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Field Dependent Hidden Variables and Principle of Normalization Versus Bell's Inequality, Quantum Superposition and Quantum Entanglement

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[Abstract]
All photons and electrons have predetermined quantum states (Hidden Variables). During photon polarization and electron magnetic polarization processes, their quantum states (Hidden Variables) can be changed either by adding energy to electron or reducing energy from photon to become a new quantum states (Field Dependent Hidden Variables). For further transformation (polarization processes), according to Principle of Normalization, a normalized quantum energy states can be achieved (Normalized Field Dependent Hidden Variables). Since Bell Inequality based on Set Theory can only be applied on the same sample space, therefore, Bell Inequality applying on the mixed sample spaces (the actual measurement) cannot be used to prove if Hidden Variables or Field Dependent Hidden Variables exist or not. Furthermore, both entangled photons and electrons have the same Hidden Variables except in opposite spin directions. Also under the same polarization processes (measurements), they both gain or lose the same energies and pass through the same threshold energy barriers to get to the same Field Dependent Hidden Variables. Therefore, they are always entangled no matter how far the distance and how fast the time are. Field Dependent Hidden Variables raises a big challenge to Bell's Inequality, Quantum Superposition and Quantum Entanglement.
[Keywords]
Quantum Entanglement, Superposition, EPR Paradox, Bell's Inequality, Hidden Variables, Electron Spin, Photon Spin, Optical Polarization, Magnetic Polarization, Schrödinger Cat.

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I. Quantum Superposition

Quantum Superposition is a fundamental principle of quantum mechanics. Any two (or more) quantum states can be added together ("superposed") and the result will be another valid quantum state; and conversely, that every quantum state can be represented as a sum of two or more other distinct states. Mathematically, it refers to a property of solutions to the Schrödinger equation; since the Schrödinger equation is linear, any linear combination of solutions will also be a solution. A single electron can be represented as a wave function with superposition of two quantum states, spin up and spin down, in Schrödinger equation.

II. Quantum Entanglement

Quantum entanglement is the physical phenomenon that occurs when a pair or group of particles is generated at the same time, they interact or share spatial proximity in a way such that the quantum state of each particle of the pair or group cannot be described independently of the state of the others, even when the particles are separated by a large distance.

Measurements of physical properties such as position, momentum, spin and polarization performed on entangled particles are found to be perfectly correlated. For example, if a pair of entangled particles is generated such that their total spin is known to be zero, and one particle is found to have clockwise spin on a fixed axis, then the spin of the other particle, measured on the same axis, even instantly will be found to be counterclockwise. However, this behavior gives rise to paradoxical effects: (1) The speed of communication could be faster than speed of light (assuming light speed is the limit of speed), (2) Any measurement of a property of an entangled particle results in an irreversible wave function collapse of that particle which can cause interruption of the entanglement and subsequently a random state of the other particle can be measured.

III. EPR Paradox

In 1935, Albert Einstein, Boris Podolsky, and Nathan Rosen [1] brought up EPR Paradox, in which Einstein and others considered such behavior to be impossible unless instant communication can be fulfilled for an infinite distance. It violates the local realism view of causality (Einstein referring to it as "spooky action at a distance") and argued that the accepted formulation of quantum mechanics must therefore be incomplete.

Furthermore, a measurement made on either of the particles apparently collapses the state of the entire entangled system instantaneously before any information about the measurement result could have been communicated to the other particle. According to quantum theory, the outcome of the measurement of the other part of the entangled pair must be taken to be random, with each possibility having a probability of 50%. However, if both spins are measured along the same axis, they are found always to be anti-correlated.

IV. Hidden Variables

Despite the impossible solution that the communication between two particles can be so fast even more than light speed, Einstein proposed a possible resolution to the paradox is to assume that quantum theory is incomplete, and the result of measurements depends on predetermined "hidden variables" [2]. The state of the particles being measured contains some hidden variables, whose values effectively determine, right from the moment of separation, what the outcomes of the spin measurements are going to be. This would mean that each particle carries all the required information with it and nothing needs to be transmitted from one particle to the other at the time of measurement. Einstein and others originally believed this was the only way out of the paradox, and the accepted quantum mechanical description with a random measurement outcome must be incomplete.

