Chapter

The Hot Disputes Related to the Generation of a Unified Theory Combining the Outcomes of ER and EPR Papers

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Abstract

We suggest a mathematical formulation which shows that gravity is the materialization of energy in space, which at zero energy input ($\mathbf{E_{ap}} = 0$) in the form of entanglement of virtual space and time phases returns an event to the initial background state with restoration of the original elementary space-time frame. Based on the suggested model, the matter-antimatter relation results from the non-uniform energy conservation principle while satisfying the conservation of energy within the boundary-mapped space-time frame. The suggested approach shows that the generation of mass is the requirement of energy conservation. The mathematic model of energy conservation involves the conjugation of the dynamic local state of space and time variables with the local energy-momentum relation, which at different energy inputs can operate at the small scale of quantum physics and the large scale of relativity. The suggested theory shows that commutation of local space-time position and energy-momentum exchange interaction is the only way for conservation of energy and momentum within a discrete space-time frame.

Keywords: Relativity, quantum mechanics, conservation of energy, origin of space-time

1. Introduction

The history of physics involves two great revolutionary theories: relativity and quantum physics. Quantum mechanics and general relativity operate at different space and time scales; therefore, the main problem for unification of these theories is due to the "mystery" of the scale of variables.

Recently, a new approach [1–3] for the unification of general relativity and quantum mechanics was suggested, which involves reconciling relativity's black hole space and quantum entanglement. Science News [4, 5] announced that a new equation ER = EPR, generated from Einstein's papers [6, 7], may provide a possible path for connection of principles of general relativity with quantum mechanics. Maldacena and Susskind [2] suggested that two distant black holes of general relativity, connected through the interior wormhole (Einstein-Rosen bridge), could be interpreted as the entangled EPR's pairs of two black holes. Maldacena and Susskind [2] showed that the formula ER = EPR (bridge between Einstein-Rosen

(ER) wormhole [6] and Einstein-Podolsky-Rosen (EPR) entanglement [7]) can be the cornerstone of the new physics theory, connecting relativity and quantum mechanics through space-time wormholes.

Grant [5] suggested that the connection of entanglement with the space-time might help to understand the origin of space-time and its behavior at the small scales of quantum mechanics.

Siegfried [8] also discussed the ER = EPR equation as a possible approach for connection of space-time geometry of relativity with the quantum entanglement.

Van Raamsdonk [9] showed that the existence of space-time is due to the quantum entanglement in the corresponding quantum system.

Carroll suggested [10] a similar approach in accordance of which space can emerge from a quantum state. Caroll's comments on connection of space-time curvature with energy are similar to the statement of general relativity, but in this approach, origin of space connected with the quantum entanglement.

While a path to quantum gravity through the wormhole became a very hot topic for the generation of new physics, it could be very useful to return to the ER [6] and EPR [7] papers to summarize the basic principles on how the combination of outcomes from the ER and EPR papers may unify different scale interactions.

The main idea of the ER paper [6] is a presentation of the physical space by field equations where space involves two identical, equal halves, separated by the symmetry and connected by a Wormhole Bridge. The separated halves of space describe the same physical space. The idea of this approach is the application of space field equations for the description of quantum level interactions.

The ER bridge, which is also called a wormhole, denotes a shortcut connection between widely separated regions of space-time. In accordance with the hypothetical equation ER = EPR [1–3], an ER wormhole between two places of space could be considered as an entangled pair in quantum mechanics.

It is necessary to note that the ER paper [6], as was claimed by the authors, does not contain the quantum phenomena and the interaction between two identical pieces of space does not lead to the "quantization of gravity."

The EPR paper [7] gives an analysis of the basic principles of quantum mechanics such as the description of state by the wave function to predict a particle's behavior. It establishes the now well-known cornerstone of quantum mechanics that two physical quantities such as position and momentum of a particle cannot be precisely determined simultaneously and that these two quantities cannot have simultaneous reality. The authors showed that the quantum mechanical description of physical reality given by wave functions is also not complete and it is necessary to assign two different wave functions to the same reality.

It is necessary to note that the conjugation of statements of the ER [6] and EPR [7] papers does not reveal a non-hypothetical mathematical equation of a dynamical event, which may explain physical reality regardless of scale.

2. The main principles of ER and EPR papers

We can select important statements of these papers, which were the cornerstone [1–3] for the unification of relativity with quantum mechanics:

a. Entanglement (connection) of two equal pieces of space through the "Wormhole Bridge" of relativity theory [6].

b. The common uncertainty principle of quantum mechanics is that when the momentum of a particle is known, its coordinate has no physical reality [7].

We should concentrate our attention to the statement of quantum mechanical uncertainty to understand why the combination of general relativity with quantum mechanics does not generate a valid mathematical formulation, which is applicable for small- and large-scale interactions.

First, it is necessary to show that a particle may have a certain identity when the change of energy in time (conservation of energy) has commutation with the change of energy, consumed in space phase of a particle (conservation of momentum). The mathematical description of momentum may be valid only if the emerged formulation comprises residing of energy-momentum exchange interaction within boundary-mapped space-time frame.

Therefore, momentum "as the quantity of motion" alone without locality is uncertain and cannot give a proper mathematical description of this quantity in any physical theory. If momentum conservation has no commutation with the energy conservation within the space-time frame, it cannot describe an event in a proper way. However, without the space-time boundary, it is difficult to get commutation of energy-momentum conservation laws. Description of motion by a model, involving a certain local boundary of the dynamical space-time frame, generates a reference frame independent of the true momentum conservation principle.

Quantum mechanics states that position and momentum cannot have simultaneous reality, due to the application of the mathematical formulation of uncertainty, which conjugates position, independent from space-time and momentum and also independent from the action-response interaction.

The Heisenberg uncertainty principle in not a mystery of nature; rather, it is an improper mathematical formulation, which does not involve missed local space-time position and conjugation of a local position with the applied force, leading to the change of momentum.

An event of measurement is not a simple displacement of a particle position in the abstract Hilbert space, but it is the change of space-time phases as an outcome of energy-momentum action-response interaction. Therefore, change of position of a system is not a linear transformation of the space dimension; it should describe commutation of local space-time frame with the action-response energy-momentum exchange interactions.

It is necessary to show that commutation of two parameters, such as local space-time position and energy-momentum exchange interaction, is the only way for conservation of energy and momentum within the discrete space-time frame.

