

Quantum Entanglement as Emergence within a Single Field: Proposal of the Same-Field Interpretation and an Information-Theoretic Approach

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Abstract

Quantum entanglement has long been understood as a non-local correlation between spatially separated particles, raising deep challenges for the foundations of physical reality. This paper proposes the Same-Field Interpretation as an alternative framework to resolve this paradox. In this interpretation, our perception of spatial separation is considered a cognitive construction generated by the brain. Entanglement is thus redefined not as an action across distance, but as a single event arising simultaneously within one unified field, which we term the same field. By framing this field as an informational field, the consistency of quantum correlations can be understood as reflecting a higher-order informational order beyond physical substance. The same-field interpretation resonates with David Bohm's holistic worldview, while reformulating it through the lens of information theory and cognitive science. This paper argues that violations of Bell's inequality are evidence of a unified informational field rather than of non-local influences. Future work includes integrating this interpretation with gravity and spacetime, designing experimental protocols to indirectly test the same field, and examining its philosophical consistency with non-dualism.

1. Introduction: The Paradox of Entanglement and the Need for Interpretation

Quantum entanglement is one of the most puzzling phenomena in quantum mechanics. Two entangled particles exhibit instantaneous correlations even when separated by great distances. Einstein famously referred to this as "spooky action at a distance," which challenged the foundations of locality and realism in classical physics. Conventional interpretations such as the Copenhagen view accept this as unavoidable, while Bohm attempted to explain it with the concept of a quantum potential. Neither fully resolved the intuitive difficulties of non-locality. This paper seeks to address the essence of the entanglement problem by questioning the cognitive basis of spatial separation itself, proposing the Same-Field Interpretation.

2. The Same-Field Interpretation: The Universe as Informational Order

In this interpretation, spatial separation is considered a cognitive construct created by the brain. What appears as two separated events is, in fact, a single occurrence within one unified field. We call this the same field. Unlike the "unified field" of physics, which refers to an underlying physical basis, the same field here denotes the simultaneous occurrence of events beyond perceptual separation. Entangled particles A and B are viewed as different aspects of one informational block, with total information always conserved. This framework aligns with Wheeler's "It from bit" perspective and the quantum information approach, suggesting that entanglement phenomena reflect informational rather than physical structures.

3. Mathematical Formulation: Connection with Quantum Information Theory

To strengthen the same-field interpretation, we employ the framework of quantum information theory. An entangled state can be represented by a density matrix $\rho = |\psi\rangle\langle\psi|$, describing a pure state within the

same field. The von Neumann entropy $S(\rho) = 0$, indicating complete informational order. When an observer measures particle A, the act corresponds to a partial trace $\rho_A = \text{Tr}_B(\rho)$, discarding B's information. The pure state then projects into a mixed state, and the uncertainty we perceive emerges. Bell's inequality assumes A and B are independent entities, but under the same-field interpretation they are inseparable. Thus, the mixedness of ρ_A reflects A's dependence on B, making non-local correlations a natural consequence.

4. Applications and Prospects

Quantum teleportation can be described not as the spatial transfer of a particle but as the reconfiguration of an informational block within the same field. Superposition and entanglement can be interpreted as manifestations of efficiency in information processing within the unified informational basis. This opens the possibility of reinterpreting practical phenomena in quantum information science from the standpoint of an integrated information field.

5. Conclusion and Future Directions

This paper presented the Same-Field Interpretation as an alternative framework for understanding quantum entanglement, treating spatial separation as an illusion and proposing a unified informational field as the foundation. Violations of Bell's inequality can be seen as evidence for the same field rather than for non-locality. Future tasks include integrating the interpretation with gravity and spacetime structures, designing novel experimental protocols to indirectly support the same field, and examining further philosophical consistency with non-dualism.

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