Classical Interpretation of Quantum Mechanics

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Abstract: Here we present the physical side of the quantum mechanics (QM) that emerges from the Scale-Symmetric Theory (SST). We showed that the quantum superposition is misinterpreted. The key to understand QM is the difference between quantum coherence and quantum entanglement. We as well explained what conditions and structures lead to relativistic invariants such as electric charge and spin, and how this affects the superposition.

1. Introduction

Quantum superposition is a widely accepted idea despite the controversial assumptions that physical systems do not have definite properties prior to being measured (the act of measurement causes collapse of the wave function to only one of the possible values) or that all possible alternate histories are real (the many-worlds interpretation).

The above assumptions are controversial because they are not associated with any real physical phenomena, that is, they suggest that in addition to classical mechanics there is some incomprehensible other mechanics called quantum.

The following basic questions appear here: Does this simultaneously living and dead cat in the Schrödinger thought experiment concern the same particles (notice that in the mainstream quantum mechanics, trajectory of a single particle never can be directly observed because it does not have a simultaneous position and momentum)? What is the nature of measurement? Why can there be different channels of decay of the same system/particle? What determines the transition from quantum to classical behaviour? Are there classical analogs to complex quantum objects? And so on.

Here, applying the real physical phenomena described within the Scale-Symmetric Theory (SST) [1], [2], we explain in simple terms the complexities of quantum mechanics (QM).

We will start with a very brief presentation of the SST and the SST definitions of quantum particle, quantum coherence and quantum entanglement.

2. A very brief presentation of the SST [1], [2]

Two very simple formulae and 7 parameters only concerning the initial inflation field (i.e. the initial SST Higgs field) lead to 5 levels of Nature. Within SST, we calculated more than one thousand quantities (the fundamental physical constants as well) which are consistent with experimental data – they concern particle physics, cosmology, nuclear and atomic physics, brain-mind theory, DNA or the Wow! signal, and so on.

The lowest level is the SST Higgs field composed of the impossible to observe non-gravitating tachyons. Their speed is $\sim 8 \cdot 10^{88}$ times higher than the speed of light in "vacuum"

c. Gravitational fields are the gradients produced by masses in the Higgs field. The SST tachyons are the classical objects so gravity is classical as well.

The second level consists of the impossible to observe superluminal binary systems of closed strings built of the SST tachyons (the spin-1 entanglons). Rotating or not entanglons are responsible for the quantum entanglement and their speed is $\sim 2.4 \cdot 10^{59}$ times higher than the c. The entanglons are the classical objects so quantum entanglement is classical also.

The third level is the gravitating Einstein spacetime (ES) composed of the neutrino-antineutrino pairs. The ES components are built of the entanglons – there are not free entanglons but they can be exchanged. SST shows that masses, weak charge and spin of neutrinos are the invariants. Speed of the ES components is c in relation to the system with which they are entangled. If not entangled (i.e. free – i.e. interacting gravitationally only) then their speed c is in relation to the stable boundary of our Cosmos (it is about 10,000 times bigger than the present-day Universe). Elementary photons and gluons are the rotational energies of the ES components. Photons in nuclear strong fields behave as gluons. The ground state of ES behaves classically also i.e. the ES components when interact gravitationally only, are the classical objects. The Standard Model (SM) concerns the excited states of the third level of Nature so in SM dominates quantum mechanics that follows from the quantum entanglement and quantum coherence (see next two Paragraphs). Rotational energies or/and quantum entanglement of the ES components cause that motion of them is more ordered – such phenomena decrease local pressure in ES – it forces inflows of additional ES components to such regions so their density increases. On the other hand, higher field density forces creation of the virtual fields (see next two Paragraphs). Quantum coherence is directly associated with the virtual fields (see next two Paragraphs).

The fourth level consists of the hadrons and electrically charged leptons. The bare electrically charged fermions consist of torus/electric-charge and central condensate both built of the ES components. The central condensate is responsible for the weak interactions whereas the loops or binary systems of such loops created inside the torus of bare baryons are responsible for the nuclear strong interactions.

The fifth level is one cosmological Protoworld that evolves in a cyclical manner. The Protoworld transforms into expanding universe, dark matter and dark energy.

3. The two-slit experiment and definitions of quantum particle, quantum coherence and quantum entanglement

Nature is trying to equalize density of the third level on a local and global scale taking into account all particles and fields including Einstein spacetime.

