General Relativity in Quantum Physics and Chaos Theory

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Abstract: We can apply the Kasner metric that is an exact solution to Einstein's equations of General Relativity to the fields composed of the superluminal non-gravitating objects i.e. to the Higgs field composed of tachyons and to the field composed of entanglons (they are the zero-helicity vector objects and they are responsible for the quantum entanglement) that during the inflation created the Einstein spacetime composed of the gravitating neutrino-antineutrino pairs. All quantities defining the ground state of the Einstein spacetime are invariant. The invariance causes that the ground state behaves as non-gravitating empty volume so to the virtual objects composed of entangled neutrino-antineutrino pairs that appear in the ground state of the Einstein spacetime, we can apply the Kasner metric as well. The zeros in the first semi-symmetric Kasner solution (0, 0, 1) we interpret as the virtual fermion-antifermion pairs whereas the 1 as virtual charge. The second semi-symmetric Kasner solution (2/3, 2/3, -1/3) we interpret as virtual torus/charge that changes its size. The new interpretation of the Einstein formula E = mcc leads to conclusion that Nature using the virtual objects, i.e. the entangled Einstein-spacetime components, "copies" the virtual objects in bigger scales so there appear the virtual and real cores of baryons, electrons and new cosmology. In such phase transitions appear the spinors applied in the Quantum Physics. The Kasner solutions define many properties of the spinors. We can partially unify the gravity and quantum physics via the Kasner solutions. The basic mathematical method applied in Quantum Physics, i.e. the action of some orthogonal groups on column vector that leads to the spin representations, is some generalization of action of matrix of rotation of a circle around the z-axis on circle on xy plane defined parametrically and written as a column – such action leads to the parametric equations for torus. The symmetrical decays of virtual multi-loops lead to the Chaos Theory.

1. Introduction

The General Relativity leads to the non-gravitating Higgs field composed of tachyons [1A]. On the other hand, the Scale-Symmetric Theory (SST) shows that the succeeding phase transitions of such Higgs field lead to the different scales of sizes [1A]. Due to the saturation of interactions via the Higgs field and due to the law of conservation of the half-integral spin that is obligatory for all scales, there consequently appear the superluminal binary systems of closed strings (entanglons) responsible for the quantum entanglement, stable neutrinos and luminal neutrino-antineutrino pairs which are the components of the luminal Einstein spacetime (it is the Planck scale), cores of baryons, and the cosmic structures (protoworlds) that evolution leads to the dark matter, dark energy and expanding universes [1A], [1B]. The non-gravitating tachyons have infinitesimal spin so all listed structures have internal helicity (helicities) which distinguish particles from their antiparticles [1A]. SST shows that a fundamental theory should start from infinite nothingness and pieces of space [1A]. Sizes of pieces of space depend on their velocities [1A]. The inflation field started as the liquid-like field composed of non-gravitating pieces of space [1A]. Cosmoses composed of universes are created because of collisions of big pieces of space [1A], [1B]. During the inflation, the liquid-like inflation field (the non-gravitating superluminal Higgs field) transformed partially into the luminal Einstein spacetime [1A]. In our Cosmos, the two-component spacetime is surrounded by timeless wall – it causes that the fundamental constants are invariant [1A], [1B].

Due to the symmetrical decays of bosons on the equator of the core of baryons, there appears the atom-like structure of baryons described by the Titius-Bode orbits for the nuclear strong interactions [1A].

We will prove that the superluminal non-gravitating Higgs field and field composed of exchanged entanglons both satisfy the initial conditions for the partially symmetric both the Kasner solution $(0, 0, 1)$ and generalized Kasner solution $(2/3, 2/3, -1/3)$. We will try to show the physical meaning of both Kasner solutions. The generalized solution leads via the new interpretation of the Einstein formula $E = mc^2$ to many properties of binary systems of spinors whereas the Kasner solution leads to spinning loops composed of entangled Einstein-spacetime (Es) components.