The concept, describing entanglement of two pieces of space [6], does not explain the driving force behind why two equal pieces of space, separated by less than two black holes, may form entangled pairs. The two-space piece entanglement approach describes entanglement of two space pieces in abstract space, while space does not have independent existence, and it changes only within space-time frame.

For description of entanglement of particles simultaneously in space and time, we need a proper structure of space-time frame. However, a description of events with the proper mathematical formulation involving dynamical space-time is the main problem associated with physical laws. As was shown by Merali [11], without knowing the origin of space-time, we will not understand physical laws. General relativity suggested the revolutionary idea that space-time and gravitational fields are the same, but an "Einstein's matter," which curves space-time, is an external entity and has no inner connection with the space-time frame. Another problem of general relativity is that its space-time has no background frame.

Rovelli's statement [12] that space-time has a relation to the electromagnetic field is the modification of general relativity. The main problem of the Rovelli's statement is that he describes quanta as an independent identity, which cannot live in space-time. Rovelli's statement did not reveal a mathematical formulation, and its quanta have no commutation with the space-time frame. The other problem of this approach is the locality of the quanta, while any particle or antiparticle cannot have independent existence.

According to Rovelli's opinion [12], there is no difference between a gravitational field and space-time, and the locality of a particle can be defined with respect to the gravitational field. This approach is similar to the Newtonian concept that acceleration has a meaning with respect to the gravitation field. However, any field, particularly a gravitational field, cannot have an independent existence; therefore the relation of locality to the gravitational field leads to the uncertainty in quantum mechanics.

Smolin [13] developed quantum field theory and suggested that at the Planck scale, space exists in the form of fundamental discrete units instead of general relativity's continuous space-time frame. But quantum field theory, similar to Newtonian physics, do not have space-time structure, which interacts with the event. The origin of discrete space and the condition of its independent existence is also not clear.

Therefore, different views on space-time and the absence of the origin of the background of space-time frame in both theories is the main problem for reconciling these theories into the unified theory. One of the main problems of these theories also is the locality of a particle in the space-time frame.

Einstein showed that space and time are simply different dimensions of the same space-time continuum. By his opinion, energy and momentum are the same quantities of space-time, which has four dimensions. The relative quantity of energy and momentum depends on the observer.

The problem of this approach is that the dynamical nature of the space-time variables connected within the continuum framework, which did not allow distinction of the local properties of time and space identities. General relativity determines the dynamics of matter by the geometry of space-time and does not explain the origin of the mass and energy, which curves the structure of space-time. The problem of Newtonian physics, regarding how the moving body responds to action in relativity theory, also remains an open question.

Unfortunately, the basic formulation of general relativity does not provide the answers to these questions. That is why the theory of relativity itself became the "observer" between Newton's physics and quantum mechanics.

It is necessary to note that problems of founding a unified theory are due to the problems of energy conservation, which is not complete in the theory of relativity and quantum physics. The approaches related to the generation of a unified theory do not use the principle of conservation of energy as the basis for the unification of relativity and quantum physics. The theory of relativity has a problem with the conservation of energy, which leads to the problem of singularity at small scales. Quantum mechanics suggests that particles borrow energy for some time and then return them. However, quantum mechanics does not explain the origin of this energy, which is borrowed and conserved in the wave function.

It is clear that for the generation of unified theory, we have to find a proper mathematical formulation of the conservation of energy, covering the higher scale space-time of relativity and the small-scale quanta of quantum mechanics. The model connecting relativity and quantum mechanics should involve the dynamic local state of space and time variables which, independent of the energy input, can operate between the small scale of quantum physics and large scale of relativity.

The known statements of Noether's theorem on conservation of energy, being philosophical in nature, are not applicable for generation of a mathematical formulation of the space-time picture of a particle.

Lagrange and Hamilton have suggested the conservation of energy in the form of differential equations, which is widely used in classical and quantum mechanics.

The problem associated with these differential equations is that they describe the dynamical laws in abstract space with an independently moving interval of time.

Another principle, which is related to the conservation of energy, is the Lagrangian action principle. For the action integral to be well defined, the trajectory has to be determined simultaneously in time and space coordinates. However, the Lagrangian action principle does not cover these requirements.

Usually, the known mathematical formulations of dynamical laws either simplify space to conserve the details of time or simplify time to preserve the spatial dimension. The Lagrangian or Hamiltonian mechanics are the examples of such an approach, which was the reason for the replacement of differential equations of classical physics by Schrödinger's wave function.

To compose a unified theory, first, it is necessary to solve the locality problem of classical physics and quantum mechanics, which describe an event as a change of state of something without relation to something itself.

3. Commutation of space-time with the principle of conservation of energy

In our early studies [14–16], we suggested that the change of a function in relation to its local position ($\mathbf{\Delta f/f_1}$) could be a sufficient entity for the identification of change. The non-unitary function $\mathbf{\Delta f/f_1}$ with the fractional feature has a "quantum mechanical behavior": the classic operator in the form of $\mathbf{\Delta f/f_1}$ portion describes the fraction of the change (spinning or vibration) of a function around its dynamical initial locality to repeat its origin. Similarly, the operator $\Delta\mathbf{S}/\mathbf{S}_1$ describes the fluctuation of space with the applied force in relation to its origin, while the operator $\Delta\mathbf{t}/\mathbf{t}_1$ describes the fluctuation of time about instant of action.

In the conjugated space-time field frame, the position of a particle, localized within the space-time frame in relation to its origin, is not a point; it exists within a very certain discrete non-virtual space-time manifold, commuting dynamic energy, which is distributed within space and time fields. On this basis, the origin of space-time is the energy, which generates space-time and holds its conservation within space and time phases.

In accordance with the above-described principle of conservation of energy within the space-time frame, the space-time becomes the resulting non-unitary inner product of energy distribution, which comprises the portions of energy consumed in space phase (event mass) and restored in time phase:

$$\frac{\frac{\Delta \mathbf{S}}{\mathbf{S}_1}}{\frac{\Delta \mathbf{t}}{\mathbf{t}_1}} = \frac{\mathbf{E_{ap}} - \mathbf{E_s}}{\mathbf{E_s}} \tag{1}$$

$$\frac{\Delta \mathbf{S}}{\Delta \mathbf{t}} = \frac{\mathbf{S}_1}{\mathbf{t}_1}\left(\frac{\mathbf{E_{ap}}}{\mathbf{E_s}} - \mathbf{1}\right) \tag{2}$$

$$\lambda = \frac{\mathbf{E_{ap}}}{\mathbf{E_s}} - \mathbf{1} \tag{3}$$

at $\lambda = 1$, $\mathbf{E_{ap}} = 2\mathbf{E_s}$.

