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A Spacetime Resolution of the Quantum Measurement Problem

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Motivation: The significant progress that quantum theory has made in recent years, has occurred despite the conspicuous absence of any consensus interpretation of quantum mechanics, and in particular on the measurement problem, which is essentially Wheeler's question: Why the quantum? The resolution of debate surrounding this issue would likely pay dividends in experimental quantum science. For example, a better understanding of the measurement process may allow design of longer lasting coherences.

Fundamental Basis of Superposition: From spacetime considerations (see references), the fundamental basis for quantum superposition is proposed to be spacetime superposition of spaces related by the Lorentz boost. In many scenarios this is equivalent to momentum superposition. Although quantum systems can be represented in many different forms (momentum basic, position basis, energy basis etc.) the definition of a fundamental basis renders these alternatives no longer equivalent. For example, although an electron in an atomic orbital may be in an energy eigenstate, it is seen as fundamentally as in a persistent state of momentum superposition.

Measurement Criterion: Measurement (operation of the probabilistic Born rule) is interpreted as any process which asks a quantum system an unanswerable momentum question, i.e., a question demanding a more specific momentum answer than the momentum superposition can deterministically provide. Measurement is an attempt to extract non-existing momentum information. If no deterministic answer is available, but some answer is demanded, then an indeterministic symmetry-breaking process must occur. An example is any diffraction experiment in which the final screen interrogates the lateral momentum of the diffracted particle. Conversely, entanglement occurs when quantum systems interact in a manner not making such demands upon each other.

Experimental Implications: The definition of a fundamental basis dictates the types of quantum system that may exist (superselection). A specific measurement criterion distinguishes probabilistic vs. entangling interactions. Both have experimental implications.

References: For further details: https://orcid.org/0000-0002-9736-7487

Keyword-1

Quantum Foundations

Keyword-2

Spacetime

Keyword-3

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