The massless photons and gluons are the non-gravitating rotational energies $E = h\nu$ of the Es components. They can be entangled via entanglement of their carriers i.e. the Es components. The field responsible for the entanglement consists of the exchanged entanglons. Using the fundamental bricks of matter, i.e. the Es components, Nature "copies" at larger scales the non-gravitating structures composed of the entanglons (i.e. tori and loops) so there appear the cores of baryons, electrons and protoworlds that lead to new cosmology. Just there appear the phase transitions of the superluminal non-gravitating Higgs field. The two lower limits for range of entanglement (that leads to the most stable objects) of the Es components are close to $2\pi r$ and $2\pi r/3$, where r is the equatorial radius of the torus/charge of stable neutrino [1A].

The entangled structures composed of the Es components decrease local pressure of the Einstein spacetime so there are the inflows of the Es components. The gravitational mass of the additional Es components is the measured mass. In vortices, the non-gravitating rotational energy E is equal to the measured mass mc^2 – such is the correct interpretation of the Einstein formula $E = mc^2$.

Emphasize that the Kasner solutions are valid for spacetime without matter so they concern the non-gravitational fields i.e. the superluminal non-gravitating Higgs field and the fields composed of the exchanged (between the Es components) entanglons.

The Es components were produced during the inflation due to the Higgs mechanism [2].

We can partially unify the gravity and quantum physics via the Kasner solutions and the phase transitions of the superluminal non-gravitating Higgs field.

The symmetrical decays of multi-loops composed of 2^n loops, where $n = 0, 1, 2, 3, \ldots$, lead to the Chaos Theory.

2. The ring/torus possessing a single hole (the single-holed ring torus) [3]

Let the radius from the centre of the hole to the centre of the torus tube be R, and the radius of the tube be r. For a torus with radial symmetry in relation to the z-axis, in Cartesian coordinates, is

$$\left(R - \sqrt{x^2 + y^2}\right)^2 + z^2 = r^2, \tag{1}$$

A physical torus is most stable for $R = 2r$ [1A].

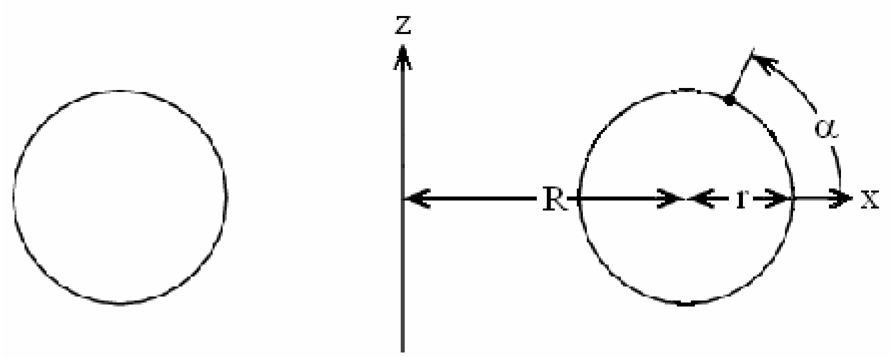
A torus can be defined parametrically by

$$x(\alpha, \beta) = (R + r\cos\alpha)\cos\beta,$$

$$y(\alpha, \beta) = (R + r\cos\alpha)\sin\beta,$$

$$z(\alpha, \beta) = r\sin\alpha,$$

where R (major radius) is the distance from the centre of the tube to the centre of the torus whereas r (minor radius) is the radius of the tube, β is the angle of rotation around the z-axis of a circle on the xy plane.



Define the inner, I, and outer/external/equatorial, O, radii of a torus

$I = R - r,$

$O = R + r.$

Define following "action"

$$\begin{bmatrix} \cos\beta & -\sin\beta & 0 \\ \sin\beta & \cos\beta & 0 \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} R + r\cos\alpha \\ 0 \\ r\sin\alpha \end{bmatrix} = \begin{bmatrix} (R + r\cos\alpha)\cos\beta \\ (R + r\cos\alpha)\sin\beta \\ r\sin\alpha \end{bmatrix} \tag{2}$$

The matrix at the front of the above expression is the matrix of rotation around the z-axis. The three-component column in the middle represents a circle defined parametrically whereas the column on the right side represents a torus defined parametrically. We can say that the "action" of the matrix of rotation on a circle leads to the torus. It is some analogy to the generalized action of orthogonal groups on column vector that leads to the spin representations – it is the one of basic mathematical methods applied in the quantum physics.