$\mathbf{S}_1$ and $\mathbf{t}_1$ are the space and time variables corresponding to the dynamic local boundary; $\mathbf{E_{ap}}$ and $\mathbf{E_s}$ are the energies of action and under action systems of interaction at conditions corresponding to the local boundaries of $\mathbf{S}_1$ and $\mathbf{t}_1$. On this basis, the space and time phases, which "absorb" applied force and carry energy, attain features of an energetic field. The minimum portion of quanta generates an elementary space-time frame.

The portion of energy conserved in space phase ($\mathbf{E_s}$) generates momentum of a particle with the mass, which curves the space-time frame to bring energy conservation to the initial state. Therefore, the space-time itself generates curvature to hold the conservation of energy within the boundary-mapped space-time frame. As Eq. (2) shows, the increase of $\mathbf{E_s}$ and the reduction of ($\mathbf{E_{ap}} - \mathbf{E_s}$) function gradually generate a curved space-time which in the form of gravitation returns an event to the initial state.

In accordance with Eq. (2), conservation of energy does not exist without localization in space-time frame, and the localization has to be non-uniform. It is easy to show that space and time are the resulting non-unitary portions of a non-uniform distribution of energy, consumed in space phase (forming mass) and restored in time phase:

In accordance with Eq. (2), the energy portion inserted to the space-time frame travels through wave of exchange interaction and determines the exact pathway of a particle. The right side of Eq. (2) describes the frequency of energy consumption in space by the matter particles, while the left side shows the frequency of the change of space and time wave fields. Following Einstein's approach that energy and momentum are the same quantities of space-time, we can show that the right side of Eq. (1) shows the ratio of available energy and momentum, commuted with the left side space-time frame. The entities $\Delta\mathbf{t}$, $\mathbf{t}_1$ and $\Delta\mathbf{S}$, $\mathbf{S}_1$ perform as the same identities of energy carrier, existing in the opposite phases. Equation (1) describes a mathematical formulation of the energy-momentum relation where space and time are the products of energy conservation and energy-momentum ingredients are the conjugated outcomes of space-time. Therefore, energy and momentum are same quantities as Einstein stated; moreover, space and time are the inner products of the energy-momentum conservation.

Now we may give specification of space, which is different from Caroll's [10] statement. We think that the relationship between space-time curvature and energy is the natural consequence of a non-uniform conservation of energy, which generates a space-time frame, carrying non-separable portions of boundary-mapped energy.

We can now give specifications of entanglement based upon the conjugation of the space-time frame with the energy resources. The phenomenon called entanglement may appear only within conjugated space and time phases, carrying conservation of energy-momentum pairs though growth of the space-time frame.

Thus, any interaction of two different pieces of space (entanglement) in reality is the entanglement of space and time phases carrying out the conservation of energy through portions of energy, distributed within these phases. The space phase without entanglement with time cannot exist. The identity called space is the materialized portion of energy, while time destroys the material portion of energy, bringing an event to the initial state. When all the available energy is consumed in space ($\mathbf{E_{ap}} = 0$), "space" particles decay to "time" antiparticles.

The entanglement of space and time phases as displayed in the form of gravitation appears with the accumulation of energy in space phase and generation of tendency to return space phase back to the background state.

The right side of Eq. (1) describes particle and antiparticle relations. Equation (2) treats the matter field through space phase, while the antimatter field is treated with the time phase. The coupling of these phases in space-time unit carries the non-uniform conservation of energy. Therefore, mass does not exist out of space-time and does not appear by sudden spontaneous symmetry breaking; at zero mass of particles, energy is not conserved.

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4. Matter-antimatter asymmetry

The space-time symmetry, which may present matter-antimatter symmetry, is possible only when energy is equally distributed between two phases. In this case, "energy is not consumed and not destroyed." This is the timeless symmetry, which violates the classical principles of energy conservation that "energy is neither generated nor destroyed but rather is transformed from one state to another."

At the small scale, energy distributed in the small portion of the space phase in the form of mass is low, and energy is predominantly distributed in time phase ingredients, performing as antiparticles. This situation takes place in the case of a proton. The total mass of quarks, forming protons, is much smaller than the mass of protons.

We can now explain matter-antimatter asymmetry and the generation of more particles than antiparticles in a pair of collision experiments. To conserve energy, any action should lead to the consumption of energy ($\mathbf{E_{ap}} < \mathbf{2E_s}$) in order to eliminate infinite timeless symmetry. The condition $\mathbf{E_{ap}} = \mathbf{2E_s}$ describes symmetry which is possible when two particles exist in symmetry with one antiparticle. This condition takes place only in proton-neutron pairs, which carry discrete symmetry of quarks with 1:2 relations.

In accordance with Eq. (2), due to the consumption of kinetic energy of collisions for the locality of generated particles, the energy carried by the produced particles is less than the energy required to restore particle-antiparticle symmetry.

The boundary-mapped space-time frame, involving a limitation on maximum velocity of the speed of light, is a requirement for energy conservation. Equation (2) presents the boundary of space-time by local position, dynamically growing in accordance with the available portion of energy. In a simple form, if there is a local position, there should be a boundary of the change of the energy, which carried by the space-time field.

The left side of Eq. (2) involves the dynamic conservation of the space-time frame as non-unitary "grains," while the right side shows the non-uniform conservation of the energy-momentum exchange relation, carrying the dynamic flux of the energy portion to the local $\mathbf{S_1}/\mathbf{t_1}$ metric of space-time frame. The gradient of energy in relation to the initial state $(\mathbf{E_{ap}} - \mathbf{E_s})/\mathbf{E_s}$ as an equivalent form of space-time "grain" becomes the "non-unitary quanta" which describes the change of the local space-time frame as an exchange interaction of a particle with the applied force. The portion of energy, distributed in space and time phases, determines the strength of force and repulsive reaction (inertia) of matter.

