

The Einstein-Podolsky-Rosen Argument and the Bell Inequalities

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Abstract

In 1935 Einstein, Podolsky, and Rosen (EPR) published an important paper in which they claimed that the whole formalism of quantum mechanics together with what they called "Reality Criterion" imply that quantum mechanics cannot be complete. That is, there must exist some elements of reality that are not described by quantum mechanics. There must be, they concluded, a more complete description of physical reality behind quantum mechanics. There must be a state, a hidden variable, characterizing the state of affairs in the world in more details than the quantum mechanical state, something that also reflects the missing elements of reality.

Under some further but quite plausible assumptions, this conclusion implies that in some spin-correlation experiments the measured quantum mechanical probabilities should satisfy particular inequalities (Bell-type inequalities). The paradox consists in the fact that quantum probabilities do not satisfy these inequalities. And this paradoxical fact has been confirmed by several laboratory experiments in the last three decades. The problem is still open and hotly debated among both physicists and philosophers. It has motivated a wide range of research from the most fundamental quantum mechanical experiments through foundations of probability theory to the theory of stochastic causality as well as the metaphysics of free will.

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