of gaining velocity at constant gravitational potential and in free fall in a gravitational field. In special relativity, acceleration at constant gravitational potential like in particle accelerators, is characterized by the buildup of "relativistic mass" which is explained as a consequence of the velocity and the related coordinate transformations. In the GR framework, due to the equivalence principle, relativistic mass is equally built up by the velocity gained in free fall in a gravitational field.

In the DU framework, the "relativistic mass" is identified as the mass contribution needed to build up the kinetic energy of an object accelerated at constant gravitational potential. In the case of free fall in a gravitational field, the velocity is obtained against a reduction of the local imaginary velocity of space due to tilting of local space. The kinetic energy in free fall is obtained against a reduction of the local rest energy of the falling object. As a result, free fall is not associated with an increase of mass, Fig. 4. *There is no place for the equivalence principle in the Dynamic Universe relying on global and local energy balance in space.*

A consequence of the relativistic mass increase in free fall in the GR is the instability of orbits in the vicinity of black holes. The instability can be traced to the velocity of free fall and escape; when the distance to a mass center (black hole center) is less than three times the Schwarzschild critical radius, the orbital velocity, according to the GR prediction, exceeds the escape velocity. In the DU framework, orbits are stable down to the critical radius. In fact, orbital velocities at radii approaching the DU critical radius, which is half of the Schwarzschild critical radius, approach zero. Slow orbits
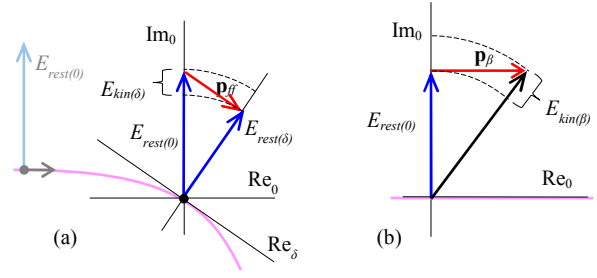
close to the critical radius explain the mass and stability of the black hole, Fig.5.

3.5. Global Relativity

Relativity in the DU is characterized as global relativity, relativity of local to the whole – instead of relativity between an object and the observer like in the relativity theory. Relativity in the DU is a direct consequence of the overall zero-energy balance in space. Instead of being described in terms of coordinate transformations, relativity in the DU is described in terms of locally available energy.

DU does not support or allow the relativity principle. The velocity of light is not a constant, instead, the velocity of light is determined by the velocity of space in the fourth dimension, which is determined by the zero-energy balance in space. A local frame of reference is characterized by the rest energy available for objects in the frame – which is a function of the state of motion and gravitation of the local frame in its parent
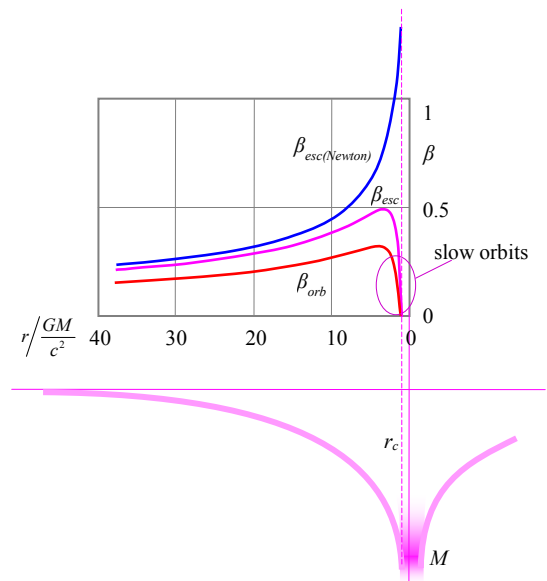

Figure 5. *The celestial mechanics based on the zero-energy balance in the DU creates stable, slow orbits in the vicinity of the critical radius of a black hole. The DU critical radius is $r_c=GM/c^2$, which is half of the Schwarzschild critical radius.*

frames – which are linked, via the system of nested energy frames (e.g. the Solar system within the Milky Way within the local group of galaxies etc.), to the state of rest in hypothetical homogeneous space. A state of rest in hypothetical homogeneous space serves as the universal state of reference for all energy states in space.

In the DU, time and distance are universal coordinate quantities; e.g., the rate physical processes like the characteristic oscillation frequencies of atomic clocks are determined by the state of motion and gravitation via the locally available rest energy. In fact, the rest energy can be seen to maintain the energy "bookkeeping" of all objects in space. Clocks in motion run slower because they release part of their total energy to the kinetic energy in space.

