Bohmian Mechanics and Contextuality

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Abstract

The purpose of the current project will be to resolve the following apparent paradox. How can both (A) and (B) be correct, where (A) and (B) are defined as: (A) (q, p) can't have predefined values to be consistent with Quantum Mechanics (QM). This can be explained by a test called "the GHZ test". This test claims to prove that there's no reality, viz. variables we measure can't have predefined values. This test was originally for spins. It has now been extended to (q, p). (B) Bohmian Mechanics (BM) assigns (q, p) precise values and has been so far shown to be consistent with all predictions of QM.
This paradox has not been studied yet and it is particularly interesting for if BM is unable to predict the QM result, then we'd know at once BM is wrong. If BM does predict the QM result, we'd know that the claim made by the GHZ state, must be valid in a restricted sense.

Background and Abstract

The Quantum Mechanics that is taught, is usually the one which uses the 'Copenhagen interpretation'. This interpretation asserts that the most complete possible specification of an individual system, is in terms of ψ which yields only probabilistic results. While it can be shown to be consistent, it is worth exploring the reasons for believing this assertion. David Bohm[a] in an attempt to investigate the truth behind this, constructed a theory with 'hidden variables' (positions and momenta (q, p) of particles) that in principle completely specified the system but in practice get averaged over. He was able to show that his theory yields the same results as Quantum Mechanics in all the physical situations he considered. Such a theory is worth studying because the following are at stake. (1) Clarity: The widely held notion that at the atomic level, we must give up any concievable precise description of nature, is plain false because there exists a heretic counter example. (2) Accuracy of conclusions: The Bell test showed that there can't be hidden variable theories consistent with predictions of QM. Yet Bohmian Mechanics (Bohm's hidden variable theory) is consistent with QM; it allows the violation of Bell's inequality. The point is that we must be extremely careful about the conclusions we draw from our equations/experiments. The Bell test excludes *local* hidden variable theories, and Bohmian mechanics is explicitly *non-local*.
There are a host of interesting questions which can be raised. For instance, one could ask why position and momentum aren't simultanesouly determinable if in princple they're well defined? In the double slit then, the particle goes through one of the slits? Can one observe these trajectories? If particles have trajectories, what happens to identical particles? What happens to spins? Does the explicit non-locality entail we can communicate faster than light? Can one distinguish between Bohmian Mechanics and the usual Quantum Mechanics expeirmentally? All these questions, except the last, have been solved or atleast addressed.

[a] Historically, de Broglie had formulated a similar theory and then gave it up until Bohm independently re-discovered it