This causes that a real bare electron (i.e. the torus/electric-charge plus central condensate) continuously emits virtual photons that carry positive energy. Because the total energy of virtual objects must be equal to zero, virtual “holes” with negative mass are created in the places of emission of virtual photons. The dynamic pressure in the Einstein spacetime tends to equalize its density, so virtual “holes” with negative mass are constantly eliminated.

Thus, around a bare particle, when it is charged, a field composed of virtual photons (that carry positive energy in the radial directions) is created.

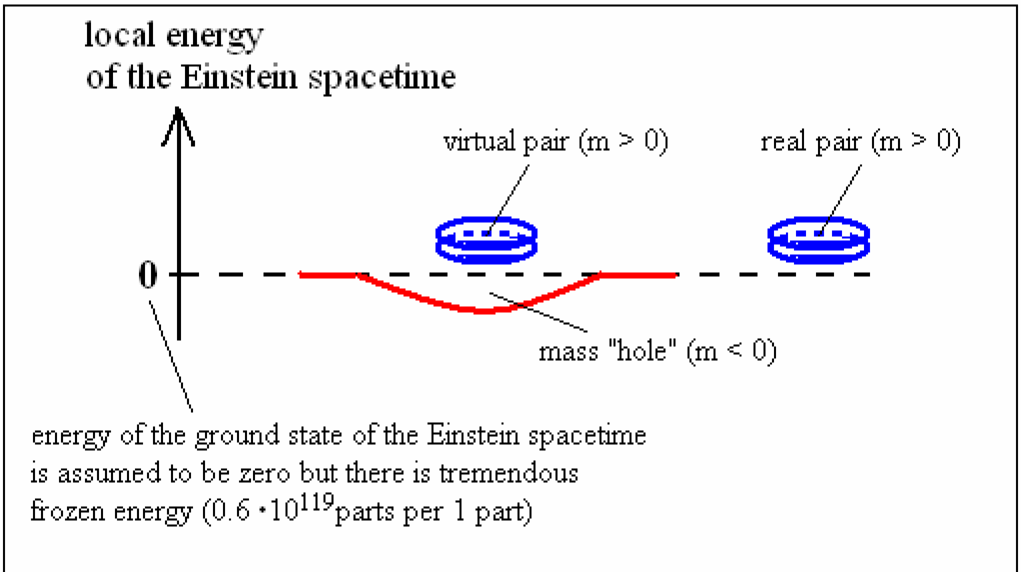
The barrier between slits divides such a virtual field into two parts. The two waves have the same frequency and constant phase difference, so they can produce a well-defined interference pattern – it is the quantum coherence i.e. it concerns the wave-like properties.

Notice that the quantum coherence does not concern the bare particle but its virtual field.

SST shows that only one virtual electron-positron pair can be created in a virtual electron field at any given time – such model leads to the anomalous magnetic moment of electron [1].

Quantum coherence concerns emissions of virtual photons by bare particles from the third level of Nature while quantum entanglement concerns emissions and absorptions of the superluminal rotating entanglons by the components of the second level of Nature. Exchanges within the second level are more energetic so quantum entanglement can kill quantum coherence.

An additional exchange of entanglon between the bare electron (in the region of coherent interference) and a part of the apparatus can change frequency of one of the two virtual waves – it causes that the well-defined interference pattern disappears. If a specific dominant frequency can not be assigned to the virtual field of an object, then such an object does not create a well-defined interference pattern, i.e. it behaves like a classical object. Characteristic frequency of virtual field depends on speed of its creator i.e. on speed of the bare particle.



A virtual object i.e. a pair (m > 0) plus mass "hole" (m < 0).

This means that quantum coherence and quantum entanglement are the different phenomena. Quantum coherence is a volumetric and wave-like phenomenon with the characteristic speed c and concerns the third level of Nature while quantum entanglement is directional and superluminal and concerns the second level of Nature.

Instead the virtual photons associated with bare electron there can be both virtual gluons and virtual photons associated with bare baryons (it concerns the bare neutron also). In the virtual strong fields are also produced virtual pairs of pions.

Generally, photons are groups of entangled carriers of elementary photons (elementary photon is the rotating ES component). The entangled and rotating ES components increase local density of the third level of Nature – this leads to conclusion that photons create virtual fields as well so even individually passing photons through a set of slits create a well-defined interference pattern. SST shows that today the CMB photons should have mass $\sim 3 \cdot 10^{-57}$ kg. It is below the upper limit defined in experiments – the solar wind magnetic field leads to the mass limit for the photon $m \leq 2 \cdot 10^{-54}$ kg – see [3] in [4].