The weak point in EPR's argument was not discovered until 1964, when John Stewart Bell proved by his inequality that the Hidden Variables interpretation hoped for by EPR, was mathematically inconsistent with the reality.

When measurements are made on a large number of pairs of entangled particles, statistically, if the hidden variables view were correct, then the results would always satisfy Bell's Inequality [3]. Since a number of experiments have shown in practice that Bell's Inequality is not satisfied, therefore it is believed that hidden variables are not true and quantum mechanics is surely based on Superposition and Complementarity.

V. Bell's Inequality

Bell's Inequality is a mathematical theory based on Set Theory (Fig. 1) [4]. Bell's Inequality is true only if all the elements in the sample space have predetermined variables. For example, in case of photon polarization, when a light beam passing through three polarizers with polarization angles A = 0^o, B = 22.5^o and C = 45^o, the intensity of the transmitted light can be shown in Table 1 [4]. Where "Real Transmission" is the actual measurement results and "Bell Transmission" is the theoretical results based on Bell's Inequality. Because the actual measurement results of Real Transmission are different from that of Bell Transmission, therefore, Bell claimed that Hidden Variables cannot be the solution of EPR Paradox. In other words, according to Bell, quantum theories such as Superposition Theory and Complemantarity Principle must be true.

Bell's Inequality sounds great, but a very important necessary condition of Bell's Inequality is missing that is "all elements in the sample space must stay unchanged no matter distribution and transformation". Therefore, all efforts using Bell's Inequality to prove that "Hidden Variables" doesn't exist are in vain.

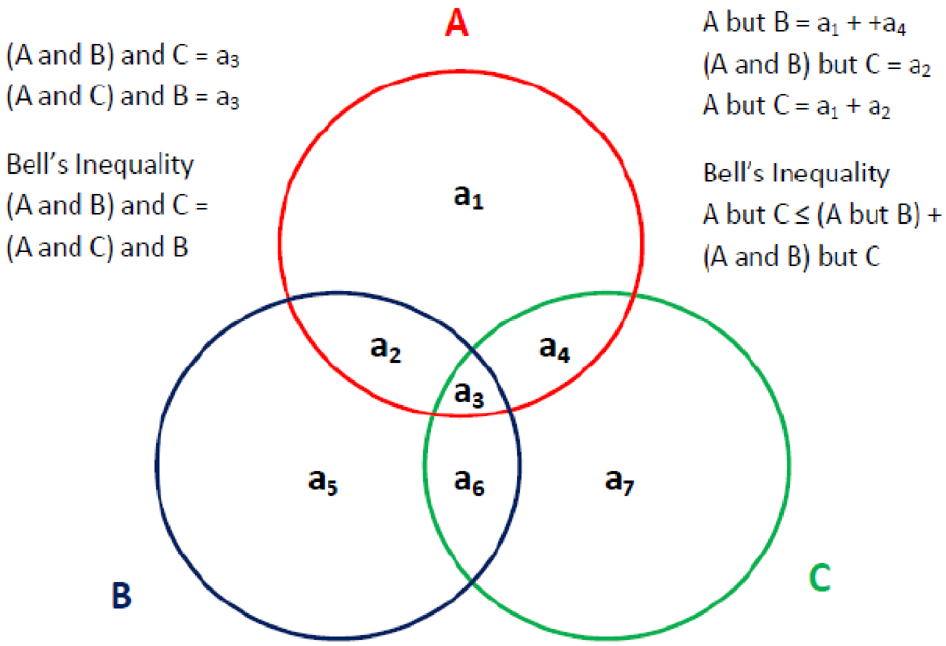

Fig. 1 Bell's Inequality Diagram – The distribution of elements in three domains (sets). All elements must stay unchanged no matter of distribution.