In contemporary physics, the extension of special relativity into general relativity relies on the equivalence principle equalizing inertial and gravitational acceleration. The analysis of the energy balances in space shows that buildup of velocity in space at constant gravitational potential requires energy input from the accelerating system which adds the total (complex) energy of motion, whereas the velocity of free fall in a gravitational field is obtained against a reduction of the local imaginary velocity of space via local tilting of space which conserves the total (complex) energy of motion. *This means that the equivalence principle actually infringes the conservation of energy.* When derived from the zero-energy balance, celestial mechanics shows stable orbits down to the critical radius of a black hole and thereby eliminates the instabilities that appear in celestial mechanics based on the use of the equivalence principle in general relativity.

3.6. Wave Function and Quantum States

The concept of wave function meant major reorientation in the description of physical reality. The wave function is a mathematical tool used to describe the probability of the occurrence of an observable physical property. In the case of a moving particle, the role of the wave function is to localize the occurrence of a matter wave, which can be thought to potentially exist everywhere. The momentum of a moving particle is described in terms of a de Broglie matter wave localized by a Fourier development of the wave function, Fig. 6(a).

In the DU framework a mass object is described as a resonant mass wave structure. The wavelength of the mass wave is the Compton wavelength or the wavelength equivalence of the mass. For a mass object at rest in a local energy frame the momenta of the standing waves of the resonator appear as a momenta in the imaginary direction. Motion in space creates a real component of momentum, carried by the de Broglie wave. The de Broglie wave can be deduced as the net wave of Doppler shifted front and back waves of a Compton resonator, Fig.6 (b), which limits the appearance of the matter wave to the vicinity of the moving mass object – without a need to a separate, mathematical wave function.

Quantized energy states in the DU framework appear as energy minima of continuous states characterized by a
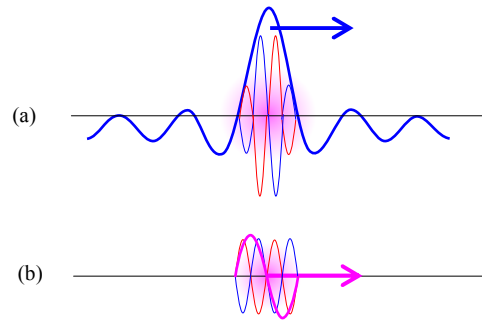

Figure 6. *Localization of the matter wave of a moving mass object. (a) In the QM-framework the localization is described in terms of a localizing wave function based on Fourier development. (b) In the DU framework, the matter wave is localized as the net matter wave of the Doppler shifted front and back waves of a Compton wave resonator describing the mass object (see Fig. 16 in [1]).*

resonance condition of the matter wave, see Section 3.3. in [1]. Many paradoxes discussed for decades in the context of interpreting quantum phenomena can be nicely solved.

3.7. Stable Structures

3.7.1. Stoney's and Planck's Scales

Historically, the first attempt to establish the linkage between gravitation and electromagnetism was the introduction of the Stoney scale units by the Anglo-Irish physicist George Stoney in the late 1800s. The Stoney mass m_S is obtained by equating the Coulomb energy of unit charges and the gravitational energy of masses m_S at distance r from each other. Planck's units are obtained by replacing the Coulomb energy with the energy of a quantum of radiation and the related wavelength. In the DU framework, atomic dimensions, and more generally, the dimensions of systems bound by electromagnetic energy are conserved in the course of the expansion of space. The dimensions of systems like galaxies and planetary systems, bound by gravitational energy, as well as the wavelength of electromagnetic radiation propagating in space, expand in direct proportion to the expansion of space. In the DU framework, Planck mass can be seen as the precursor for elementary mass objects conserving their dimension, and the Planck distance as the precursor for gravitationally bound systems in space.

3.7.2. Elementary Particles

Existing structures come in various sizes, but all are based on the stable elementary particles and atoms. The only particles stable in a vacuum are the electron, the positron and the proton. The rest of the elementary particles are unstable and either artificially made, save the neutron, or born in collisions by cosmic particles with molecules in the upper atmosphere.

The electron was the first elementary particle to be recognized from interpretations of several experiments carried out over some years. The discovery cannot be credited to one researcher, (by J.J Thomson in 1897, named by George Stoney) because a long chain of experiments, observations and

development of scientific instruments was needed; natural radioactivity (Henri Becquerel 1896) and cosmic rays (Victor Hess 1911-1912) were discovered and the first particle accelerators built (John D. Cockcroft and E.T.S. Walton 1930). The accelerators produced new particles by collisions, and a search for a theory of particle properties began. Murray Gell-Mann and George Zweig (1964) proposed the 'quark' model for the explanation of the internal structure of the elementary particles.

