FWT-theorem, the one-particle contextuality, two-particle nonlocality, entanglement, Wheeler's experiments with delayed choice, and all that ...

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The beginning of the discussion we will begin with the words of P. Davis [1], expressed by him more than thirty years ago on the results of the Aspect's experiment.

"Quantum physics undermines a simplified classical relationship between the whole and its parts.The quantum approach requires considering particles only in their relationship with the whole. Therefore it was incorrect to consider elementary particles of substance as separate material objects which, being connected in ensembles, form larger objects. When a more accurate description of the world emerges as a set of relations."

It should be noted that the author had in mind a more general relationship, not reducing to the absolute of well-known topological (continuity, proximity, borders) or geometric (path, point) properties.

It is known that the representations of the relations of the whole and the part faces serious difficulties in the geometric description quantum mechanics , although this geometric relations of the parts are used in formalisms, for example, of corpuscular-wave dualism. This is clearly shown by the results of experiments in the Wheeler delayed choice [2]. First of all, a new variable is introduced, which takes only two values corresponding to the nature of the visualization of the observed pattern: corpuscular and wave. Corpuscular picture quite traditional can be described in a classical way with the introduction of the concepts of points, ways, trajectories, etc. In [2] under the *measurement* refers to the active procedures *retrieve* or *erase* some information; under the *supervision* - passive procedure of the prediction of the results of the measurement, in the corpuscular-wave case, prediction of the corpuscular or wave aspect of a quantum object with 100% accuracy during subsequent individual measurement. The distribution curves are obtained as the results of multiple measurements, that is, in experiments with an ensemble of particles.

Changing the picture of visualization is associated with the spread of the *single.* On the basis of the distribution of singles, the possibility of nonlocal quantum communication. For example, in [3], a quantum paradox is considered in which the presence or absence of an interference pattern of 2 x-photon path-entangled system is determined by the choice of measurement, which is a potentially nonlocal signal. Although the mechanism of change a visual image of the wave-particle duality (distribution of the single) is currently unknown, however, there were repeated attempts to use the distribution of *singles* for the implementation of the FTL data transmission.

In [3] it is shown that for the considered cases even when interference schemes can be switched on or off, there will always be *signal* or *anti-signal* interference "pictures", which are added even if there is entanglement [9] and coherence at the same time. This circumstance masks any observed interference. This behavior can be attributed to what is called "complementarity of one- and two-particle interferences "in the literature. However, the authors of [3, p.13] note that

... "is existing... mechanism by which the formalism of quantum mechanics blocks nonlocal signaling ... in the context of the standard quantum formalism, Nature appears to be well protected from the possibility of nonlocal signaling."

The photonic dualism " wave-particle "provides" simultaneous " coexistence of these two hypostases of the macrocosm. Switching of the observation method (initiation of a *single*) is not a usual signal propagation regulated by STR and, apparently, is capable to provide instantaneous change of the visual image of interference, that is, "propagation of a *single*". Actually, this is the key point in the possibility of implementing the ultralight transmission of information. To the extent feasible with the use of controlled parameters of systems is the subject of consideration of article [3]. According to the authors,

[1]) **I beg your pardon for my not very good English!** The original text in Russian**:** http://vixra.org/pdf/1804.0380v1.pdf

the visualization of singles is already the current moment of today's physics, the reality of which is confirmed experimentally. However, the obtained next negative results in the attempt of rendering a *single*, this remarkable quantum phenomena. In addition, they believe that the existence of singles is not contrary to the theory of relativity, and their distribution is not regulated SRT. A new certainty in the properties of such "*signals*" is presented in [10].

In February 2009, an article [4, p.1] was published in which the authors proposed a proof of the theorem (*FWT*-theorem), which is surprising in its significance for quantum theory. In particular, it says:

... "The two theories that revolutionized physics in the twentieth century, relativity and quantum mechanics, are full of predictions that defy common sense. Recently, we used three such paradoxical ideas to prove "The Free Will Theorem" (strengthened here), which is the culmination of a series of theorems about quantum mechanics that began in the 1960s. It asserts, roughly, that if indeed we humans have free will, then elementary particles already have their own small share of this valuable commodity. More precisely, if the experimenter can freely choose the directions in which to orient his apparatus in a certain measurement, then the particle's response (to be pedantic—the universe's response near the particle) is not determined by the entire previous history of the universe"...

In March 2016, the first experimental results were announced on verification of this theorem [5].