It is easy to show that the non-uniform conservation of energy has to be the ground concept for the unification of relativity and quantum physics. Starting from the basic statement of general physics that energy is conserved through its conversion from one form to another, we arrive at the concept that a dynamical event of energy conversion has to have locality within finite space and time coordinates. In principle, the features of energy conservation during its conversion from one form to another are clear from Planck's theory of black body radiation, which changes the frequency of energy with radiation. The change of frequency of radiation is the result of non-uniform locality of energy within the space-time field.

The known statement of energy conservation that energy can neither be created nor destroyed but can only be transformed from one form to another does not involve the space-time frame of this transformation. Noether's theorem, describing energy and momentum conservation, separately also does not describe change of energy in space-time frame because time and space are not separable entities.

The non-uniform conservation of energy leads to the collapse of the concepts on uniformly moving different reference frames in relation to which all-physical laws are valid. It is clear that even light cannot be the reference frame because light energy is non-uniformly conserved.

Eq. (1) shows that the space-time frame, which emerges from the non-uniform splitting of photons, is the fundamental building block of energy and matter: the space-time frame generates ordinary matter, which in energy-mass exchange interaction carries accelerated conservation of energy.

Within the non-uniform conservation of energy through the space-time frame, the unification of electromagnetism with the space-time frame becomes an obvious concept. The multiple $\mathbf{S_1/t_1}$ $(\mathbf{E_{ap}/E_s} - 1)$ of Eq. (2) is the localization of the electromagnetic field $(\mathbf{E_{ap}/E_s} - 1)$ within the local space-time $\mathbf{S_1/t_1}$ frame. The local space-time $\mathbf{S_1/t_1}$ metric undergoes change with the consumption of energy flux. The energy flux $(\mathbf{E_{ap}/E_s} - 1)$ is not uniform and presents the local energy portion, remaining from the exchange interaction. That is why electromagnetism is not Galilean invariant.

Equation (2), due to the involvement of the local frame of space-time and exchange energy-mass interaction, predicts the precise measurement of velocity and the local position of a particle; the exchange interaction eliminates the reference frame phenomenon, and different observers will have the same measurement if they have the same exchange interaction, coupled with the local position.

Equation (2) explains the uncertainty principle in a way that, in order to probe the small scale of space, we have to apply large amounts of energy. Probing the state of a particle to get information is possible only through an exchange interaction. At the Planck scale, there is no space-time frame, and the exchange interaction (2) is the reason why we cannot obtain any information and probe the state of a particle at Planck's scale. On this basis, by probing vacuum we can get information only on discrete uniform conservation of energy in the form of particles-antiparticles, breaking the symmetry with the formation of the space-time frame.

The condition, when the portion of energy conserved in space phase is equal to the portion of energy in time phase, could be considered as a uniform conservation of energy in the form of "Noether's symmetry." This condition corresponds to the relation:

$$\mathbf{E_{ap}}=\mathbf{2E_s}\ (2)\ \mathbf{\Delta S/S_1} = \mathbf{\Delta t/t_1}\ (3)\ \mathbf{\Delta S/\Delta t}=\mathbf{S_1/t_1} \qquad (4)$$

At the condition (3), the unlimited translation of energy portions between the opposite phases of space-time variables in the form of matter-antimatter fluctuations should lead to the "ultraviolet catastrophe." However, annihilation takes place within an asymmetric space-time frame; therefore, the non-uniform distribution energy moves in the direction of space expansion, which eliminates the ultraviolet catastrophe. On this basis, continuous uniform conservation of energy, matter-antimatter symmetry, and uniform continuous existence of any type of symmetry is impossible.

In symmetry, the space-time manifold of a particle after the change should look the same (4). But at $\mathbf{E_{ap}} = \mathbf{2E_s}$ (2), the space and time fields are symmetrically interchangeable only in a discrete mode (2) where after the change the space-time frame holds the local state (4) only within the frame of discrete symmetry.

We think that the performance of the three particles of baryonic space-time **n-p** matter in the form of boson-fermions relations follows this requirement. Therefore, without discrete performance of energy-mass exchange interaction in an elementary space-time unit, baryonic matter cannot exist in a symmetric manner. The strong and weak forces appear as the coupling product of exchange interaction in order to hold the discrete symmetry of the space-time frame of the baryonic matter.

In accordance with the non-uniform conservation of energy, the spin as the space-time identity is the "face" of a particle. The particle may have identity of baryonic structure if it has the space-time frame in discrete symmetry at $\mathbf{E_{ap}} = \mathbf{2E_s}$ with the participation of dynamic three jet particles.

Therefore, within the principles of non-uniform conservation of energy, light is not a uniformly moving reference frame. Light photons cannot exist without space-time frame and, due to the moving within the non-uniform space and time phases, have features of electromagnetic wave.

The space-time, which has to carry conservation of energy, generates a non-virtual local frame and moves it relative to the state of energy restoration.

The condition $\mathbf{E_{ap}} = 0$ of Eq. (2) is the background state of the discrete space-time field where asymmetric space and time variables, for maintaining conservation cycles, undergo the discrete translation as the portions of energy in the different fields. At this state, all types of the interactions are discretely unified.

In accordance with Eq. (2), the gravitational field is the reverse phase of the electromagnetic field (negative energy solution), which restores energy at the origin. In the gravitational field, there is no space-time frame, while the electromagnetic field generates the space-time field and moves in the form of a wave through this frame. Due to the conservation of electromagnetic waves through the space-time frame, it propagates through transverse waves, while gravity moves back to background state through a longitudinal wave.

It is necessary to note that it is not possible to get singularity-free quantization of space without a background space-time frame. The time parameter in quantum mechanics is an external entity, and quantum theories do not provide a dynamical space-time frame. The model in the form of Eq. (2) provides an entirely new function for the quantization of time.

Model (2) shows that energy appears as the inner product of the coupling of space and time fields (right-handed translation), and in reverse order, the origin of space-time variables is the decay of energy into virtual space and time entities (left-handed translation), with restoration of energy at the background state. This is the non-uniform, non-static conversion of energy from one form to another. On this basis, time appears as the product and boundary of the discrete non-Noetherian dynamic conservation of energy, carrying energy within the space-time frame. Due to the action-response interaction (2), we observe an event only in the past.

Model (2) describes a background-dependent space-time frame where the background state is not a fixed state but the dynamical origin of energy conservation cycles.

The space and time phases of energy conservation at the background Planck scale do not have a space-time frame; rather, they exist in the form of condensate without a shape. This approach is different from Wheeler's opinion that at Planck scale space and -time have a space-time foam [11].