VI. Field Dependent Hidden Variables

In fact, all photons and electrons have their predetermined quantum energy states (Hidden Variables). Through polarization process either by optical polarize lens for photon or magnetic field for electron, subject to the polarization strength based on the polarization angle, an energy barrier (for photon) [5] or a threshold energy (for electron) [6] are established.

In case of optical polarization, for those photons which have higher energy than the energy barrier (established by the polarization angle) will pass through the polarizer and keep the same polarization direction as the polarizer, or otherwise, they will be blocked by the polarizer.

In case of magnetic polarization, for those electrons which have initial energy higher than the threshold energy (established by the polarization angle) will gain the polarization energy (provided by magnetic field) to overcome the energy barrier and flip of to the opposite spin direction, or otherwise, they will maintain the original spin status in the new polarization direction.

The quantum energy states of photons and electrons after transformation (optical polarization and magnetic polarization) are named Field Dependent Hidden Variables. They are determined by the original quantum energy states (Hidden Variables) and polarization field (polarization angles). Because of the even distribution, after transformation, the probability to find the polarization status, either passes or block out the photons, or spin up or spin down the electrons, is also dependent on the polarization fields (polarization angles) of the polarization processes (measurements).

VII. Principle of Normalization

In optical polarization (for photon) and magnetic polarization (for electron) processes, before transformations, both photons and electrons have their fixed quantum energy states (Hidden Variables). After transformations by adding energy to electrons and reducing energy to photons, they are regenerated with Field Dependent Hidden Variables (the new quantum energy states in the new polarization directions). For further transformations, both photons and electrons repeat the same distribution patterns as the previous transformations. This is named "Principle of Normalization".

For example, as shown in Table 1, in real transformation obeying Principle of Normalization, the ratio of photons pass through B polarizer noted as (A and B) is 85%. Furthermore, according to Principle of Normalization, the ratio of these photons pass through another C polarizer noted as ((A and B) and C) is 72.25% (because 85% x 85% = 72.25%). It is bigger than the ratio of photons pass through C polarizer noted as (A and

C) which is 50%. It is also different from the ratio of photons pass through C polarizer then B polarizer noted as ((A and C) and B) which is 42.5% (because 50% x 85% = 42.5%).

In the above example, "((A and B) and C)" and "((A and C) and B)" are in different normalized sample spaces transformed from the sample space of Field Dependent Hidden Variables ((A and B) and (A and C)). Since Bell's Inequality is based on Set Theory which can only be applied on the same sample space. In other words, all elements used in Bell's Inequality must come from the same sample space, therefore, Bell's Inequality applying on mixed sample spaces cannot be used to prove if Hidden Variables or Field Dependent Hidden Variables exist or not.

VIII. Fail of Bell's Inequality

Furthermore, the fail of Bell's Inequality in Field Dependent Hidden Variables can be represented by mathematics as follows:
In Bell's Inequality based on Set Theory (Fig. 1) (Table 1),
$(A \cap B) \cap C = (A \cap C) \cap B$
$(A \cap \text{-}C) \leq (A \cap \text{-}B) + (A \cap B) \cap \text{-}C$
$(A \cap B) \cap C \leq A \cap C$
Where ∩ is "AND Operation" in Set Theory based on the same sample space. All elements (photons and electrons) stay unchanged (maintain the same Hidden Variables) during AND operations.
However, in optical polarization (for photon) and magnetic polarization (for electron) based on Principle of Normalization (Table 1),
$(A \cap B) \cap' C > (A \cap C) \cap'' B$
$(A \cap \text{-}C) > (A \cap \text{-}B) + (A \cap B) \cap' \text{-}C$
$(A \cap B) \cap' C > A \cap C$
Where ∩' and ∩" are "AND Normalization Operations". Elements are from sample spaces of Field Dependent Hidden Variables and Normalized Field Dependent Hidden Variables.

Table 1 The Real Transmission and Bell Transmission of three polarizers with polarization angels A = 0^{o}, B = 22.5^{o}, C = 45^{o}.