Emphasize once more that quantum coherence concerns virtual fields (it has wave-like properties) while quantum entanglement is due to emission and absorption of superluminal entanglon(s).

4. Wavefunction and its collapse

Consider the situation when the density of the bare particle or virtual pair is close to the density of the virtual field. Then, due to the superluminal quantum entanglement, such objects can do a hocus-pocus involving the disappearance in one place of the virtual field and appearing elsewhere in the field, and so on. SST shows that at low energy bare nucleons should have classical trajectories (density of surface of the nucleon torus is about 170 million times higher than the ES) but due to their virtual fields, they create a well-defined interference pattern.

We see that in addition to the virtual field of the electron, its state determines the wavefunction that allows you to calculate the probabilities of finding the bare electron in different places of space. Such a wavefunction is the result of the disappearance and appearance of the bare electron at various places of the virtual field of the electron – this wavefunction is the result of the superluminality of quantum entanglement.

Such model suggests that quantum coherence and quantum entanglement are the real phenomena while the wavefunction of bare electron is a mathematical trick to define the probabilities of finding the bare electron in different places of space. But wavefunctions of more complex particles/objects such as baryons or atoms with many electrons can be partially real (different parts of such objects can be in different quantum sub-states because of different interactions) and partially a mathematical trick (there are bare particles, for example relativistic pions, behaving in a quantum way).

A measurement stops for a moment the part of quantum entanglement that leads to the wavefunction of the bare electron – it is the collapse of wavefunction of the bare electron. Note that the virtual field of the electron exists all the time while the bare electron, at a given moment, is only in one place.

Emphasize that bare electron cannot be simultaneously in different places of space.

5. The wave-particle duality

Consider the two-slit experiment with single particles sent one at a time – we observe well-defined interference pattern. It leads to the wave-particle duality because the particle is measured as a single object at a single position while the wave describes the probability of detecting the particle at a defined place on the screen. The probability of detection is the square of the amplitude of the wave.

Within the SST, it is very easy to explain the wave-particle duality. On the screen we detect the bare particle – it behaves as a single object. But the interference of the separated parts of the initial virtual field of such particle, changes direction of motion of the bare particle – it leads to the interference pattern for many particles.

Emphasize that the wave-like property of a quantum particle concerns its virtual field while the particle-like property concerns the bare particle. Of course, there is strong correlation in behaviour of both the bare particle and its virtual field.

6. Measurement

The smallest objects in the Cosmos as the SST tachyons and entanglons cannot be quantum objects because of lack of virtual fields around them.

Quantum behaviour is characteristic for complex structures that are the excited states of ES which is the part of the third level of Nature. The detector measures the sub-state in which there is some part of such complex structure.

The redirected superluminal entanglons from the areas between the measured part of the system and other parts of it, to the detector reduce the set of probabilities to only one of the possible values. We see that the measurement is the result of redirecting some amount of quantum entanglement and quantum coherence in a system to the detector. We can call the parts/sub-states of the complex system the “worlds”. Only in such a way the quantum “many worlds” should be interpreted.

Different sub-states of a system can be in different way entangled with the rest of the system so there appear different probabilities for redirecting the partial entanglements.

7. Schrödinger’s cat

Bare particles in a system cannot be simultaneously in two or more different states (see Paragraph 12) so it concerns a set of entangled atoms also. This suggests that the proposed by Schrödinger thought experiment has no sense. But we can consider a system composed of one alive cat (atoms in a set of atoms are entangled) and dead one (atoms in other set of atoms are entangled) both in a quantum coherence (i.e. there is one virtual field). A measurement creates quantum entanglement between, for example, a detector and the living cat – then the detector collapses the two-component wavefunction to the living cat. The created entanglement is responsible for loss of the coherence between the living cat and dead one.

8. Channels of decay of the same system/particle

Mass and type of interaction of virtual particle/pair created between defined parts of a system/particle in the cost of quantum entanglement, determines the channel of decay of the system/particle.

9. Transition from quantum to classical behaviour

The electromagnetic constant, G_{em}, for interacting electrons is $\sim 4 \cdot 10^{42}$ times higher than the gravitational constant G [1]. On the other hand, thermal motions inside a mass can cause that the frequency of its virtual field will be completely blurred so the SST classical gravity dominates and such mass will not give a well-defined interference pattern.