It suggests that internal structure of the spinors and circles/loops is associated with theory of tori. The same we can say about the generalized Kasner solution – it as well leads to shape and proportions of the fundamental spinor and some loop.

We can partially unify the gravity and the quantum physics via the Kasner solutions.

Formula (2) describes a left-handed torus. We will need some description of binary system of tori in which spins are parallel and their directions overlap whereas internal helicities are opposite. The angle β changes from 0 to 2π and the changes in β define spin of a torus and its spin/toroidal direction. Since spins are parallel so for both tori is $\Delta\beta > 0$. The changes in α angle define the chirality of a torus and its chiral/poloidal direction. Since the internal helicities, so the chiralities as well, are opposite so for the left-handed torus α changes from 0 to 2π whereas for the right-handed torus α changes from 2π to 0 i.e. there instead α is: $2\pi - \alpha$ or $-\alpha$ i.e. $\Delta\alpha < 0$. This means that for right-handed torus is

$$x(-\alpha, \beta) = (R - r\cos\alpha)\cos\beta,$$

$$y(-\alpha, \beta) = (R - r\cos\alpha)\sin\beta,$$

$$z(-\alpha, \beta) = -r\sin\alpha.$$

The sum of the columns for the left-handed and right-handed tori is

$$x(\beta) = 2R\cos\beta,$$

$$y(\beta) = 2R\sin\beta,$$

$$z(\beta) = 0,$$

i.e. we obtain one circle on xy plane that radius is $2R = 4O/3$, where O is the equatorial/outer radius of the tori. If O defines radius of electron applied in quantum physics then the radius $4O/3$ is the radius of electron obtained in the classical theory of electrically charged particles. The obtained result $2R$ is for two overlapping tori. In reality, such situation is impossible i.e. in reality there is a loop that is the binary system of entangled loops. The obtained solution suggests that then the loops have radius $2O/3$ but it is in physics as well the wrong conclusion. The Es components in a loop have the spin speed equal to the speed of light. In the torus of electron such situation is only on its equator. This means that electron-positron pair arises from a binary system of loops and both have the same equatorial/external radii equal to O. Spin of the binary systems is unitary whereas of the components is half-integral. After annihilation of an electron-positron pair there appears the non-gravitating loop in which the Es components rotate but due to the Kasner solution, such loop can expand and at infinity the rotational energies disappear i.e. there is a loop composed of the exchanged entanglons. The upper limit for the radius of such loop is the radius of our Cosmos [6]. We can see that information is coded on the surface of our Cosmos (on the boundary of the Einstein spacetime [1B]) – it is the holography [7].

Emphasize that a binary system of tori with parallel spins and opposite internal helicities (i.e. the zero-helicity vector object) can transform into spin-1 spinning loop (it is a double loop and each component carries the half-integral spin) and vice versa.

3. Kasner solution, generalized Kasner solution and a generalization of the generalized Kasner solution

The Kasner metric [4] is an exact solution to Einstein's Theory of General Relativity (GR). It is for an anisotropic cosmos without matter so it is a vacuum solution i.e. solution for the non-gravitating Higgs field and fields composed of the exchanged entanglons. The metric in 4-dimensional spacetime is

$$ds^2 = -dt^2 + t^{2a}\, dx^2 + t^{2b}\, dy^2 + t^{2c}\, dz^2, \tag{3}$$

where a, b and c are the Kasner exponents. It describes spatially flat the equal-time slices. In different directions space is contracting or expanding at different rates defined by the Kasner exponents. If commoving coordinate differs, for example, by Δx for a test particle then the physical distance is $t^a \Delta x$.