Polarizer	Real Transmission	Bell Transmission
A	100%	100%
A and B	85%	75%
A but B	15%	25%
(A and B) and C	72.25%	50%
(A and B) but C	12.75%	25%
(A but B) + ((A and B) but C)	27.75%	50%
A and C	50%	50%
A but C	50%	50%
(A and C) and B	42.5%	50%
Bell's Inequality (A but C) ≤ (A but B) + ((A and B) but C)	50% > 27.75%	50% ≤ 50%
Bell's Inequality (A and B) and C = (A and C) and B	72.25% ≠ 42.5%	50% = 50%
Remarks	Doesn't meet Bell's Inequality	Meets Bell's Inequality

In both photon polarization and electron magnetic polarization processes, all photon and electron with their quantum energy states (Hidden Variables) in the polarization direction before transformation can be changed to a new field dependent quantum energy states (Field Dependent Hidden Variables) in the new polarization directions either by adding energy to electron or reducing energy from photon due to the transformation processes. Furthermore, a normalized subsequent polarization process can convert further Field Dependent Hidden Variables to Normalized Field Dependent Hidden Variables (normalized quantum energy states). In other words, all elements (photons and electrons with their quantum energy states) after transformation are in a new sample space, which are no longer the same elements and sample space before transformation. Because in real transmission measurements, all elements (photons and electrons) in mixed sample spaces are used for the calculation of Bell's Inequality, also Bell's Inequality is based on Set Theory which can only be applied on the same sample space, therefore, Bell's Inequality applying on mixed sample spaces cannot be used to prove if Hidden Variables or Field Dependent Hidden Variables exist or not. Because of the actual existence of Hidden Variables and Field Dependent Hidden Variables, there are no such things as "Quantum Superposition", neither "Schrodinger's Cat can be both alive and dead". It is indeed true that "God doesn't play dice". The world always obeys Locality and Realism, Einstein's EPR Paradox and Hidden Variables are correct after all.

Furthermore, in Quantum Entanglement, both entangled photons and electrons have the same Hidden Variables except in opposite spin directions. Also under the same polarization processes (measurements), they both gain or lose the same energies and pass through the same threshold energy barriers to get to the same Field Dependent Hidden Variables, therefore, they are always entangled no matter how far the distance and how fast the time are. Everything is predetermined, there is no mystery, no surprise and certainly no "Spooky" behaviors.

IX. Conflicts in Quantum Mechanics

According to Yangton and Yington Theory, both wave and particle properties (Wave Particle Duality) can coexist in a spinning polarized particle such as a photon or electron at all times, no matter the environment and location. In Double Slit Interference experiment [7], particle detector can be used to influence the phase angles of particle waves such that the interference patterns can be diminished or even cancelled. However, this experiment can't be used to prove the nonexistence of wave properties. Therefore, "Complementarity" meaning "both wave and particle properties cannot coexist while being observed or measured simultaneously" is not true.

In addition, for both photon and electron with their predetermined quantum energy states (Hidden Variables), energy can be added to electron or removed from photon through an interactive transformation process (polarization or magnetic field measurement). Also subject to the threshold energy depending on the strength of the polarization (the angle of polarization), they can be moved to a new quantum energy states (Field Dependent Hidden Variables) either remaining the same spin mode if original energy state is lower than the threshold energy or flipping of to the opposite spin mode if original energy state is higher than the threshold energy. (In case of photon polarization, low energy photons are blocked out by the threshold energy – the transformation energy barrier). Also, according to Principle of Normalization, both photons and electrons can be transferred further to normalized quantum energy states (Normalized Field Dependent Hidden Variables) through further transformations.

Because of the different quantum energy states caused by transformations make different sample spaces, and Bell's Inequality based on Set Theory which can only be applied on the same sample space, therefore Bell's Inequality applying on mixed sample spaces cannot be used to prove if Hidden Variables or Field Dependent Hidden Variables exist or not. Since both Hidden Variables and Field Dependence Hidden Variables actually exist, Schrödinger's Cat cannot be alive and dead at the same time. As a result, "Quantum Superposition" cannot be true neither.