10. Classical analogs to complex quantum objects

There is the similarity of the internal structure of electrically charged fermions to the construction of the Active Galactic Nuclei (AGN). In order to transform an AGN into a bare fermion, we must replace the central black hole with an ES condensate (it is responsible for the weak interactions), the dim baryonic torus of the AGN with a torus/electric-charge built of entangled ES components, we have to replace the dispersed baryonic-leptonic matter with the virtual field of the considered fermions, and we must replace the gravitational interactions with the quantum entanglement and the other Standard-Model interactions.

SST shows that the present-day CMB photons should consist of 4^{16} entangled elementary photons (we call them the photon galaxies [2]). Structure of such a bare photon galaxy should be similar to structure of massive spiral galaxy i.e. there should be some analogs to the disc, galactic bulge, globular clusters, single stars (the elementary photons are the analogs to single stars) or to binary systems of stars (the binary systems of elementary photons are the analogs to binary systems of stars) all built of the entangled elementary photons. Such a photon galaxy, due to the superluminal quantum entanglement, should behave in the quantum way. The energy should be evenly distributed between all elementary photons. Each photon galaxy should produce single virtual field composed of both the virtual photons moving in radial directions and the virtual “holes” in the ES. The wavefunction of the bare photon galaxy gives information about the probability of one bare photon galaxy being in a particular place. Wavefunction of a photon is a result of the superluminal quantum entanglement.

There is lack of trajectories of bare quantum particles because we cannot know the position and momentum simultaneously – it results from the unobserved classical quantum entanglement between bare particle and detector when we such particle observe [5].

11. “Quantum” minds [6]

According to SST, electric pulses in brain produce the dark-matter (DM) loops and knots/solitons. The spins of the ES components in the DM objects are polarized in different way than in electromagnetic wave so they cannot interact electromagnetically. Mind consists of the dark-matter loops and knots/solitons – they are entangled in a quantum way, i.e. via the SST entanglons. Identical parts in different DM knots/solitons attract each other. In such a way act our minds. The knots represent sub-states so a mind is a spatial superposition of the sub-states. Notice that the dark-matter knots do not occupy the same points of space.

12. Relativistic invariants

The wavefunction, which is the result of quantum entanglement, defines behaviour of the bare electron while a wave-like behaviour is a result of quantum coherence of the virtual field of the bare electron.

The bare electron displays a particle-like property while the virtual field of the electron a wave-like property. It suggests that relativistic invariants should concern the bare electron, precisely, the torus/electric-charge.

In QM, the existence of relativistic invariants such as electric charge or spin is the subject of speculation. As SST shows, this is due to the incompleteness of QM. On the other hand, the separation of the relativistic mass of, for example, the proton from the relativistic invariant that is the electric charge of proton is not possible.

SST shows that the torus/electric-charge, which is the part of bare proton (it is in the core of proton), can not be simultaneously in different positions with different probabilities, which suggests that the quantum superposition is misinterpreted.

SST shows that electric charge is the spin-1/2 torus composed of the entangled ES components. To conserve its spin, it, when accelerated, have to move parallel or antiparallel to the spin. When we accelerate the torus/electric-charge, to conserve the spin of the torus (spin $= m_{rel}\, v_{spin}\, r =$ constant; due to the very strong quantum entanglement of the ES components the torus consists of, the radius r of it is the relativistic invariant) and to conserve the resultant speed c of the ES components, the spin speed, v_{spin}, must decrease whereas relativistic mass, m_{rel}, have to increase – it is realized by adding new ES components to the torus. The additional components of Einstein’s spacetime added to the torus interact with the torus in such a way that the number of electric lines created by it does not change, so the charge is a relativistic invariant. We can see that the electric charge can not be divided into parts.

On the other hand, in QM, the gauge invariance is equivalent to changes in the phase of a wavefunction which is unobservable – wee see that it says nothing about physical side of the problem.

Presented here the SST theory of relativistic invariants shows that the Copenhagen interpretation that a particle (here it is the bare electron) can be in multiple possible states at the same time when is not observed is incorrect. The same concerns the many-worlds interpretation.

13. Quantum computers

In theory of quantum computing, the qubit (quantum bit) can be found to exist in states ***0***, ***1*** or the superposition state of both ***0*** and ***1***. When we consider a spin-0 electron-positron pair then, when we do not observe the pair, there can be following states: spins ***up-down*** (the state, say, ***0***), ***down-up*** (the state ***1***), and the superposition $\boldsymbol{\gamma}$ of ***0*** and ***1***: $\boldsymbol{\gamma = \alpha 0 + \beta 1}$, where $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ are complex numbers and the modulus squared of $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ represents the probability of finding the qubit in state ***0*** and ***1*** respectively i.e. $|\boldsymbol{\alpha}|^2 + |\beta|^2 = 1$.

