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Contrary Inferences for Classical Histories in the Consistent Histories Approach

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The non-relativistic quantum theory is one of the most successful theories in the history of science, since it has been verified experimentally in several different situations and with extremely high precision. Despite the fact that its mathematical formalism is universally accepted, its conceptual foundations have always been a subject of scientific dispute. The standard interpretation is that of the Copenhagen school which has many conceptual and practical problems. One of the most prominent is the distinction between the classical and quantum world, as well as the issue of the quantum-to-classical transition. Closely related to these is also the famous measurement problem.

An alternative interpretation of quantum theory based on the histories approach is the consistent histories theory [1-5]. The space of states consists of all the possible histories of a quantum system and the aim is to derive probabilities for the realization of a (coarse-grained) history of this system. The probability of a history, which is defined in relation to the other histories belonging to the corresponding partition of the histories space, are assigned only when a condition defined on this coarse-grained-histories set holds. When such a set satisfies the consistency condition, it is called consistent histories set (CHS). Unfortunately, there are many CHS which are not mutually compatible. This leads to the existence of contrary inferences, which are defined as two contradictory arguments both implied with probability one [6]. Of course, this issue does not arise in the classical world. The existence of contrary inferences comes from the existence of zero covers [7]; specifically, by covering the full histories space with two (overlapping) zero quantum measure sets. It is known that, in quantum theory, many interpretational problems arise because of the existence of zero quantum measure covers, e.g. the Kochen-Specker theorem and the contextuality [8]. The strangeness of contrary inferences is typically justified by proponents of the consistent histories, by arguing that these appear in the small scale (far from the classical domain), where counterintuitive properties are expected to appear. Then the technical way to avoid such issues is to focus on and compare propositions belonging to a single CHS, an assumption justified in the microscopic world, but much less in classical scales.

In this talk, we give an example of two contrary classical propositions in the context of consistent histories approach. We analyze the arrival time of a (semi-) classical free particle in an infinite square well. By selecting two different partitions of the histories space, we find a quantum measure of zero cover, which consists of two coarse-grained sets. Thus, we end up with contrary inferences for a classical particle. The consequences of this example for histories formulations of quantum theory will be shortly discussed.

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