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COSMOLOGICAL ORIGIN OF QUANTUM UNCERTAINTY

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Abstract

This paper concerns the derivation of quantum uncertainty relation from brane cosmological model. It is based on representation of our Universe as a four-dimensional shell (brane) with finite thickness in the additional space. This model was introduced by Gogberashvilly and Rundall-Sundrum for the construction of interactions hierarchy and for expanding Einstein's general relativity laws to higher dimensions. With that, the thickness of brane is defined by the time of initial brane spontaneous creation. It is shown here that the Heisenberg uncertainty relation is a consequence of such cosmological model because we, being bound to four-dimensional space, are not able to measure precisely the parameters of particle movement in such a brane waveguide formed in the additional dimension.

1 Introduction.

Quantum mechanics, which mathematical apparatus was created by Schrodinger and Heisenberg, is based on the uncertainty principle, according which the uncertainty of mutual measurement of physical values, cannot be made lower some level [1]. Einstein with coauthors had put in doubt the completeness of quantum mechanics [2]. Copenhagen group of physisists lead by Bohr believed that it is sufficient to consider in practice only the result of measurement and the wave function describing the quantum state of particle experiences collapse under the measurement [3]. Afterwards, it was shown experimentally that paradoxical situation described by Einstein, Podolsky and Rosen [2]

Everett had proposed approach different in respect to Copenhagen group [4]. It supposes the simultaneous objective existence of multiple Universes, each of them corresponding to its own Hilbert space. This manifold is possibly infinite. Quantum measurement transfers observer into one or another Universe. The approach close to it is approach of hidden variables developed in [5]. Within this approach, Schrodinger equation on the wave function is supplemented by equation on local hidden variable defining objectively the density of probability for a particle to be in one or another state. It determines the result of measurement making the wave function entity more realistic.

Here, we consider the three-dimensional trajectory of particle in four-dimensional brane in five-dimensional universal space as hidden parameters. Then the waveguide equation attains the visual sense describing the propagation of particle as a wave in such membrane universal waveguide. In such a waveguide, it is possible also to consider also the corpuscular propagation of particle as spiral zigzaglike propagation of this particle with the reflection from the boundaries of waveguide. With that, spin moment of particle can be regarded as the mean of spiraled particle movement quantization in the universal space in contrast to the orbital moment describing spiral movement of particle in our space that is situating on the brane surface.

2 Uncertainty relation

Let's consider for simplicity the single-dimensional zigzag like scheme for propagation of a particle in such universal membrane (brane). It uses two-dimensional model [6, 7] that is shown in Fig.1 in general and its practically straight line part shown in Fig. 2 on the short range. range.

The boundaries of such waveguide can be regarded as cosmological domain walls first theoretically considered by [8] and [9]. Later, toroidal cosmological model was introduced [10], where large circle of tor is time

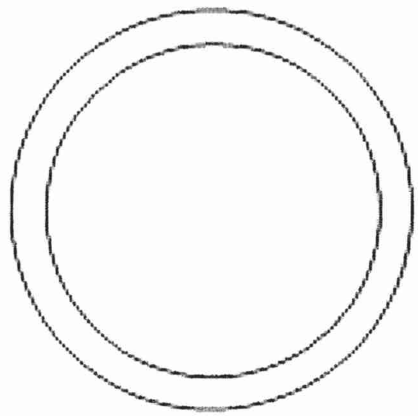

Figure 1: Two-dimensional model of universal membrane.

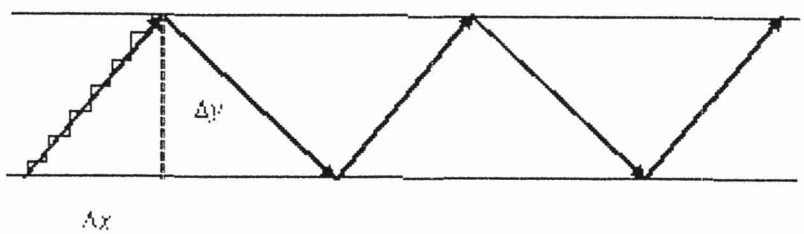

Figure 2: Waveguide model of particle propagation in universal membrane.

and small one is our three-dimensional space. So, our model here in Fig.1 corresponds to this transversal circle of this toroid model. With that, this toroid topology could be attained by Universe in the course of Bing Bang.

