Spacetime in Everett's interpretation of quantum mechanics

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Sixty years ago, Hugh Everett III suggested [1] that when a quantum observable is measured by an apparatus, all possible results of the measurement exist. Many different ways to understand this statement have later been proposed, which roughly fall under the headings of many worlds, many minds and decohering sectors of the wave function.

Understanding multiplicity is, in my view, a pressing problem in making sense of Everett's approach [2]. Related to this is the problem of the nature of space, or spacetime. It turns out that interpreters of Everett view spacetime in different ways. Healey [3] argued that if systems split in the same space, there results a multiplication of mass-energy. Accordingly, the split can be viewed either as a multiplication of states, or as a multiplication of spaces. The latter has been advocated by Lockwood [4], Bacciagaluppi [5] and Tappenden [6].

There are several problems in understanding the split into distinct spaces or spacetimes. If the split occurs on an equal-time hypersurface, relativistic invariance is lost. The split could conceivably occur along a light cone, but even in this case precise conditions for the split to happen must be given. Specifying these conditions then parallels the problems raised by state vector reduction. Alternatively, one can envisage a Deutsch-like continuity of worlds [7], in which case the analog of recombination would make more sense.

Vaidman [8] and Wallace [9] have advocated a single spacetime. Here the problem is to understand the projection from configuration space to three-space. To put it vividly, how can the live cat and the dead cat in Schrödinger's setup, which are admittedly widely separated in configuration space, literally overlap in three-dimensional space?

Wilson [10] has suggested that the spacetime of quantum mechanics and quantum field theory is not the same as the macroscopic spacetime.

I intend to analyse the consequences of each of these ways to view spacetime in Everett's approach. I will argue that much remains to be done for this approach to be sufficiently well-defined.

References

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