We claim that the change from ***up-down*** to ***down-up***, and so on is because the electron and positron exchange the spin-1 superluminal entanglon which is the classical "particle". We can see that presented phenomenon has classical explanation. We cannot control the exchanges of the spin-1 entanglon so there is probability $|\boldsymbol{\alpha}|^2$ that we will detect state ***up-down*** and probability $|\beta|^2$ that we will detect state ***down-up***. There is not in existence the supposed quantum superposition $\boldsymbol{\gamma = \alpha 0 + \beta 1}$ i.e. that the states ***0*** and ***1*** can simultaneously (in the same time) coexist.

14. The product of the free-electron wavefunction and its complex conjugate as the probability density, P(r, t), of the position

14.1 The SST structure and inner dynamics of free electron

The bare electron, "moving" or in the rest, is created from the ES components always as the resting particle – there is moving the electron wavefunction. There is the bare electron – it consists of the invariant torus/electric-charge as the polarized ES with invariant mass/energy/spin-1/2 loop (it has a half of the mass of the bare electron [1]) overlapping with the equator of the torus and there is the invariant central ES condensate (it has a half of the mass of the bare electron also [1]). Densities of the bare electron are very close to the density of ES so due to the superluminal quantum entanglement, the bare electron disappears in one place of ES and appears in another one, and so on. This means that we can introduce probabilities of finding the bare electron in different places of ES. Because of such behaviour, contrary to the bare baryons (they are the core of baryons [1]) we cannot say about classical/observed trajectory of the bare electron. Size of such region should be defined by the de Broglie electron wave length: $\lambda = hc/E = h/p$. Highest probability of creation of the bare electron (after annihilation of it in the first place) is in places with highest total density so we can use a cosine ($\cos(kx - \omega t)$) to describe the behaviour of the bare electron (of the real part of the electron) in its virtual field – below we showed that the backward flow in ES can lead to following exponential wavefunction: $e^{-i(kx - \omega t)}$. The bare electron can be detected directly because it is both stable and real.

We wrote that Nature tries to equalize density so we can assume that in surrounding of the electron electric charge there are created virtual photons with positive energy/mass (which are emitted in radial directions) and corresponding to them virtual ES "holes" with negative mass/energy. In surrounding of the bare electron are produced the virtual electron-positron pairs which decay to virtual photons. Highest probability for production of such virtual pairs is in places in which the total density is equal to the mean density of ES so the number density of the virtual photons in such places is highest also. Such conditions are satisfied in distance $\lambda/4$ from the centre of the region occupied by the bare electron, where λ is the de Broglie electron wave length. The distance $\lambda/4$ corresponds to phase shift equal to $\pi/2$ radians – it concerns the negative density of the virtual "holes" in ES also. It leads to conclusion that we can use a sine to describe the distribution of the virtual photons – in front of the sine there should appear the imaginary unit $i = \mathrm{sqrt}(-1)$ because it concerns the virtual/imaginary part (it cannot be detected directly because it is virtual/imaginary). We can see that the behaviour of the bare electron plus the virtual field composed of the virtual photons lead to following wavefunction: $\psi = e^{i(kx - \omega t)} = \cos(kx - \omega t) + i\sin(kx - \omega t)$.

We wrote that Nature tries to equalize density so it tries to fill the ES "holes". It leads to conclusion that there appears a virtual backward flow in ES – it is moving in radial direction towards the centre of the bare electron so in front of the $i\sin(kx - \omega t)$ there appears the sign "–". The inertia of such flow causes that density of it is highest in the centre of bare electron so we indeed can use a cosine to describe the quantum behaviour of the bare electron. We can see that the behaviour of the bare electron plus the virtual backward flow in ES lead to following complex conjugate of the wavefunction ψ: $\psi^* = e^{-i(kx - \omega t)} = \cos(kx - \omega t) - i\sin(kx - \omega t)$.

We wrote that electrons are created as the resting particles so what is physical meaning of their relativistic mass? Speed of electron concerns its wavefunction, not the electron itself. With increasing speed of electron there increases frequency of the disappearance and appearance of the bare electron so there is higher and higher number of the ES condensates (over time, the condensates dissolve in ES). We can see that the relativistic mass of electron is distributed in space whereas the bare electron is not (it is the relativistic invariant).