We have the possibility to determine the particle coordinate only when it is situated on the brane surface. Let us denote the uncertainty of coordinate as the half of distance between two successful measurements $\triangle x$ with minimally possible time between them. The minimum value of time between such measurements is realized atmaximum speed of particle replacement from one reflection to another in horizontal direction, i.e. at the movement of particle with speed of light. Particle speed in our space is defined as the rate of its replacement along its trajectory between two positions on brane (Fig. 1). Actual velocity of particle is determined by its trajectory in universal waveguide (Fig. 2). The maximal speed of particle realizes when particle moves completely in our space and minimal velocity realizes when particle reflects from upper boundary at the possibly most steep trajectory. The movement of particle can be imagined in quantum picture as the stepwise chain of transitions (quantum jumps) in horizontal and vertical directions (Fig. 2). With that, the uncertainty of velocity is determined by the rate of particle transmission only in vertical direction. It is equal to

$$\triangle v = \frac{\triangle y}{\tau}, \tag{1}$$

where $\triangle y$ is the thickness of membrane and

$$\tau = \frac{\triangle x}{c}. \tag{2}$$

is the time duration of one zigzag movement. It can be obtained from (1) and (2) that

$$\triangle x \triangle v = \frac{c \triangle y}{2} \tag{3}$$

The precision of the determination of particle's coordinate in the universal space (that is in radial direction in Fig.1 and vertical direction in Fig.2) is defined by brane thickness. The precision of all measurements is determined by minimal value of energy uncertainty. In relativistic theory, this value is equal to the energy of particle's rest mass mc^2. Let's consider the particle at rest as the particle that is not moving on brane which model is shown in Fig. 1 and the brane as quantum object that is rotating simultaneously in the clockwise and counterclockwise directions. Then, we will see that the energy of particle at rest is composed from kinetic movements of this particle in two opposite directions that is exactly equal mc^2. On the other hand, this particle's energy uncertainty is equal to energy of particle as de Broglie wave $h\omega = h\frac{2\pi c}{\lambda}$, where ω is frequency and λ is de Broglie wavelength. At the propagation in the waveguide this wavelength must be resonant to its thickness $\lambda = \triangle y$. Hence, we have

$$\triangle y = \frac{h}{mc} \tag{4}$$

That coincides completely with known relativistic formula for coordinate determination precision [11]. The substitution of (4) into (3) gives

$$\triangle x \triangle p = \frac{h}{2}. \quad (5)$$

When particles move along the brane with the velocity less than the speed of light, horizontal uncertainty $\triangle x$ increases and relation (5) transforms into the Heisenberg uncertainty principle

$$\triangle x \triangle p \geq \frac{h}{2}. \quad (6)$$

Thus, global universal membrane model (brane) yields the uncertainty principle of quantum mechanics describing, as it seemed before, only microscopic world. This description of particle's movement proceeds on the corpuscular level by the introduction of objectively existing additional dimensions in the framework of membrane universal waveguide with the thickness equal to particle's de Broglie wave.

3 Conclusion.

Thus, introduction of additional dimensions gives the possibility for quantum mechanics to be more complete explaining the uncertainty of particle parameters measurement by its corpuscular propagation in the universal membrane waveguide. It corresponds to the theory of hidden variables that, in the contrast to the theory of local hidden variables initially considered by John Bell [12, 13], is nonlocal one since points in additional dimensions have nonlocal character in respect to local points in our space-time. Eventually, Bell wrote in his book [14]: "If a hidden-variable theory is local it will not agree with quantum mechanics, and if it agrees with quantum mechanics it will not be local." Thus, non-local hidden variables used here support quantum mechanics yielding its main item - uncertainty principle.

Introduction of such additional dimensions makes, also, general relativity more physically substantiated. General relativity theory states that gravitation is a consequence of space-time curvature, but the curvature itself is just a mathematical abstraction. With the objective existence of multidimensional space-time, our four-dimensional space-time is the insertion in this multidimensional space and, accordingly to one of Friedman solutions of Einstein equation, is described by four-dimensional sphere with scalar curvature characterized by radius of this sphere. The finite thickness in additional dimensions yields quantum description of reality.

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