Much more general solutions are obtained by a generalization of an exact particular solution derived by E. Kasner [4] for a field in vacuum, in which the space is homogeneous and has Euclidean metric that depends on time according to the Kasner metric

$$dl^2 = t^{2a}\, dx^2 + t^{2b}\, dy^2 + t^{2c}\, dz^2. \tag{4}$$

The Kasner metric is an exact solution to Einstein's equations in vacuum if the Kasner exponents satisfy the following Kasner conditions

$$a + b + c = 1, \tag{5a}$$

$$a^2 + b^2 + c^2 = 1. \tag{5a}$$

The volume of the spatial slices always goes like t. We will show its physical meaning. There is

$$t = t^{a + b + c}. \tag{6}$$

It suggests that time t splits into three factors.

Isotropic expansion or contraction is not allowed due to the lack of matter.

The Kasner solution is ($a = 0$, $b = 0$, $c = 1$). If not, then at least one Kasner exponent must be always negative. If, for example, the time coordinate t to increase from zero then because the volume of space is increasing like t, at least one direction corresponding to the negative Kasner exponent must contract.

For following solution (0, 0, 1), the Ricci and Riemann tensors vanish so to describe internal structure of such object we need some extension of GR i.e. the Scale-Symmetric Theory.

All quantities describing the ground state of the Einstein spacetime composed of the free luminal neutrino-antineutrino pairs are invariant, [1A], so it behaves as non-gravitating field (as empty volume) so we can apply to it the Kasner metric that is an exact solution to Einstein's equations of General Relativity (0, 0, 1). It means that we can apply this solution as well to the carriers of gluons i.e. to the neutrino-antineutrino pairs [1A]. According to SST, outside the nuclear strong fields the gluons behave as photons [1A]. The above solution we can interpret as two different quark-antiquark pairs (0 and 0 because the total charge of a pair is equal to zero) and the charge of the core of baryons (1) [1D]. When energy of collision increases then pairs of lighter quarks disappear whereas of heavier ones appear in such a way that there still are two different quark-antiquark pairs plus the charge of the core.

The partially symmetric generalized Kasner solution is ($2/3$, $2/3$, $-1/3$). We can interpret this solution as a torus in which the sizes along x and y increases whereas the size along z-axis decreases – it looks as a transformation of a torus into loop.

Gravity is directly associated with the gradients produced in the superluminal non-gravitating Higgs field by masses [1A]. The properties of the superluminal non-gravitating Higgs field satisfy both the sets of the initial conditions for the Kasner solution and the generalized solution. The field composed of tachyons/pieces-of-space or the fields composed of the exchanged entanglons are non-gravitating so they are free from gravitating matter. Anisotropy is local but it is enough to produce anisotropic objects. Of course, the global symmetry must be conserved. The pressures of the considered fields are very high (the tachyons and entanglons are the superluminal objects) so they are homogeneous and have Euclidean metrics. Moreover, they are practically flat (but can be curved) even if there is some distribution of masses.

Now we will prove that during the inflation the volume of the spatial slices for the considered fields went like time t.

In the General Theory of Relativity (GR) we apply formula for the total energy E of particles in the Einstein spacetime for which is obligatory the Principle of Equivalence i.e. mass M denotes both the inertial mass and gravitational mass.

Assume that the word “imaginary” concerns physical quantities characteristic for objects that have broken contact with the wave function that describes state of the Universe. This means that such objects cannot emit some particles. Assume that the tachyons are the internally structureless objects, i.e. they are the pieces of space, so they cannot emit some objects. From this follows that the tachyons have only the inertial mass m. Substitute ic instead c, iv instead v and im instead M, where $i = sqrt(-1)$. Then the formula for the total energy E_T of a field composed of tachyons is:

$$E_T = -\, i\, m\, c^2 / (1 - v^2 / c^2)^{1/2} = m\, c^2 / (v^2 / c^2 - 1)^{1/2}. \qquad (7)$$

We can see that the GR leads to the imaginary superluminal non-gravitating Higgs field composed of the tachyons. For $v >> c$ we obtain

$$E_T = m\, c^3 / v = m\, c^3 / (s / t) \sim t. \qquad (8)$$

We can see that energy of the superluminal non-gravitating Higgs field had increased during the inflation. It was possible only because the ordered linear motions of tachyons in a very big piece of space, during a collision with other big piece(s) of space [1A], [1B], transformed into chaotic motions i.e. inner temperature of the inflation field increased. It was due to the initial collision of two very big pieces of space initially timeless [1A]. During the inflation, the energy density of the created cosmos was conserved

