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EPR Paradox, Quantum Nonlocality and Physical Reality

Eighty years ago Einstein, Podolsky and Rosen demonstrated that the instantaneous reduction of wave function describing a couple of entangled physical systems led to so called EPR paradox. The paradox disappears in statistical interpretation of Quantum Theory (QT) according to which a quantum state does not describe completely an individual physical system but only an ensemble of identically prepared physical systems. Quantum probabilities are not degrees of belief of some intelligent agents but they are objective properties of physical experiments which might emerge from some more detailed description of quantum phenomena. QT predicts strong correlations between the outcomes of measurements performed on different members of EPR pairs in far-away locations. Searching for an intuitive explanation of these correlations John Bell analysed so called local realistic hidden variable models and proved that these models always satisfy Bell inequalities which are violated by the predictions of QT. Several different local models were constructed and inequalities proven. Some eminent physicists concluded that Nature is definitely nonlocal and that it is acting according a new law of nonlocal randomness. According to this law perfectly random, but strongly correlated events, can be produced at the same time at far away locations and a spatio–temporal, local and causal explanation of their occurrence cannot be given. We strongly disagree with this conclusion and in this talk we analyse various finite sample proofs of Bell and CHSH inequalities and so called Quantum Randi Challenges. We will also show how one can win so called Bell's game without violating locality of Nature. Nonlocal randomness is inconsistent with local quantum field theory, with standard model in elementary particle physics and with causal laws and adaptive dynamics prevailing in the surrounding us world. The experimental violation of Bell-type inequalities does not prove the nonlocality of Nature but it only confirms the contextuality and complementarity of quantum observables and gives a strong argument against the point of view according to which the experimental outcomes are produced in irreducible random way. Time permitting we will explain "sample homogeneity loophole" which could not be closed in several experiments testing local realism.

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