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On Reality in Physics and the EPR Paradox

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Generally speaking, reality is what we can perceive with our senses. In physics this means that reality is what we see on our measuring devices, in other words it is the result of a measurement.

In the special case pertaining to the Einstein Podolsky Rosen (EPR) paradox, two particles are emitted from a common source and travelling in opposite directions, they eventually meet two observers, Alice and Bob. Assume that the particles are photons and that these observers measure linear polarization states. According to quantum mechanics, before the measurement, the two photons are in an entangled state. Then the outcome of the measurement depends only on their polarization angular difference [1]. This then violates Bell's inequalities as shown experimentally by Nobelists Clauser, Aspect and Zeilinger and by others [2].

At this point it is important to note that the entangled state is non real in the sense given above, since it cannot be measured directly. On the contrary, the states observed by Alice and Bob are perfectly real. It is important to remark also that by speaking of a state, one considers the simultaneous polarization state of both photons. The non-real entangled state is then a linear superposition of the two possible real states of the system and this state is present from the beginning and until the time of the measurement.

According to Einstein's concept of reality in nature, the creation of the combined sate observed by Alice and Bob can only take place by transmission of information between the two observers, since this transmission occurs at maximum speed c, the speed of light in vacuum, the presence of these states at any moment is in contradiction to special relativity and constitutes a paradox. Clearly this paradox disappears if we consider non-real intermediate entangled states in the process [3].

However, in my opinion, Einstein's objection against non-real phenomena in quantum mechanics has to be taken seriously and in particular his idea of hidden variables is not simply disproved by polrization experiments.

More generally, Einstein's belief that quantum mechanics is incomplete, is verified by the fact that quantum mechanics and relativity cannot be combined in a completely satisfactory fashion.

A last word on Schrödinger's cat: this is a very confusing matter. Clearly the cat is a real macroscopic object and it can therefore be only alive or dead, but not both at the same time. What is in a non-real superposition state, is the radioactive substance at the origin of the infernal killing device. Speaking of Schrödinger cat states in quantum mechanics is a language abuse, since it suggests that the cat can be in a state of dead and alive simultaneously.

Conclusion

Quantum mechanics is based on principles, which cannot be understood in terms of macroscopic reality.

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