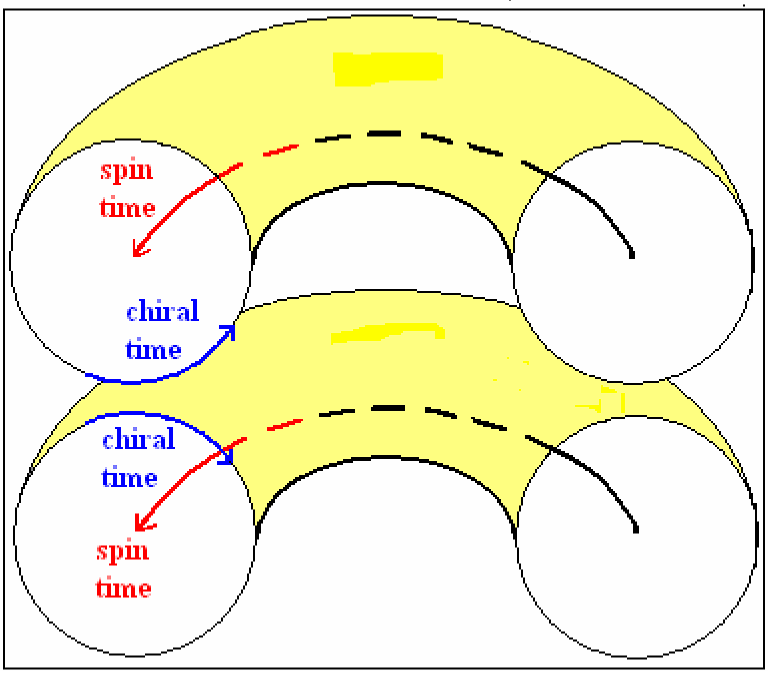
$$E_T / V = const., \qquad (9)$$

i.e. energy density of the inertial mass only is independent on time. Since the energy E_T is directly proportional to time so during the inflation the volume of the spatial slices went like time t. It is the last conditions that must be satisfied the generalized Kasner solution could be valid

$$V \sim t. \tag{10}$$

Since for the exchanged entanglons is $v >> c$ so formula (10) concerns the field composed of the exchanged entanglons as well. This means that both Kasner solutions concern some fundamental phase transitions of the superluminal non-gravitating Higgs field.

The formula (6) suggests that when the superluminal non-gravitating Higgs field or the field composed of the entanglons expand or contract then time t splits into three factors. There appear two symmetrical times. They can be the chiral times. There as well appears the third time which can be the spin time. The binary system on the figure is the zero-helicity vector particle which components have opposite internal helicities and the parallel spins that directions overlap.



The tori are the most stable objects for $R = 2r$. We can see that the poloidal circumferences associated with the chiral speeds are two times shorter than the toroidal circumference associated with the spin speed. Assume that a test particle is moving with the speed of light c and that the unit of time is equal to period of spinning. Then, the two chiral units of time are two times shorter than the single spin unit of time i.e. the spin time is going two times slower than the chiral times. If we assume that the outer radii of the tori are unitary $O = R + r = 1$ then $R = 2/3$ whereas $r = 1/3$. This means that the Kasner exponents associated with the two chiral times are equal and are $a = b = 2/3$ whereas the third associated with the spin time is $c = -1/3$. The sign "–" results from the fact that when a region of the considered field contracts then the unit of the spin time decreases (–) whereas the two units of the chiral times increases (+). It leads to following solution $(2/3, 2/3, -1/3)$ that is the generalized Kasner solution.

Emphasize that when a region of the considered fields contracts then there arise the zero-helicity vector particles. Since the upper limit for speed in GR is the speed of light c so the obtained zero-helicity vector particles/spinors must be the Einstein-spacetime components.

The Einstein-spacetime component is the essential component of the lacking part of ultimate theory i.e. the Scale-Symmetric Theory [1A].

Nature “copies” the non-gravitating objects using matter and then “copies” the gravitational objects at lager scales so there appear the bigger loops and the cores of baryons, the bare electrons and protoworlds that lead to new cosmology [1A], [1B]. Just there appear the phase transitions of the superluminal non-gravitating Higgs field [1A].