14.2 Forms of the wavefunction $\psi(x, t)$

From diffraction experiments such as the Davisson-Germer experiment or Thomson experiment and from the demand that a wave packed with a wavenumber k and angular frequency ω has a group velocity equal to the velocity of the classical free particlewith momentum p and energy E we reach the following conclusion:

*The wavefunction $\psi(x, t)$ representing the particle with an unspecified position, the well-known momentum p and kinetic energy E, moving in the positive direction of the **x**-axis, should have one of the forms [7]

$$\cos(kx - \omega t), \quad \sin(kx - \omega t), \quad e^{i(kx - \omega t)}, \quad \text{or } e^{-i(kx - \omega t)} .$$

All such wavefunctions are the solutions to the Schrödinger equation.

SST shows that the same conclusion results from the structures and dynamics of bare electron, photon or bare baryons (they are the core of baryons [1]).

14.3 The probability density of the position P(r, t)

We can see that the four wavefunctions listed in Paragraph 14.2 only partially describe the inner dynamics of the electron. In reality, the mathematical expression which describes the inner dynamics of the electron as fully as possible is the probability density of the position **P(r, t)** [7]

$$P(r, t) = \psi^*(r, t)\, \psi(r, t) = |\psi(r, t)|^2 .$$

This expression says about the quantum behaviour of the bare electron and about the two moving parts of the virtual field i.e. about virtual photons moving away from the bare electron and about the backward flow in ES towards the bare electron. All these three elements have positive energy so they all define the probability density of the position of the bare electron.

Because of the complex exponential functions, the probability density of the position is a real value so it can be measured – we assume that the probabilities are represented by moduli of the wavefunction.

In such a way we use the wavefunction to draw out the probability information.

14.4. The expectation value as the probabilistic expected value of the measured result of an experiment and the operators

In quantum mechanics, the expectation value is the probabilistic expected value of the measured result of an experiment.

The expected value for the position of the bare electron along the **x**-axis is

$$\langle x \rangle = \int \psi^* \, x \, \psi \, d^3 r = \int x \, P(x, t) \, d^3 r ,$$

where ψ is a normalized function.

Notice that $P(x, t)$ depends on position and time so to obtain expected value for momentum or energy, they must be expressed by r and t – it is the reason that we need operators

$$\text{Energy operator} = i \hbar \, \partial / \partial t \text{ or momentum operator} = - i \hbar \, \partial / \partial r .$$

Operators (which represent interactions) act on wavefunctions so they can change their amplitude so they can change probabilities of finding the bare particles in different places of space.

15. Summary

Here we showed that SST leads to virtual particles, wave-particle duality and non-locality of quantum entanglement i.e. to an essential part of quantum mechanics. On the other hand, physical side of quantum superposition is incomplete if not in its infancy.

Observed quantum phenomena are the results of well defined here the quantum coherence and quantum entanglement.

We showed that relativistic invariants such as electric charge of electron or its spin, i.e. the invariants associated with the torus/electric-charge of the bare electron, cannot be simultaneously in different places of space. The wavefunction of the bare electron is a mathematical trick that follows from its quantum behaviour but its collapse has physical meaning. Quantum coherence and quantum entanglement cause that more complex systems/particles can be as a whole in one quantum state only but different parts of such system/particle can be in different sub-states – it concerns the minds also.

A system is in quantum coherence when creates one virtual field with one characteristic frequency.

We cannot treat the bare particles as mathematical points because then many quantum processes are incomprehensible.

It is not true that there can be in existence massless energy not carried by physical volumes. A direct transformation of massless-energy/motions into mass/physical-volume is impossible. It is possible to transform indirectly in grainy fields a massless energy into mass. At first, the massless energy decreases local pressure of a field because motion of rotating object is more ordered. Next, there appear inflows of additional particles the field consists of – such inflows increase local mass density of the field.

Each particle consists of a bare particle and its virtual field created because of the difference between local density and global density. Even a classical particle surrounded by virtual quantum field can produce a well-defined interference pattern.

Measurement is the result of redirecting of some amount of quantum entanglement and quantum coherence of a system to a detector.

SST shows that the idea of a particle being in multiple possible states at the same time when not being observed is not realized by Nature. But it is true that different parts of a complex system can be simultaneously in different states – it does not concern the relativistic invariants.

Emphasize that quantum behaviour appears when we replace the gravitational interactions on the exchanges of the superluminal binary systems of closed strings (entanglons) the neutrinos consist of. Whole quantum mechanics we can explain via classical phenomena.

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