A New Look at Quantum Domain and the Dual-slit Adventure

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Abstract A quantum particle is an elementary or a composite particle having a mass value lower than the Planck mass, and so it is subjected to a self-actuated jittery motion instead of a translational motion due to gravitation, however, under an exogenous cause it may undertake motion in space along with a waveform comprising of virtual particles created out of space. As a result it appears as a wave-particle unity instead of duality with its wave and particle nature simultaneously interacting with the conventional dual slit(s) or the input-output beam splitters causing interference even under delayed-choice scenario, provided it continues to remain in the quantum domain. Any observation made on the quantum particle by an external source will render it out of the quantum domain by imparting additional energy and then it will behave like a particle only. Thus reality of nature is a true spectacle and an unambiguous manifestation in the universe at all times.

Keywords Quantum domain, Wave-particle unity, Dual-slit, Beam splitter, Delayed-choice

1. Introduction

In this article the *quantum behavior of a particle* in relation to the conventional dual-slit experiment has been looked into from a different point of view in terms of its *motion through space* the result of which generates a waveform comprising of virtual particles created in space while the wave along with the particle travels through space towards the slit(s) causing the traditionally observed phenomena of interference or not, depending upon the number of slits open at the time of crossing the same. On the other hand, in case of making an observation on the particle by a device located after the slit(s), the effective mass of the particle increases due to an additional amount of energy and momentum imparted to it thus rendering it out of the quantum domain thereby causing no interference and behaving as a particle only.

We start with the following concepts, be those fictive or hypothetical only [1] [2].

- *Universe is a continuum* of transcendental, transitional and physical entities.
- *State of nothingness* is the primary source being a transcendental entity only.
- *Space is a transitional entity* being a continuum born out of state of nothingness.
- *Matter is a physical entity* comprising of discrete constituent particles in space.

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We may further extend our above concepts to the following indispensible notions.

- The *state of nothingness* is quantitatively equivalent to a *null set* ($\{0\}$) containing no elements and not even existing as a set, and therefore from the point of view of physics it does not comprise space, time, motion, mass, particle or anything at all.
- A pair of two equal and opposite charges in conformity with *Euler's relation* ($e^{i\pi} + 1 = 0$) is spontaneously created out of the state of nothingness along with a mandatory separation thus inducting space and allowing motion to take place.
- Each *charge gets localized* within space being in perpetual oscillatory transition between electric and magnetic energy like in a resistance free LC circuit giving rise to an intrinsic angular frequency and spin angular momentum in union with an intrinsic linear dimension inside the space, which create the elementary particle and anti-particle pair having mass, as an extended version of space unlike a point.
- We introduce a fictive property of *lethargy* ($L_e = m/c^2$), as also ($E = L_e * c^4$) with usual notations, in symmetry with energy, and inclusive of pressure, stress and shear also, which therefore encompasses all three dimensions of space, mass and time without any physical manifestation.

2. Motion of a Particle through Space

Motion of a particle, elementary or composite, involves a change of position in space by complete withdrawal from the initial to the final position, thereby implying that the particle must be finite and discrete whereas space must be a continuum only.

We now delineate the *quantum domain* of particles in motion having following essential quantum properties based on Planck units and taking into consideration reduced Planck constant $(\hbar)$, gravitational constant (G) and speed of light in free space (c).

- Quantum action $(\hbar)$
- Quantum slowness $(1/c)$
- Quantum length or Planck length $(l_P = \sqrt{\hbar G c}/c^2)$
- Quantum time or Planck time $(t_P = \sqrt{\hbar G c}/c^3)$
- Quantum gravitational mass or Planck mass $(M_P = \sqrt{\hbar G c}/G)$

We may re-write the above expression for Planck length as $(l_P = (M_P/c^2) * G)$ inferring that gravitation is a self-actuated phenomenon for any particle, elementary or composite, due to its having the minimum mass value equal to Planck mass; unlike other three fundamental interactions caused by exchange of mediating particles. However, for a particle with a mass value less than Planck mass and in absence of any other exogenous interaction, instead of a translational motion in a definite direction under gravitation the particle will exhibit a jittery motion in view of the principle of equiprobability and having an infinite number of degrees of freedom.

Moreover, the right-hand side of the General Relativity equation, with usual notations, may be written as $(8\pi G * (E/c^4))$ or in terms of lethargy as $(8\pi G * L_e)$, thus implying that spacetime curvature is caused by lethargy, and then by using notations of Planck length and Planck mass it may be written as $(8\pi l_P * (L_e/L_{eP}))$, thereby entailing that the ratio of the total amount of lethargy within the concerned volume of space and the lethargy equivalent of the Plank mass brings about the spacetime curvature as a linear multiplier of Planck length. So we may infer that the phenomenon of gravitation does not manifest itself with a mass value below the Planck mass thereby rendering the concept of quantum gravity as untenable. On the other hand, the state of nothingness realizing an ideal singularity and so causing the spacetime curvature attain a mathematically infinite value peers with the infinite non-manifest energy potential of the state of nothingness.