According to Rovelli, [11] the state of the system may be certain when it has reference to a second physical system. In accordance with model (2), the second system is the applied force (energy) which generates the exchange interaction.

5. Detailed features of the uncertainty principle of quantum mechanics

Now based on model (2), we can explain details why the combination of momentum-position in quantum physics leads to uncertainty. Model (2) predicts that local position in the form of a point cannot give information about momentum or position, which can be relevant only to the exchange interaction with the applied force. Force and an event individually have no free existence, and they exist only through an exchange interaction. The exchange interaction generates velocity, which describes this interaction in the form of discrete packets showing how many times the reflected energy of exchange interactions repeats that interaction.

The uncertainty principle describes the commutation of momentum and position in the form, which does not hold conservation of energy. The uncertainty principle does not describe the change of position within the space-time frame and presents momentum without the energy-momentum exchange interaction.

When there is no applied energy ($E_{ap} = 0$), gravitational and inertial forces cancel each other, and a particle falls back to the initial state. This approach explains electromagnetic phenomenon, which has to be understood through interaction within two space-time frames.

Local position has conjugation with the force (energy) carrying particle which itself is a carrier of space-time. Therefore, a local position exists only through interaction with the force-carrying particle, which does not obey Lorentz symmetry.

Model (2) involves the exchange of interaction of energy portions in space-time instead of the curvature tensor of relativity. Inertia is not determined by mass itself because the mass of a particle has no independent existence.

Model (2) involves the energy-momentum exchange interaction and, similar to Maxwell's antisymmetric field tensor, describes antisymmetric energy distribution in the space-time field.

Particle physics connects the formation of mass with the breaking of symmetry, but symmetry, as is known from Neother's theorem, is associated with the conservation law. Therefore, breaking of symmetry has to be analyzed within the principles of energy conservation.

The model of non-uniform conservation of energy (2) involves the commutation of space-time and energy-momentum ingredients that explains symmetry breaking in the distribution of energy within the asymmetric boundaries of space and time phases.

It is obvious that non-uniform conservation of energy within an asymmetric space-time frame excludes the existence of continuous symmetry of particles-antiparticles, whereas continuous symmetry needs infinite energy resources to hold symmetry.

Model (8) connects space-time position with the energy-momentum exchange relation and shows that this relation within space-time boundary-mapped frame cannot be subject to uncertainty because position as a spatial variable does not have existence, independent of time.

6. Principles of generation of mass and gravitation

One of the main problems related to the generation of mass by spontaneous breakdown of continuous symmetry, given by the Higgs mechanism, is that this mechanism does not connect the generation of mass with the space-time locality of a particle and does not explain why background continuous symmetry has to be broken in an unnatural way. The mechanism of mass generation also has to explain why collision experiments produce more matter particles than antimatter particles.

In this chapter, we will discuss how the non-uniform energy conservation concept is an alternative mechanism of mass generation. The non-uniform distribution of energy portions within asymmetric space and time phases requires generation of fields with different energetic properties (frequency and amplitude) which is the only way for carrying conservation of energy through these fields. The coupling of two fields with different energetic properties as energy consuming and energy restoring phases generates the non-virtual space-time frame, which appears to be the non-uniform conservation of energy through energy-mass exchange transformations ($\mathbf{E_{ap}/E_s} - 1$).

The background state of a space-time frame is the relation of virtual asymmetric space and time phases, which proceeds through the conversion of energy from one form to another (8), through the translation of asymmetric entities, such as $\mathbf{\Delta S/S_1}$, $\mathbf{\Delta t/t_1}$, carrying energy portions as virtual matter and antimatter particles.

We can describe the non-uniform background energy-mass translation by conversion of light photons to electron/positron pairs, which is a well-known quantum mechanics translation event. Quantum mechanics states that during this translation, energy conservation is held by fluctuations, such as particles that borrow energy and return it after a very short time:

$$\boldsymbol{\gamma}/\boldsymbol{\gamma} = \mathbf{e}^+/\mathbf{e}^- \tag{5}$$

The energy-matter translation given by Eq. (5) does not count the time phase of energy conservation and the locality of the produced particles, while the translation between photons and leptons takes place in abstract space. Equation (5) could be the discrete translation of energy in the form of infinite fluctuations of the background quantum state. It is clear that in this case there is no natural way for breaking of the continuous symmetry of discrete fluctuations, forming time-independent infinite symmetry of matter-antimatter relations. Equation (5) does not reflect the borrowed time in the change of energy.

Conservation of energy requires a certain finite frame for locality, therefore space and time cannot exist as separate variables. The formation of a particle within any time scale without locality in space phase leads to nonconservation of energy.

On this basis, we replaced Eq. (5) with the relation:

$$\boldsymbol{\gamma}/\boldsymbol{\gamma} = -(\mathbf{e}^+/\mathbf{e}^- + \boldsymbol{\nu}_\mathbf{e}/\boldsymbol{\nu}_\mathbf{e}{}^-) \tag{6}$$

The right side of Eq. (6) involves an additional identity in the form of neutrinos to cover the missing part of energy conservation in a time-dependent frame. Equation (6) represents the mechanism of energy conservation, which involves the decay of energy into asymmetric space and time field particles (2), characterized by different energy densities. Conversion of light photons from one form to another for conservation needs the generation of phase differences, which appears with the formation of $\mathbf{e}^+/\mathbf{e}^- + \boldsymbol{\nu}_\mathbf{e}/\boldsymbol{\nu}_\mathbf{e}{}^-$ pairs.

The space field particles, comprising $\mathbf{e}^-/\mathbf{e}^+$ pairs, have more energy density, while time phase particles, comprising $\boldsymbol{\nu}_\mathbf{e}/\boldsymbol{\nu}_\mathbf{e}{}^-$ pairs, have energy portions of a high frequency. It is precisely for this reason that the mass for neutrinos is significantly less than that of electrons. The right-handed antineutrino and left-handed neutrino pair together with the electron/positron pair represents the distribution of energy within virtual space and time phases. Due to the locality within space, close to Planck's size, the performance of virtual matter particles became time-dependent, and it attains a velocity less than the speed of light photons. Hence, the parity translation (6) became non-invariant.