We can see that there are possible following oscillations: binary-system-of-tori ←→ spin-1-double-loop. It is the reason why a double loop can transform into electron-positron pair or into quark-antiquark pair and next, a pair into loop, and so on.

From the generalized Kasner solution we can decipher the shape and proportions of the Einstein-spacetime components but we cannot calculate the sizes and other physical quantities – it is possible within the Scale-Symmetric Theory. It is beyond the GR.

There some generalization of the generalized Kasner solution is possible.

The internal structure of the zero-helicity vector particles leads to additional two conditions. For the units of the chiral and spin times is

$$\Delta t^a / \Delta t^c = \Delta t^{2/3} / \Delta t^{-1/3} = \Delta t = 1/2, \tag{11a}$$

whereas for the chiral and spin times is

$$t^a / t^c = t^{2/3} / t^{-1/3} = t = 2. \tag{11b}$$

The condition (11a) gives $\Delta t^a = 0.62992$ and $\Delta t^c = 1.2599$.

The condition (11b) gives $t^a = 1.5874$ and $t^c = 0.79370$.

Only one of the four values is independent, for example the $t^c = 0.79370$. If radius of a homogeneous ball is 1 then the t^c is the radius of a ball that mass is two times smaller. This means that the $\Delta t = 1/2$ represents the symmetrical decays of particles when such decays are possible. Such symmetrical decays appear in the atom-like structure of baryons, [1A], and lead to the Titius-Bode law for the nuclear strong interactions. The $t = 2$ represents a splitting/transformation of a double loop into two tori – it leads to the bifurcation described within the Chaos Theory [1C]. For multi-loops that consist of 2^n loops, where $n = 0, 1, 2, 3, \ldots$, the $t = 2$ can represents as well the period-doubling for increasing radius [1C]. We can see that the generalization of the generalized Kasner solution leads to the Chaos Theory.

An entangled non-gravitating double loop from “infinity” (it is the edge of our Cosmos [6]) can produce binary system of tori and vice versa – it looks as holography.

Due to the finite maximum density of the pieces of space there do not appear any singularities.

Many Chapters in SST concern the General Relativity, Theory of Chaos and Quantum Physics [1] – these areas of knowledge follow from the succeeding phase transitions of the superluminal non-gravitating Higgs field.

4. Summary

We can apply the Kasner metric that is an exact solution to Einstein’s equations of General Relativity to the fields composed of the superluminal non-gravitating objects i.e. to the Higgs field composed of tachyons and to the field composed of entanglons (they are the zero-helicity vector objects and they are responsible for the quantum entanglement) that during the inflation created the Einstein spacetime composed of the gravitating neutrino-antineutrino pairs.

All quantities defining the ground state of the Einstein spacetime are invariant. The invariance causes that the ground state behaves as non-gravitating empty volume so to the virtual objects composed of entangled neutrino-antineutrino pairs that appear in the ground state of the Einstein spacetime, we can apply the Kasner metric as well.

The zeros in the first semi-symmetric Kasner solution (0, 0, 1) we interpret as the virtual fermion-antifermion pairs whereas the 1 as virtual charge. The second semi-symmetric Kasner solution (2/3, 2/3, –1/3) we interpret as virtual torus/charge that changes its size.

The new interpretation of the Einstein formula $E = mc^2$ leads to conclusion that Nature using the virtual objects, i.e. the entangled Einstein-spacetime components, “copies” the virtual objects in bigger scales so there appear the virtual and real cores of baryons, electrons and new cosmology. In such phase transitions appear the spinors applied in the Quantum Physics.

The Kasner solutions define many properties of the spinors.

We can partially unify the gravity and quantum physics via the Kasner solutions. The basic mathematical method applied in Quantum Physics, i.e. the action of some orthogonal groups on column vector that leads to the spin representations, is some generalization of action of matrix of rotation of a circle around the z-axis on circle on xy plane defined parametrically and written as a column – such action leads to the parametric equations for torus.

The symmetrical decays of virtual multi-loops lead to the Chaos Theory.

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