Qeios

Peer Review

Review of: "Fundamental Issues and Measurement Problem in Quantum Mechanics"

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Review Report: Fundamental Issues and Measurement Problem in Quantum Mechanics

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1. Summary of the Proposal

The author addresses the classic "Measurement Problem" in Quantum Mechanics (QM) by proposing a resolution based on a categorical distinction between the mathematical elements of the theory. The central thesis suggests classifying physical quantities into two distinct types:

Type A (Real Quantities): These correspond to observables that result in specific eigenvalues in a single measurement. According to the author, only these possess ontological reality at the level of the individual event.

Type B (Theoretical Quantities): These include the Wave Function (ψ) and the State Vector. The author argues that these are not real physical objects associated with an individual particle, but rather statistical tools describing an *ensemble* of systems.

From this perspective, the article argues that the "collapse of the wave function" is a pseudo-problem. Since the wave function was never a real physical entity of an individual system, it does not physically "collapse"; it merely fulfills its role of predicting probability distributions.

2. Original Contributions

The article attempts to distinguish itself by formalizing an epistemological separation often left implicit in statistical interpretations. The main contributions include:

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The Type A / Type B Taxonomy: A formal rule of segregation where Hilbert space mathematics (Type B) is distinguished from direct ontological interpretation, reserving "reality" only for measurement results (Type A).

Reframing the Collapse Paradox: By denying the individual reality of superposition, the author offers a logical exit: there is no mysterious physical transition because the initial state was informational (epistemic) rather than physical matter.

Reaffirmation of the Ensemble Interpretation: The work updates arguments from the statistical interpretation, attempting to shield it against single-measurement paradoxes by positing that QM does not need to completely describe individual cases.

3. Challenges and Suggestions for Expansion

For the proposal to be considered a robust solution within the current landscape of quantum foundations, it would be beneficial for the author to address three significant areas in future revisions or discussions.

Addressing Physical Realism (Zurek's Approach): The article adopts a predominantly instrumentalist stance. However, the current research program in quantum foundations often seeks *Scientific Realism*. It would be valuable for the article to discuss how its Type A/B distinction compares to approaches like those of **Wojciech Zurek** and Quantum Darwinism. Specifically, how does the author's view address the nature of the system prior to measurement without a physical mechanism for reality selection?

The PBR Theorem Context: A significant development in the field is the **Pusey-Barrett-Rudolph (PBR) Theorem** (2012), which provides a "no-go" proof for models where the quantum state is purely epistemic (Type B). The article would be significantly strengthened by explicitly addressing the PBR theorem. The author should explain how this specific model evades the conditions of the theorem or why the theorem's conclusions about the onticity of the quantum state do not apply here.

The Transition to the Classical World: While the article states that measurement selects a value, it would be beneficial to explain the mechanism behind the stability of the macroscopic world. Theories of decoherence explain *how* superpositions are suppressed and *why* classical states are selected. The article should consider expanding on how the Type A/B distinction accounts for the emergence of a stable classical reality without an explicit dynamic mechanism.

4. Conclusion

The article presents logical internal consistency based on its own definitions (Type A/B separation) but presents some issues in connecting with crucial advances in the foundations of physics. By ignoring the

need for a physical mechanism for classical emergence and by not refuting proofs of the reality of the wave function (such as PBR), the work needs to revisit certain hypotheses to expand its explanatory power regarding the physical constitution of the quantum universe.

Declarations

Potential competing interests: No potential competing interests to declare.