The Pauli exclusion principle (Wolfgang Pauli 1925) dealt with the electronic structure of atoms, and 'spin' (Ralph Kronig, Samuel Goudsmit and George E. Uhlenbeck 1925) was adopted as an explanation of the magnetic moment of the electron. Much of the confusion within the theory of elementary particles [12] can be traced to these choices.

In spite of the fact that the rest energies of the elementary particles are 100 MeV and above, the concepts adopted in the relatively low energy atomic physics were introduced into the theory of the elementary particles without notable criticism.

The Standard model of elementary particles is a theory of interactions. Particles are divided into two categories, namely leptons and hadrons. The Standard model does not account for the physical properties of the leptons (electron, muon, tau and their neutrinos), but assumes the hadrons to be composed of even more elementary constituents called quarks, kept together by gluons. The Standard model does not enable calculation of accurate values for the measured properties of particles, which are the rest energy, magnetic moment and the elementary electric charge. This situation is especially disturbing for the electron and the proton, which are the basic constituents of matter.

3.7.3. Search for Order in Natural Structures

Antique astronomers tried to find regularities in the observed motions of celestial objects in order to figure out a structural model of the skies. Eudoxus's model based on homocentric spheres around the Earth, and Philolaus's model based on a Central Fire, reflected the Pythagorean idea of spheres as perfect forms – like also the models of Heraclides and of Aristarchus questioning the central position of the Earth. The epicycle model as a purely empirical, Earth-centered description of the planetary motions took over due to its better accuracy – even though the antique astronomers understood it as a mathematical tool rather than a structural model. A functional model of the planetary system had to wait for Copernicus's Sun-centered model: Kepler relied on Copernicus's Sun centered system, and found the elliptic orbit in his search for mathematical beauty in the system.

Kepler is also known for his search for a geometric model of the Solar system, known as the Platonic solid model. However, it took circa 170 years until a mathematical rule for the distances from the Sun of the planets was found by Bode and Titius. The rule is called the Titius-Bode (T-B) rule. The mathematical expression for the rule can be represented as $r=4+n$, where r is the semimajor axis of the orbit, $n=0, 3, 6, 12,$

asteroids, 48, 96 …, and the semimajor axis for the Earth is 10 ($n=6$). A doubling behavior can be seen in the values of n, but until now no generally accepted theory has been presented for the T-B rule.

3.7.4. Period Doubling

Period doubling is a universal property of nonlinear dynamical systems. It can be rather safely stated that no natural process is truly linear, and that the period doubling phenomenon should be almost omnipresent in natural dynamical systems. Lehto [2] has recently shown that the internal structures and physical properties of particles like the electron, proton, neutron and the lambda particle can be calculated from the Planck time (period) assuming period doubling in three and four internal degrees of freedom.

The same applies to the structure of the Solar system. Furthermore the quantized redshifts of the Local Group of galaxies, if interpreted as velocity, fit the velocities produced by the period doubling process. This is known as the Lehto-Tifft rule [13]. Interestingly, a direct connection between the electron-positron pair, the Hydrogen magnetic moment reversal and the cosmic background radiation is also found. Period doubling discloses the mechanism of the buildup of stable structures and gives a unifying explanation for the physical properties of matter.

3.8. From the Whole to the Local

The most fundamental re-evaluation of the theory structures comes from the holistic perspective of the Dynamic Universe. Instead of concluding the structure of whole space from local interactions and the postulates behind those, the DU first postulates the structure of space as the energetically optimal structure closing a 3-dimensional entity; the 3-dimensional surface of a 4-sphere. Following the principles of energetics, energizing of mass in space appears as a result of the contraction – expansion process of the 4-sphere. The singularity turning the contraction phase into the ongoing expansion phase replaces the concept of Big Bang in the standard cosmology model. Accordingly, the energy of mass did not appear instantly as an undefined quantum fluctuation, but via a long-lasting process following the laws of dynamics identified in our observable environment. The buildup of local energy structures, from elementary particles to galaxy groups, is guided by period doubling mechanism and the conservation of the total zero-energy balance of gravitation and motion in space. Local structures are not stochastic entities but definite parts of the whole. The rest energy of any mass object is counterbalanced by the gravitational energy arising from the rest of space.