The most important points of the article should certainly include the mathematical proof of the limitation, up to the lack of functional connection between perturbation and response, which is equivalent to the absence of the influence of the past on the future and of the immediate environment on the quantum object. More precisely, the essence of the proven theorem lies in the fact that, if experimenters can obtain any state regardless of the background of the "collapse" of the wave function (i.e., previous measurements), something similar should be done for elementary particles. Namely, the authors note:

... "The free will theorem states that if experimenters have free will in the sense that their choices are not a function of the past, so must some elementary particles. The theorem goes beyond Bell's theorem as it connects the two fundamental resources behind quantum technologies: single-particle contextuality, which supplies the power for quantum computation, and twoparticle non-locality"... [5, p.1]:

and argue that the state vector of a quantum system can't serve as " storage" for its possible states.

In our opinion, this theorem is a good Preface to the discussion of the relational interpretation of quantum mechanics, namely - *interpretation*, since it does not affect the structure of quantum theory.

The essence of the contradictions arising between quantum mechanics and relativity theory can be understood from the consideration of the photon model of the Aspect's experiment .

What are the features of experiments with photons?

1. The photon is relativistic object. All events related to the movement of the photon can be considered both timelike and space like, since they are located on the border of these areas − the light cone. The first allows to consider these events as occurring in "one point", that is as locally causally connected; the second − as "simultaneous and various", causally unrelated (nonlocality). However, the movement of the photon takes place in a specific frame of reference, and the events are really divided both spatially and in time. In the power of one-particle contextuality, of two-particle nonlocality, entanglement, locality/nonlocality, causality/ not causality − all are "in-one". In these quantum states, generally speaking, there is no past, no future, no close, no distant. Although in a particular frame of reference (with factorization of spatial-temporal relations by 3+1) manifests itself and the first, and the second, and third, and fourth. However, light-like events in 4-space degenerate into a dimensionless 4-point without any "degrees of freedom" for interpretation. Quantum theory binds them together by means of entangled States of several particles, which can be registered detectors as separate objects.

2. Entangled quantum objects as a whole can be described as pure states, that is, using wave functions. The components that make up this entangled integrity - sub'objects and referred to as "particles" - cannot be described by wave functions. They are described by density matrices. The main feature of the description of states with the help of density matrices is their nonzero entropy, which means that the described object has an information capacity. The one-particle contextuality, two-particle entanglement and non-zero entropy give the possibility of exchange of information and its transfer between sub objects included in integrity. The mechanism and speed of information transfer between the components of the complete system are currently unknown.

3. A photon is a quantum object and has a dichotomous property is the "polarization". The monochromatic beam of light (apparently, this is one of the few properties in classical physics, subject to real quantization) has the same property. On this basis, experiments with light can adequately simulate the behavior of photons in relation to their polarization.

It should be noted here that the relational interpretation of quantum mechanics eliminates the contradiction between the theory of relativity and quantum mechanics, as it "puts out from the brackets" space-time relations for point events (see, for example: [7, 8]).

However, here it is possible to sum up some results on the consideration of spatiotemporal relations.

The first certainty in the factorization of spatiotemporal relations is the ability to enter a variable with values: a wave, a particle. The possibility of its visualization is confirmed experimentally. The change of the picture of the result is associated with the concept of a *single*, a new object, the spread of which is not regulated topologically and geometrically. At this stage, there are no concepts of proximity, distance, time interval, and therefore speed. From the CTR claims do not arise.

For the particle also there is arising another certainty - the path marking the points of birth of the particle and its detection. About certainty of the trajectory here is no question, therefore, the distance can't be considered. This is also confirmed experimentally. However, the possibility of manifestation of the point event prototype and, as a consequence, geometric 3 - and 4 - points, the occurrence of locality properties is obvious

The creation of conditions leveling the manifestation of the Heisenberg uncertainty principle leads to the possibility of describing trajectories and moments of time, that is, to the geometry and dynamics of the point in measurable performance and on the basis of metric topological properties (proximity, continuity, etc...). An elementary example of output to the traditional macrolevel description is given in [12].

In the work [11] an attempt of philosophical generalization of the results presented here is made.

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FWT-theorem, the one-particle contextuality, two-particle nonlocality, entanglement, Wheeler's experiments with delayed choice, and all that ...

Abstract.
In continuation of the discussion of the results of the Aspect's experiments. An overview of the new results.