Qeios

Peer Review

Review of: "Psi-Onticity, Contextuality and Realism in Everettian Quantum Mechanics"

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This paper addresses the frequent claim that Everettian quantum mechanics is a realistic theory. The conclusion of the paper is that any such claim leads to a contradiction and therefore is not sustainable. To lead up to this conclusion, the author embarks on an analysis of the concepts of realism and onticity as applied to the elements of Everettian quantum theory.

This is a much-discussed area, and as in much of this discussion, the author's argument is subject to confusion between the categories of *reality* and *truth.* The state of an electron is not an object and cannot be real in the way that an electron may be real; the state is a description of the electron, and the appropriate question is whether it is a true description, or more generally whether it is capable of objective truth. However, this confusion is so widespread that I will try to discount it in assessing the paper.

There remain a number of misunderstandings and invalid arguments which I will specify in detail.

p.2 Ontic constituency: the author declares that relative states, relative states, and density operators are disjoint alternatives for ontic constituents of EQM. This appears to mean that only one of these can be real. But the usual position would be that they are all real. The author may have in mind the question of which of these constituents is fundamental and which are derived from the fundamental ones. But something that is derived from real fundamental constituents is nonetheless real; this, for example, is true of branching structure in Everett's theory. It is also true of relative states, which are derived from the fundamental entity of the universal quantum state.

Universal onticity: it is not clear what it means for a state to *contain* ontic constituents.

doi.org/10.32388/O75AW4

Weak noncontextuality: it is not clear what is meant by a *distribution* of elements in the ontic state space. Is it a question of what elements there are in the ontic state space? Or is the distribution something that follows from a particular quantum state vector?

pp. 3-4 This long paragraph concludes with the statement that advocates of EQM "diverge in the objects to which they are willing to assign ontological primacy". I am not aware that any of the authors quoted discuss "ontological primacy" at all. Branching structures and density operators are always *derived* or *emergent* from the primary structure of the universal state; the density operator always refers to a system regarded as a subsystem of the universe. Which objects are ontologically primary and which are derived is not of fundamental importance. In classical mechanics, are position and force fundamental (as in Newtonian mechanics) or position, velocity, and potential (as in Lagrangian mechanics), or position, momentum, and the Hamiltonian? Does it matter?

Having stated the Harrigan-Spekkens definition of psi-onticity (no ontic fact can be allowed to hold in more than one quantum state), the author attempts to derive realism from it by assuming the contrary, which he states as "more than one distribution of ontic facts corresponds to a quantum state" and deriving a contradiction with realism. But this statement is not the contrary of the Harrigan-Spekkens definition.

p.7 The author attributes to Wallace the position that "branching structure is what is real", and treats this as if it is the only thing that is real. This is not Wallace's position, which is that branching structure is real, but it is not the only thing that is real.

pp 8-9 The author similarly misstates Everett's position as "only relative states are meaningful". This refers only to subsystems of the universe: the quantum state of the universe is meaningful and is not relative to anything.

p. 10 The author states that if a quantum state is not decoherent, neither is its time-evolved counterpart. This is fundamentally wrong: decoherence can be (and usually is) *brought about* by the time evolution of a non-decoherent state.

p.11 The author describes non-separability as "a feature of 'Oxford' EQM". No: while counter-intuitive, it is a well-known feature of all QM.

The author's attempt to show that the character of EQM as a realist interpretation is inconsistent with the quantum eraser configuration is rendered invalid by these misunderstandings.

I do not recommend publication.

Declarations

Potential competing interests: No potential competing interests to declare.