We further know that for a mass value equal to Planck mass, all the four lengths e.g. Planck length, Compton length, De Broglie length and Gravitational radius trivializing the numerical factor, will be equal and since all elementary particles and their stable composites, which may go on to produce atoms and molecules, are having mass values lower than the Planck mass while at the cosmological level objects are having mass values considerably higher than it, we may consider Planck mass to be on the threshold between the quantum regime and the macroscopic one, thereby once again purging out the perception and the need of a quantum gravity in the true sense of the quantum realm.

Thus the motion of a quantum particle having a discrete physical form inside space, which is a continuum without having any physical composition, can only take place by an exchange of the position of the particle with another particle of similar rest mass adjacent to it, which we may call a *virtual particle*, created out of free space. The spacetime curvature generated by the presence of the quantum particle will cause an equivalent amount of lethargy adjacent to it thereby creating a virtual particle in space out of the state of nothingness. This virtual particle will be the result of an impending motion of the quantum particle, and so there will be an innumerable number of such virtual particles, created at random, surrounding the particle in motion in view of equiprobability and infinite degrees of freedom. An analysis of the relative motion between the quantum particle and any virtual particle is as follows.

$\Delta T_1 = Time\ measured\ in\ particle's\ frame\ of\ reference$

$\Delta T_2 = Time\ measured\ in\ virtual\ particle's\ frame$

$\gamma = Lorentz\ factor$

$\gamma mc^2 = Total\ energy\ of\ particle$

$mc^2 = Rest\ mass\ energy\ of\ virtual\ particle$

$\gamma mc^2/\Delta T_1 = Rate\ of\ exchange\ of\ energy = mc^2/\Delta T_2$

$\gamma mc^2 * \Delta T_2 \propto Action\ taken\ place \propto mc^2 * \Delta T_1$

$\Delta T_1 = \gamma * \Delta T_2$

$\Delta L_1 = Space\ measured\ in\ particle's\ frame\ of\ reference$

$\Delta L_2 = Space\ measured\ in\ virtual\ particle's\ frame$

$\gamma mc^2/\Delta L_2 = Strength\ of\ interaction\ in\ between = mc^2/\Delta L_1$

$\Delta L_1 = \Delta L_2/\gamma$

The particle with a uniform velocity, free from any other exogenous cause, will undertake a trajectory obeying the action principle, however, exchanging along its way its position with other virtual particles, in a random manner like small perturbations only, in view of the jittery motion due to self-gravitation as elucidated earlier while maintaining a definite trajectory as far as possible. This will result in the formation of a *waveform* out of the sea of virtual particles moving along with the particle. It is similar to a waveform traveling through the water surface transmitted by the vibrating particles of composition. This analogy may be visualized by taking into account space being a continuum and a transitional entity between the transcendental state of nothingness and the physical form of matter particles. Thus a *wave nature* of the particle will also be observed pertaining to the conventional concept of *wave-particle duality* of the quantum particle in motion. We will now consider a number of specialized experiments carried out from time to time, the results of which will vindicate our above postulate fully.

3. Dual-slit or Equivalent Beam Splitter-interferometer Experiment

One critical consequence of the above conjecture will be *interference of waves* after it is allowed to pass through *dual*

slits, or its equivalent beam splitters, as has been discerned during experiments. However, it has further been witnessed that if the particle is subjected to observation by an external device located after the slits, the interference pattern ceases to develop, thereby imparting purely a particle nature only.

Now whichever way the experiment is carried out, and whether or not the particle is having prior knowledge about the number of open slits, physics will remain unaltered and follow its own rule: *Interference will be caused by dual slits (or its equivalent beam splitters) only, otherwise the particle behavior will be dominant in case of a single slit.*

This physical aspect can be fully explained and supported by our postulate that irrespective of the nature of the experiment, the particle at all times travels as a particle only, however, associated with it at all times again a waveform of virtual particles. Therefore, in reality the quantum particle is not called for making any choice about its behavior depending upon the number of slits, whereas the observer by deciding about the number of slits presents a pre-determined status for the particle along with its associated waveform to interact with the slit(s) following the conventional rule of physics only; provided of course the particle continues to remain within the quantum realm at all times.