Furthermore, in Quantum Entanglement, both entangled photons and electrons have the same Hidden Variables except in opposite spin directions. Also under the same polarization processes (measurements), they both gain or lose the same energies and pass through the same threshold energy barriers to get to the same Field Dependent Hidden Variables Therefore, they are always entangled no matter how far the distance and how fast the time are. Everything is predetermined, there is no mystery, no surprise and certainly no "Spooky" behaviors.

Even though Quantum Mechanics has been misinterpreted by some famous scientists in the past millennium, also a serious challenge has been raised to against Superposition Theory and Complementarity Principle – the heart of Quantum Mechanics, still Quantum Mechanics is a very well established scientific theory based on the quantized properties of particles and the probability and statistic natures of multiple quantum states.

X. Conclusion

All photons and electrons have predetermined quantum states (Hidden Variables). During photon polarization and electron magnetic polarization processes, their quantum states (Hidden Variables) can be changed either by adding energy to electron or reducing energy from photon to become a new quantum states (Field Dependent Hidden Variables). For further transformation (polarization processes), according to Principle of Normalization, a normalized quantum energy states can be achieved (Normalized Field Dependent Hidden Variables). Since Bell Inequality based on Set Theory can only be applied on the same sample space, therefore, Bell Inequality applying on the mixed sample spaces (the actual measurement) cannot be used to prove if Hidden Variables or Field Dependent Hidden Variables exist or not. Furthermore, both entangled photons and electrons have the same Hidden Variables except in opposite spin directions. Also under the same polarization processes (measurements), they both gain or lose the same energies and pass through the same threshold energy barriers to get to the same Field Dependent Hidden Variables. Therefore, they are always entangled no matter how far the distance and how fast the time are. Field Dependent Hidden Variables raises a big challenge to Bell's Inequality, Quantum Superposition and Quantum Entanglement.

References

[1]. Einstein A, Podolsky B, Rosen N; Podolsky; Rosen (1935). "Can Quantum-Mechanical Description of Physical Reality Be Considered Complete?". Phys. Rev. 47 (10): 777–780. Bibcode:1935PhRv.47.777E. doi:10.1103/PhysRev.47.777.

[2]. Magazine, Elizabeth Gibney, Nature. "Cosmic Test Bolsters Einstein's "Spooky Action at a Distance"". Scientific American. Retrieved 4 February 2017.

[3]. Mermin, N. David (July 1993). "Hidden Variables and the Two Theorems of John Bell" (PDF). Reviews of Modern Physics. 65(3): 803– 15. arXiv:1802.10119. Bibcode: 1993RvMP...65..803M. doi:10.1103/RevModPhys.65.803.

[4]. Edward T. H. Wu. "Hidden Variables versus Bell's Inequality and Conflicts of Superposition, Complementarity and Entanglement in Quantum Mechanics." IOSR Journal of Applied Physics (IOSR-JAP), 12(3), 2020, pp. 24-35.

[5]. Edward T. H. Wu. "Photon Polarization and Entanglement Interpreted by Yangton and Yington Theory." IOSR Journal of Applied Physics (IOSR-JAP), 12(3), 2020, pp. 01-06.

[6]. Edward T. H. Wu. "Quantum Entanglement and Hidden Variables Interpreted by Yangton and Yington Theory." IOSR Journal of Applied Physics (IOSR-JAP), 12(2), 2020, pp. 39-46.

[7]. Edward T. H. Wu. "Single Slit Diffraction and Double Slit Interference Interpreted by Yangton and Yington Theory." IOSR Journal of Applied Physics (IOSR-JAP), 12(2), 2020, pp. 10-16.

Edward T. H. Wu. "Field Dependent Hidden Variables and Principle of Normalization Versus Bell's Inequality, Quantum Superposition and Quantum Entanglement." *IOSR Journal of Applied Physics (IOSR-JAP)*, 13(2), 2021, pp. 48-53.