Ángel S. Sanz

Quantumness beyond quantum mechanics
Departamento de Física Atómica, Molecular y de Agregados
Instituto de Física Fundamental (CSIC)
Serrano 123, 28006 - Madrid
Spain

Nowadays there is no doubt that quantum mechanics is the most successful theory ever devised to explain the physical world. Its scope goes beyond fundamental physical aspects, reaching technological applications which are currently part of our daily life. However, this theory is still a veiled mystery at a deeper level of understanding, when we seek a clear interpretation of the physics underlying quantum systems. A good reason for this can be found in the probabilistic nature commonly attached to this theory. Accordingly, nothing precise about a quantum system can be said (regardless of what we may mean by a quantum system), but we can only access to a probabilistic knowledge of it. A feasible way to surmount this drawback comes through Bohmian mechanics. This theory of quantum motion allows us to understand the individual evolution of quantum systems, keeping at the same time the formal equivalence with standard quantum mechanics in the statistical limit (i.e., when carrying out a sampling over many realizations for such systems or, equivalently, many identical systems).

The core idea in Bohmian mechanics, namely a reformulation of the quantum formalism in terms of hydrodynamical concepts, can also be exported to other physical contexts where waves or distributions are the primary descriptor. In other words, we usually separate quantum physics from other wave theories. However, Bohmian mechanics allows us to establish a bridge between them, carrying its interpretational insight into other physical problems, not necessarily quantum-mechanical ones. Although the kind of waves dealt with by quantum mechanics and other wave theories is very different in nature, the way these theories operate is in essence the same, i.e., the same type of concepts (e.g., coherence, interference, diffraction, tunneling, discreteness, etc.) and principles (e.g., uncertainty, superposition) are always involved. Taking this into account, it is possible to establish a sort of feedback regarding the understanding of both wave phenomena, in general, and quantum phenomena, in particular.

Here, I would like to bring into discussion a debate focused on such a fundamental question. Actually, recent experiments, such as those carried out by Coulter's group with Bohmian-like motion in classical fluids or those by Steinberg's group on the inference of photon paths, make this discussion even more necessary than ever. With this in mind, I shall introduce this discussion through the concept of coherence (present to any wave theory), which will be analyzed in terms rays or trajectories, thus trying to render some light on its physical meaning at a deeper level.

Several physical contexts will then be considered where it will be shown how a Bohmian-like view proves to be useful to understand the underlying physics.

Ángel S. Sanz was born in Madrid in 1975. He studied Physics at Universidad Autónoma de Madrid, graduating in 1999 and getting his PhD in the same University in 2003. After a short postdoctoral period in this University, he moved to the University of Toronto, where he was postdoctoral fellow in the group of Paul Brumer, from 2004 to 2005. By the end of 2005, he moved back to Madrid, to the Instituto de Física Fundamental (IFF-CSIC), where he has conducted a long and stable research, first as postdoctoral fellow and at present as research associate. Although his main subject of research at present is the application of Bohmian mechanics and its phenomenology to explore both the quantum world and other physical wave theories, the problems in which he is involved cover a wide spectrum, such as waveguiding, matter wave interferometry, interference and diffraction, chemical reactivity, Markovian evolution, decoherence and entanglement, or relaxation and transport phenomena, some of them not being directly related to Bohmian mechanics.

http://www.unive.ac.at/wnf11/congress/abstract/sanz_angel.html