3.1. Wheeler's Delayed-choice Gedanken Experiment with a Single Atom

In the specially devised "Wheeler's delayed-choice gedanken experiment with a single atom" [3] which is an atomic version of the earlier optical one, conducted at Australian National University using helium atom the decision about the number of beam splitting pulses (equivalent of conventional dual slits) is randomly made only after the traveling atom is subjected to the first beam splitting pulse, thus not allowing it to decide in advance (as per conventional wisdom) whether to manifest its particle or wave nature. Since the quantum particle is always associated with its waveform it will interact with the output beam splitting pulse causing interference under the delayed-choice mode or not.

A modification of the above experiment may be suggested so as to increase the temperature of the single helium atom thus imparting additional momentum and energy to it before being subjected to the first beam splitting pulse, in such a manner that the effective mass of the atom becomes equal to or more than the Planck mass value, thereby rendering it out of the quantum threshold, and so the atom will behave as a particle only at all times thereafter not being associated with a waveform of virtual particles.

3.2. Controlled Double-slit Electron Diffraction

Under the experiment "Controlled double-slit electron diffraction" [4] emulating the conventional dual-slit experiment with electron, a similar situation with the associated waveform of virtual particles will prevail for interference. However, during the act of observation made by a device located after the slit(s) the quantum particle will receive additional momentum and energy from the exogenous source raising its effective mass to the value of Planck mass or more driving it out of the quantum domain thus no longer embracing a waveform causing the loss of the interference phenomenon.

In order to confirm the above we may suggest the following experiments.

For a single-electron dual-slit apparatus:
- Eliminate the light source after the dual-slit
- Introduce an accelerator for the electron before the dual-slit
- Accelerate the single electron till it starts to depict purely particle behavior

For a single-photon dual-slit apparatus:
- Eliminate the light source after the dual-slit
- Introduce an exciter/energizer for the single photon before the dual-slit
- Excite/energize the single photon till it starts to depict purely particle behavior

3.3. Delayed-Choice Experiments and the Metaphysics of Entanglement

In another similar tryout "Delayed-Choice Experiments and the Metaphysics of Entanglement" [5] that is based on conventional double slits only, even in the case of the *delayed-choice* scenario, as also for the use of the specially devised *quantum eraser*, an identical argument of associated waveform of virtual particles will explain all observed behaviors. Moreover, the more interesting case of *entanglement swapping* including the *delayed-choice* variation of the same can be fully explained by the quantum behavior of particles as have been depicted under the concept of the *state of nothingness* [1] [2]. Since the entangled particles comprising any pair are related to one another through the state of nothingness only, they will communicate between themselves instantaneously. In the same way any one particle of an entangled pair will communicate with a particle of another independent entangled pair thus swapping the entanglement effectively between the remaining two particles.

3.4. GHA Double-prism Experiment

The "General Complementarity and The Double-prism Experiment" [6] also known as the "GHA experiment" unambiguously supports our postulate of *wave-particle unity in place of duality* thereby contradicting the complementarity principle of mutual exclusiveness of wave and particle nature of the quantum particle under consideration, however, with a marked difference. According to our postulate both the quantum particle and its associated waveform of virtual particles will go along the reflecting path while the waveform only will follow the tunneling path. Therefore, we will obtain the wave and the particle picture simultaneously.

We may suggest the above experiment to be carried out with a single neutral atom which should be excited to the

extent that its effective mass becomes more than Planck mass value before it strikes the double-prism, and in that case there will be no waveform associated with the particle and so the particle nature of it shall only be ascertained.

4. Conclusions

From the above analysis we may note that any particle, elementary or composite, having an effective mass below the Planck mass value will act as a quantum particle and undertake motion in space along with a waveform comprising of virtual particles created out of space in view of the impending motion of the particle, thereby causing interference at all times in the case of dual slits (or their equivalent beam splitters) even under the delayed-choice mode irrespective of the nature of the set up albeit will act as a particle only when an external observer imparts additional momentum and energy to it rendering it out of the quantum domain. Moreover, entanglement between two quantum particles is effected through the state of nothingness thereby causing instantaneous communication as also entanglement swapping including under the delayed-choice status.

The above consideration gets vindicated in case of the double-prism experiment confirming the wave-particle unity instead of duality. For the conventional dual-slit or input-output beam splitter set up there will be interference at all times even under the delayed-choice mode since the waveform will always be associated with the particle. Based on these observations we may conclude that *reality of nature is a true phenomenon* in our universe, starting from the quantum domain through the cosmological one, in an unambiguous manner, in view of the quantum particle being finite and discrete having a physical form while space being a continuum and a transitional entity only. Therefore statements and explanations e.g. "no phenomenon is a phenomenon until it is an observed phenomenon" implying "the past has no existence except as it is recorded in the present" may be summarily cast aside without any ambiguity.

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