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A Non-Local Lorentz-Invariant Quantum Spacetime

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From the EPR paper in 1935, to Bell's theorem in the 1960s, to Aspect's EPR experiment in the 1980s and its recent refinements demonstrating km range correlations, it has become increasingly clear that entangled quantum mechanical systems are inherently nonlocal. EPR experiments highlight the theoretical divergence between quantum mechanics (QM) as a theory of matter in need of a theory of spacetime and special relativity (SR), for which the converse is true. Essentially by definition, quantum nonlocality is incompatible with an interpretation of Minkowskian spacetime as a single 4D metric space, in which all relations between points are defined by a metric.

A priori, one might expect that QFT, as a successful theory incorporating both relativistic and quantum concepts, would provide a conceptual unification of spacetime and quantum theory, but this has not proven to be the case. Also, despite the wide variety of interpretations of quantum mechanics, no consensus ontology has emerged.

Quantum nonlocality demands some form of nonlocal spacetime: we consider here a spacetime consisting of multiple coexisting metric spaces. Within any one space its own metric ensures locality, but between spaces no metric is defined, so interactions between points in different spaces are inherently non-local. Following this (while honoring Lorentz invariance), we outline a new proposal in which special relativistic spacetime is reinterpreted as a superposition of multiple 4D spaces. Each space contains unique content, described by a complex-valued density function. By then postulating a coupling between spaces, quantum mechanical features such as non-locality, superposition and wave behavior naturally emerge. Remarkably, Planck's constant is shown to govern the coupling between spaces, revealing a fundamental interdependence between spacetime and quantum concepts. The resulting picture is of a set of superposed metric spaces tightly coupled by a 'quantum glue'in proportion to m/h. We show that this is compatible with existing SR & QM theories, with however momentum as the fundamental physical basis of quantum superposition, and so having significant implications for the quantum 'measurement problem'. The coexistence of multiple spaces necessitates a redundancy of physical description, providing an explanation for the origin of gauge theories.

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