HPS/Pl 125: Problem 8

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Wallace mentions an objection to Bohmian mechanics originally due to David Deutsch: because Bohmian mechanics includes a wave function evolving via the Schrodinger equation (and that's all the many-worlds interpretation says that there is), Bohmian mechanics includes a vast number of parallel universes (adding particles does nothing to remove these parallel universes). Thinking about the ontology of Bohmian mechanics and the many-worlds interpretation, how do you think a Bohmian could best respond to this objection?

The many-worlds of the Everett interpretation stem from the need to resolve a basic issue. The quantum algorithm gives us a probability amplitude for each possible outcome of a quantum computation. However, the result of any measurement made is deterministic. For reasons we've covered at length, we think that quantum mechanics must be a ψ-ontic theory (where the wave function is a real element of the ontology). This means that *something* must happen to transition from the probability amplitude to a definite outcome since both reflect the true state of the world. The many-worlds interpretation resolves this by *avoiding* resolving it — simply conclude that the definite outcomes all occur, so that the only thing we need to be real is the probability almplitude (or, more precisely, the wave function that defines it). In this way, subscribers to the many-worlds interpretation say that the many-worlds *emerge* from standard wave function time evolution. Then, by this account, any interpretation that includes a wave function evolving in time by the schrodinger equation without an explicit collapse law should also give rise to the same emergent many-worlds.

Bohmian mechanics is such an interpretation. The wave function evolves in time via the schrodinger equation, but with a key difference from the standard interpretation. Under Bohmian mechanics, there is both a wave function and a particle in the fundamental ontology. The wave function evolves in accordance with the schrodinger equation as normal, but in addition, the particles have definite positions and velocities at each moment in time. The particles move according to the guidance equation, which is a deterministic equation that depends on the wave function. Put precisely, the world according to Bohmian mechanics consists of a set of particles which move around with definite positions with velocities determined by the wave function.

The determinism here is what allows us to avoid the objection mentioned from the many-worlds interpretation. The particles have a definite position at each moment in time, and follow deterministic trajectories. Put another way, there is a single physical world defined by the particles' positions, which are fully determined by the specification of the universal wave function and the initial conditions of the particles. Multiple worlds do *not* emerge from schrodinger evolution. The Schdrodinger evolution acts on the wave function, which plays a guiding role in the particles' motion, but it is the motion of the particles that defines the physical world.

As an example, consider the case of entanglements that are often used to showcase the many-worlds interpretation. In the case of Schrodingers cat, proponents of many-worlds claim that we see a branching of worlds. In one world, the cat is alive, while in the other, the cat is dead. Under Bohmian mechanics, however, we will see that this branching is not necessery. Yes the wave function will decohere into two distinct packets, one with a living cat and one with a dead cat, but in the physical world, the cat willl always be either alive or dead at any given time. Expressed in a simplified manner, it was always determined from the initial conditions of the cat and the experimental setup that the cat would live or die, meaning that the cat follows only one trajectory given by the decohered wave function.