Mathematically, the Dynamic Universe shows the development of the universe from emptiness in the past – via singularity – to emptiness in the future – or via a finite turning point back to a new cycle of energy buildup and the expression of physical existence.

4. Summary

Present theories are results of a long evolution path from antique metaphysics to modern empirical sciences and mathematical physics. Antique metaphysics stressed primary causes and fundamental principles but disregarded empirical support for the ideas. A fresh start in the Late Middle Ages stressed empiricism as the basis of scientific development. Important choices made, were the postulation of the relativity principle by Galileo Galilei, and the equivalence principle by Isaac Newton, who set the bases of mechanics for more than 200 years. Force received the status of a base quantity in physics – the importance of the concept of energy as work and integrated force had to wait for the introduction of electromagnetism and thermodynamics. Energy was recognized as a primary conservable. In the framework of relativity theory, mass was interpreted as a form of energy, which linked the historically older conservation law of mass with the more general conservation law of energy.

Conservation of the balance between the centripetal force by gravitation and the centrifugal inertial force by orbital motion in Newton's solution of the planetary system required the Copernican system description defining the structure of the planetary system. Conservation of energy in a thermodynamic system requires the definition of the closed system studied. In quantum mechanics, a closed system is defined by boundary conditions; the energy conserved is typically described in terms of Hamiltonian as the sum of the kinetic energy and the potential energy in the system – following the basic principles of energetics.

The Dynamic Universe extends the scope of energetics to space as a whole by closing the 3-D space through the fourth dimension assuming the simplest and "most perfect" possible geometry, a sphere. The spherically closed 3-D entity appears as the 3-surface of a 4-sphere. *As an effective mathematical tool, the DU applies complex function presentation of energy and its constituents: mass, motion and structure.* The momentum, angular momentum, and the energy of motion are expressed in terms of mass and motion, the potential energy in terms of mass and distance. Mass as the common factor in all expressions of energy can be defined as the "wave-like substance" for the expression of energy – covering also the forms of electromagnetic energy. The complex function formalism discloses the linkage between the dynamics of space as the imaginary component and the dynamics in space as the real component of the complex energy expressions.

Local structures in the DU are derived through multistep diversification processes from the whole – in contrast to the reductionistic scheme of building the whole as the sum of local structures. Period doubling can be seen as a universal mechanism in the buildup of local structures − from elementary particles to galactic systems. Any local structure is linked to the rest of space – to the whole. Any motion in space is linked to the motion of space in the direction of the 4-radius of the structure.

As a holistic approach, the Dynamic Universe starts from the whole and devolves down to the local. The holistic, energy
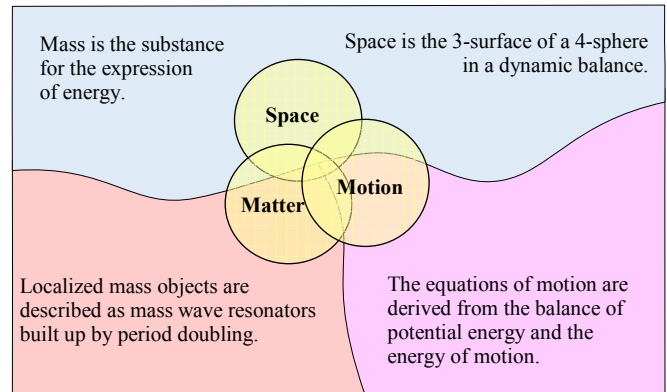

Figure 7. *Solving the puzzle with a holistic view of the universe. Space is described as an energy system with the energies of motion and gravitation in a dynamic balance.*

system based approach of the Dynamic Universe means a radical reduction in number of postulates. The description of space, matter, and motion can be based on postulates in common, Fig. 7. *The DU is primarily an analysis of the energy resources available for the manifestation of physical processes and structures in space*.

The Dynamic Universe is a unifying theory. Instead of unifying the current theories it creates bases for a theory in common to the subareas in physics and cosmology. *A key issue is a unified expression of energy which allows physical interactions to be studied as energy conversions rather than force interactions*. The unified expression of energy is achieved once mass is identified as the wavelike substance for the expression of energy, and the energies of motion and gravitation are expressed as complex quantities combining the local effects with the effects related to the rest of space. In view of the studies of Tuomo Suntola and Ari Lehto the basic principles governing the universe are truly simple: spherical symmetry, conservation of total energy, and period doubling in nonlinear dynamical systems.

Acknowledgment

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