Generation of $\mathbf{e}^-/\mathbf{e}^+ + \boldsymbol{\nu}_\mathbf{e}/\boldsymbol{\nu}_\mathbf{e}{}^-$ particles (6) is the translation of the energy of photons to virtual space and time phase particles which could be specified as "empty space" particles. The "empty space" is the medium where $\mathbf{e}^-/\mathbf{e}^+ + \boldsymbol{\nu}_\mathbf{e}/\boldsymbol{\nu}_\mathbf{e}{}^-$ particles form a fluid with a continuum spectrum. In the absence of energy flux ($\mathbf{E_{ap}} = 0$), a loss of the space frame takes place with the translation of virtual particles back to photons. However, particles before giving the "borrowed' energy back lose localization in space phase and lose some portion of the energy which has to go in parallel with the absorption of photons by $\mathbf{e^-/e^+}$ pairs. This phenomenon is the main feature of energy nonconservation during the return of "borrowed" energy of quantum fluctuations. Generation of space phase and distribution of energy in the space field leads to the non-uniform conservation of energy in space by absorption of photons by $\mathbf{e^-/e^+}$ pairs with the formation of pairs of heavy bosons.

7. The Higgs mechanism

The question as to why particles need mass is the main question of fundamental physics. Based on the Standard Model, the generation of mass by particles is due to the spontaneous breaking of symmetry within pairs of particles-antiparticles in the universe. The Standard Model applies Higgs mechanism in order to explain the phenomenon of spontaneous symmetry breaking.

In accordance with the Higgs mechanism, space is filled with a field, and when the weak force particles (electron, quarks) move through Higgs field, they gain mass. However, the Higgs field does not give mass to protons, which are generated from quarks. The Higgs mechanism does not explain why photons are not given a mass when they pass through the Higgs field.

It is necessary to note that particle physics news involves hot discussions surrounding the discovery of Higgs bosons. The Higgs mechanism does not explain why field suddenly shifted matter-antimatter symmetry to a mass generation event. Many other questions also remain open, such as where the Higgs field came from and why the universe should contain the Higgs field for creating matter-antimatter asymmetry.

Based on the non-uniform conservation of energy, we can explain why conversion of kinetic energy, produced from collision of matter-antimatter pairs, breaks the symmetry. Model (2) shows that conservation of energy gives associated mass which is localized in the space-time frame in order to eliminate singularity in energy conservation. From model (2), it also follows that the zero value of the field takes place at $\mathbf{E_{ap}} = 0$, which leads to ripples between space and time phases in the so-called Higgs Field.

Model (2) shows that at $\mathbf{E_{ap}} = 0$ all energy is accumulated in the form of mass, and the space-time frame decays to virtual space and time ingredients. Virtual space and time ingredients annihilate each other as ripples of particles and antiparticles with the generation of gravitational energy accelerating to the background state with the longitudinal wave. The background space does not go to the zero value because in this case the energy of the universe will be infinite. At $\mathbf{E_{ap}} = 0$, the radioactive decay of the space-time frame produces heavy bosons $\mathbf{W^+}$, $\mathbf{W^-}$ and $\mathbf{Z}$. At minimum space, the energy accumulated in time phase generates location of $\mathbf{W^+}$, $\mathbf{W^-}$ bosons in quarks with generation of space-time frame of matter.

When all the available energy is consumed in space ($\mathbf{E_{ap}} = 0$), the background space (Planck scale) with the lowest valley of energy becomes the vacuum state and generates gravitational attraction toward all the ingredients of decay of space-time frame to the background state.

Coupling of gravitational energy with virtual space and time leads to the regeneration of non-virtual space-time frame of matter.

The two parts of space, carrying different contents of energy, have entanglement, but they have no symmetry and are not two identical, equal halves, which was suggested by the authors of the EP paper [6]. The widely separated regions of space carry non-uniform conservation of energy within the space-time frame; therefore, the entanglement of nonidentical pieces of space is due to the connection of energy within space and time phases regardless of space and time scales.

In accordance with our concept of the non-uniform conservation of energy principle, the phenomenon called mass generation is the requirement of energy conservation. Based on model (2), generation of mass is not a spontaneous symmetry-breaking event; it is the requirement of energy conservation that is carried through a discrete non-uniform space-time frame. The space and time parameters work as particles and antiparticles carrying energy conservation through their integrated frame.

Model (2) describes the conjugation of force ($\mathbf{E_{ap}}$) and matter (**Es**) particles, forming the space-time frame of a matter. On this basis, light energy can be observable only if it reflected from the space-time frame of matter. The force-carrying particle ($\mathbf{E_{ap}}$) generates its conjugated particle ($\mathbf{E_s}$) that has a mass, simultaneously conserving energy and momentum. The model shows that when the corresponding particle has no mass, the conservation of energy diverges to infinity.

Model (2) may explain why photons do not attain mass when they pass through Higgs field. Model (2) comprises of massless ($\mathbf{E_{ap}}$) and mass-containing particles ($\mathbf{E_s}$). At $\mathbf{E_{ap}} = 0$, particles which form the so-called Higgs field have no space-time configuration. Assuming information that the Higgs boson may decay to a pair of photons, we can describe the generation of Higgs field particles and photons through Eqs. (7) and (8):

$$\mathbf{e^+/\nu_e + e^-/\nu_e{}^- = e^+/e^- + \nu_e/\nu_e{}^-} \tag{7}$$

$$\mathbf{e^+/\nu_e + e^-/\nu_e{}^- = -e^+/e^- + \nu_e/\nu_e{}^- = 2Y} \tag{8}$$

Scheme (8) describes the generation of light photons from dark matter. Due to the consumption of light photons for generation of space-time frame of observable matter, the conversion reaction (8) does not have the same velocity in both directions and is, therefore, not a time reversal invariant process.

Now the question is how we can describe the mass of protons, which does not originate from Higgs bosons. By Standard Model, the mass of protons comes from binding energy-gluons.

