HPS/Pl 125: Problem 9

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Explain the incoreherence problem with respect to Everettian quantum mehcanics, and either defend what you take to be the best solution, or argue that the incoherence problem cannot be solved.

The many-worlds interpretation of quantum mechanics fundamentally changes the way we must think about probabilities. In the Copenhagen interpretation, we have only a single outcome of a measurement, and assign probabilities to the possible outcomes. This is in keeping with our classical intuition about probabilities (though, as Wallace goes to great lengths to point out, this "classical" understanding of probability is itself subject to tremendous issues). In the many-worlds interpretation, however, we have a branching of the universe in which *all* possible outcomes of our measurement occur. This is a radical departure from our classical intuition about probability — if all possible measurements obtain, what does it mean to say that one outcome is more likely than another?

The objection raised above is the *incoherence problem*. Why should we assign probabilities, and particularly different probabilities, to outcomes that all actually occur? If many-worlds is correct, then we must have some justification for assigning probabilities to outcomes that are all realized according to the Born rule.

The most compelling option for solving the incoherence problem is that of non-frequentist, non-primitivist rationalism. This approach avoids critical issues that can be found in frequentism and primitivism.

Frequentism is inherently flawed as a solution to the incoherence problem, because it is fundamentally incompatible with the many-worlds interpretation. Each outcome of a measurement obtains in a different branch, so what does it mean for an outcome to be more frequent? We need to fall back on some notion of branch counting over long term frequencies, but this is unsatisfying. Our quantum algorithm tells us to assign weights to different branches in the case of a single measurement. On this single measurement, both outcomes will occur, and it seems clear to me that without a radical move to understand frequentist probabilities in an unintuituve way, we cannot justify using these weights as probabilities through frequentism.

Primitivism is also unsatisfying, for reasons more pragmatic than technical. Primitivism is the view that probabilities are primitive, a law of nature that is accepted alongside Everettian quantum theory. This is a non-starter — quantum theory has dynamics that are well understood and precise, and it is not clear that we should have to accept unmotivated primitive probabilities.

With the many-worlds interpretation, we have a precise way to assign weights to branches, and a clear physical account of what occurs in a measurement. We should therefore resist the urge to take as primitive these probabilities as long as it is possible to avoid it by making progress considering the physical consequences of the theory.

The rationalist approach avoids these issues by taking probabilities to be derived from the credences of rational agents. An agent has an uncertainty about which quantum branch they will find themselves on following a quantum measurement. Since they are rational, they must apportion their credences about which branch they will end up on in a way that maximizes their utility. Now we have a setup to work with. Since the rational agent should apportion their credences in accordance with true probabilities, if we can derive from decision theory plus quantum theory that the rational agent should assign credences in a particular way that matches the Born rule, then we have a solution to the incoherence problem. Wallace provides an example of such a proof in the reading, and there are other examples of candidate proofs given in the literature.

While these proofs aren't without their issues (Wallace's proof, for example, requires one to make heavy assumptions about the probability space of the agent's credences), they are the best candidate solution to the incoherence problem. The rationalist approach makes true progress by deriving the Born rule from therefore should be pursued as far as it remains viable.