

Quantum Reality: to Be and Not-to-Be

The question of how to interpret quantum mechanics is not yet understood clearly in terms of reality. Contrary to the founders of quantum mechanics, especially Niels Bohr (1885–1962), Albert Einstein (1879–1955), with Boris Podolski and Natan Rosen, defended a simplified version of realism in nature postulating the concept of hidden parameters. They have formulated the well-known EPR paradox, which is depicted in Figure 1 for two well-separated quantum objects that cannot communicate faster than the speed of light.

In a nutshell, their reasoning can be summarized as follows. Because no influence of any kind can propagate faster than the speed of light, and assuming that induction is a valid way of reasoning in quantum mechanics, we cannot reconcile two obvious premises: one is realism, phenomena are caused by a physical reality whose existence is independent of human observers, and the second is local causality (assuming independence of well separated objects). One cannot reject any of these self-evident truths. Hence one is led to conclude that the description of reality as given by wave functions is not complete (Einstein et al., 1935).

Any quantum object can be described as a particle or a wave, which could lead to a paradoxical observation. Moreover, a quantum object can be in an entangled state described by the superposition of the wave functions ψ in the form

$$\psi = 1/\sqrt{2} |\uparrow\rangle + 1/\sqrt{2} |\downarrow\rangle$$

that is a composition of two opposite properties, e.g., spin up (relative to an axis) with the probability $\frac{1}{2}$ and spin down with the probability $\frac{1}{2}$. This is illustrated using the idea of a hypothetical cat in a box suspended between life and death attributed to Erwin Schrödinger (1887–1961), who proposed a famous thought experiment, which is known as Schrödinger's cat in academic literature, as allegorically shown in Figure 2. It cannot be determined whether the cat is dead or alive until the box is opened; similarly, one cannot determine the spin until the particle is measured and, surprisingly enough, the measured value depends on the observer. Many laboratory tests show that, despite Einstein's objections, a strange character of the quantum world must be accepted. In fact, in the quantum world there are some mysterious phenomena that are well described by entangled states. Two opposite properties of particles are realized with some probabilities. It is strange, but there not in contradiction to have both states simultaneously.

Anyway, it seems to me that quantum theory requires a new philosophical concept of *existence* of elementary constituents of the microworld. In my view, this scientific paradigm requires **new** philosophical concepts of being based on modern metaphysics (Macek, 2000). Referring to the celebrated quote from Hamlet: *to be or not be*, the basic question for a new metaphysics is: how *to Be and Not-to-Be*?