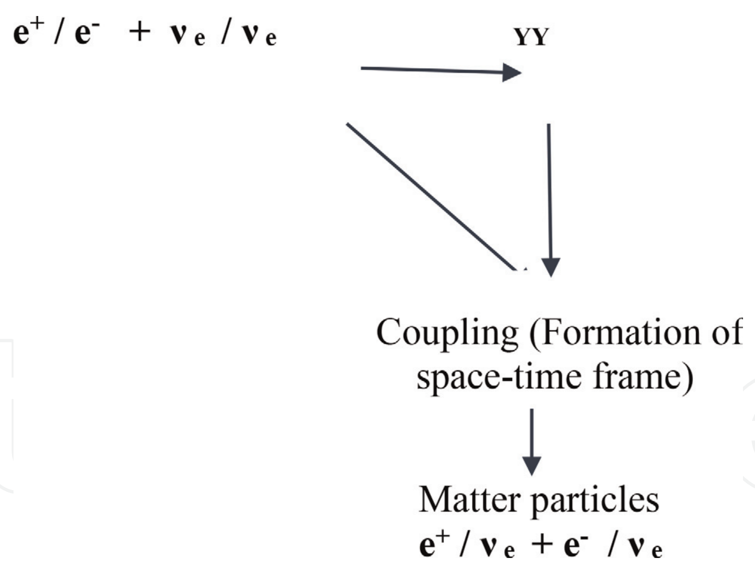
The coupling of energetic field with the virtual particles $\mathbf{e^+/e^- + \nu_e/\nu_e{}^-}$ leads to the insertion of energy to the virtual particles with the generation of quarks and space-time frame:

$$\mathbf{2Y + e^+/e^- + \nu_e/\nu_e{}^- = e^+/\nu_e + e^-/\nu_e{}^-} \tag{9}$$

The coupling reaction (9) maintains the conservation of energy and momentum within the boundary-mapped space-time frame.

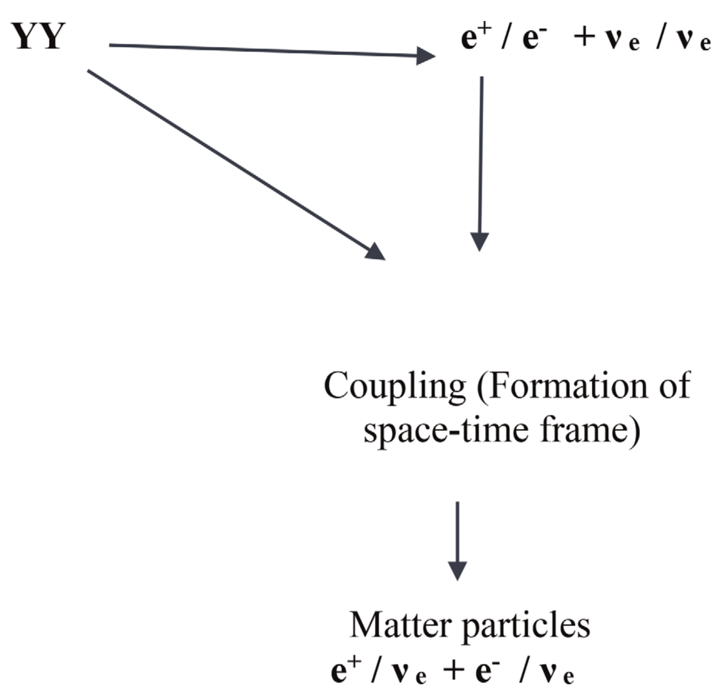
The virtual particles $\mathbf{e^+/e^- + \nu_e/\nu_e{}^-}$ exist in the form of dark matter and became observable only after the generation of the space-time frame. Similarly, the photons, generated from decomposition of matter space-time frame, exist in the form of dark energy and become observable only after interaction with the space-time frame of matter.

Therefore, matter and energy are observable only within interactions with the space-time frame. Interaction of virtual particles with the energy photons is such a coupling of virtual particles with themselves. These interactions follow the scheme, which is shown through the conversion (10):



(10)

We may present the scheme (10) in the reverse order:



(11)

Model (2) explains the invariance of time reversal transformation in scheme (10). The energy of space-time matter $\mathbf{E_s}$ is always less than the energy of photon particles. The process moves in the direction of expansion of the space-time frame of observable matter.

Scheme (11) in a similar way explains the generation of matter. Light photons transform to ingredients of matter particles, such as electron/positron and neutrino pairs. Due to the consumption of light energy during the coupling of photons with the ingredients of matter particles, the conversion of light photons is not invariant to the reversal of time.

8. The energy-mass equivalence

In accordance with the theory of relativity, mass and energy are different manifestations of the same identity, and the equivalence of mass and energy is a consequence of the symmetries of space and time [17]. This statement of the theory of relativity does not explain when the difference between mass and energy disappears and when energy and mass became different entities.

Based on model (2), the mass-energy equivalence is the consequence of energy conservation, which is carried through antisymmetric space-time phases. When there is no available energy to be conserved within space-time, the difference between energy and mass disappears. The difference between energy and mass appears when there is an energy (electromagnetic, kinetic) applied to space-time frame of a system. Production of energy in proton-proton collision experiments leads to the separation of mass from energy with the generation of a space-time frame of the produced particles.

It is necessary to show that the energy-momentum exchange interaction, which generates mass, is similar to Lorentz's theory of the generation of electron's mass. Lorentz connected mass with the electromagnetic effect and suggested that "back reaction of electric and magnetic fields leads to the generation of mass" [18]. However, Lorentz did not explain the nature of back reaction of electric and magnetic fields. Lorentz's formulation does not involve energy-momentum exchange interaction.

Lorentz's theory of electron mass is a very important approach for understanding the mass problem. Model (2) explains Lorentz's statement on the nature of apparent and true masses [18]. Model (2) shows that the motion of any body, for example, an electron, takes place with the consumption of energy, which is imported to the space-time frame. Due to the correlation of the mass with the applied energy, we measure only the apparent mass but never the true mass.

When $\mathbf{E_{ap}}$ of model (2) is zero, space-time decays and moves back to the background state. In this case, the local energy portion responsible for the local state disappears. In accordance with model (2), when space-time frame undergoes decay ($\mathbf{E_{ap}} = 0$), the difference between space and time variables disappears which generates a condensate field where the space and time portion of energy are uniformly mixed. Separation of space and time variables from the background condensate and the formation of space-time frame consume energy, while merging them restores that energy at the initial state. Therefore, energy is conserved only through the non-uniform distribution within the boundary-mapped space-time frame and the energy-momentum exchange interaction within the space-time frame.

At the background state, all available energy of the universe, accumulated within minimum space, leads to the separation of space and time portions of energy from condensate with the formation of space-time frame with asymmetric boundaries. Energy level in the non-uniform conservation stage is less than the energy of background condensate of uniform energy conservation stage.

Background vacuum and black hole are the boundary conditions of space-time frame and energy conservation. Due to the exchange interaction, black hole space has a strong gravitational effect toward electromagnetic energy and consumes all the available portion of energy. Vacuum is the other extreme of space-time and has strong gravitational effect to the portion of energy consumed in space. Therefore, electromagnetism and gravitation are two phases which transform into each other, satisfying the non-uniform conservation of energy. On this basis, the phenomenon called mass in the form of inertia appears as the carrier of energy conservation within an asymmetric space-time frame.

Due to the absence of space-time frame, a gravitational field in the form of a longitudinal wave does not react with the matter. On this basis, gravity has no discrete behavior, and there is no quantization of this field.

It is necessary to note that the combination of electromagnetism and gravity is not enough to complete the unified theory. In accordance with the concept of conservation of energy and momentum within the space-time frame, a complete unified theory requires the combination of electromagnetism and gravity with the space-time frame.

Therefore, our approach shows that description of space-time cannot be more fundamental than energy conservation, but the combination of space-time with the conservation of energy becomes a fundamental theory of reality.

Model (2) does not describe a particle as an entity, which is localized in space and evolves in time, but it presents a particle and space-time as a resulting quantity produced from each other.

Decomposition of a space-time frame ($\mathbf{E_{ap}}$ = 0) leads to the loss of information which is why black hole radiation does not carry any information. Black hole radiation leads to the restoration of energy at the initial state and the starting of new information, carried by the new space-time frame.

In Eq. (2), the $\mathbf{E_s}$ in the denominator is the dark matter, but in the numerator is the dark energy. When $\mathbf{E_{ap}}$ = 0, all the photon energy transforms to dark energy which disappears between dark energy and dark matter.

The exchange interaction of space and time portions in space-time frame leads to the formation of electric and magnetic fields with the generation of time translational non-invariant electromagnetic energy. The $\mathbf{E_{ap}} - \mathbf{E_s}$ parameter of the equation presents the vector potential of electromagnetism, which vanishes due to the consumption in space.

Therefore, electromagnetic energy cannot exist without discrete space-time frame and exchange interactions. Light is observable only through the reflection from space-time frame, and without space-time frame energy is dark. Higgs field has no space-time frame, which is why it is a scalar field. Quantum excitation is the redistribution of energy portions between space and time phases.

By Bose-Einstein statistics, two bosons with identical properties can be in the same place at the same time. Based on model (2) bosons have no space-time frame, which is why there is no difference between light bosons. Interaction of light bosons with the space-time frame and absorption of light with the growth of the matter space-time structure make light observable.

Model (5) explains the phenomenon called "nonlocality." The function $\mathbf{E_{ap}} - \mathbf{E_s}/\mathbf{E_s}$ of model (2) which describes action-response parity is the origin of local action. At $\mathbf{E_{ap}}$ = 0, a particle has no space-time frame and has no certain locality. When a particle has no space-time ($\mathbf{E_{ap}}$ = 0), all particles are the non-distinguishable ingredients of antimatter "condensate."

At $\mathbf{E_{ap}} - \mathbf{E_s} > 0$ a particle has its own space-time frame and, therefore, independent locality. The condition $\mathbf{E_{ap}}$ = 0 eliminates the action-response behavior of a particle which loses spin and moves to the background state. Therefore, energy conservation comprises of two steps: the decomposition of matter to an energetic field and the reverse process of transfer of an energetic field to matter.

In accordance with model (2), particles have space-time existence at positive energy state and have momentum in the opposite direction. The positive energy solution alone does not complete energy conservation. In accordance with our approach, the relationship between curvature of space-time and energy is the natural consequence of cyclic energy conservation within boundary-mapped space-time.

In accordance with model (2), the positive and negative energy states are not symmetric. The negative energy state is the second portion of energy, conserved in the form of Higgs field. At the state of zero positive energy ($\mathbf{E_a}$ = 0), particles do not follow Pauli's exclusion principle and, thus, have no local space-time position; in other words, all the particles occupy the same position.

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Dirac analyzed the relation of energy and momentum-using equations, which involves the sum of these parameters. Model (2) suggests a different approach and involves the ratio of the available portion of energy and the energy, which is consumed by momentum, which eliminates the divergence of energy to infinity.

Now returning to Rovelli's statement [12] on relation of space to the electromagnetic field, we may add that space-time itself through energy distribution is generated from an electromagnetic field and as a medium carries an electromagnetic field. Merging of energy quanta with the generated space-time leads to the expansion of space of an event.

9. Conclusion

In this paper, we extended our analysis on the nature of space-time to give an input to the hot disputes on the generation of a unified theory by entanglement of two equal pieces of space through "Wormhole Bridge" which was the outcome of the ER and EPR papers. We suggest that the unification of the theory of relativity with quantum mechanics is possible only through the proper mathematical formulation of the law of conservation of energy within the space-time frame. In accordance with this approach, the conversion of energy from one form to another requires a non-separable space locality and time frame which generates a boundary-mapped space-time structure wherein the consumption of light photons generates identities, such as space and time particles, carrying distribution of energy within the emerging non-uniform space-time field.

The non-uniform conservation of energy within the boundary-mapped space-time manifold leads to the generation of a deterministic dynamical law. This concept unifies all the interactions of nature within the asymmetric space-time manifold, carrying the non-uniform conservation of energy through coupling of energy-momentum conservation frames. It also describes the origin of mass, as the product of the non-uniform conservation of energy within the non-invariant energy-mass relation. We showed that gravity is materialized in space energy, while time at zero energy state ($\mathbf{E_{ap}} = 0$) in the form of ripples of space and time phases returns an event to the initial background state with restoration of a new elementary space-time frame. Based on the energy conservation model (2), at matter-antimatter symmetry, the difference between energy and momentum disappears which destroys the space-time frame of the universe.

When energy is consumed by a space-time frame or by $\mathbf{e^-/v^-} + \mathbf{e^+/v}$ particles with the formation of quarks, the space-time frame returns to its origin after consumption of all the available portion of energy. Only energy, accumulated at background state, may separate $\mathbf{e^-/e^+} + \mathbf{v/v}$ dark field particle pairs and generate quarks. When the matter has no space-time frame, it is not observable. The dark matter and dark energy are "dark" due to the absence of space-time frame, and energy, which is produced from the decomposition of the space-time frame, is not observable. The dark energy becomes an electromagnetic energy when it interacts with the space-time frame.

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