**Field Combination Insulation Principle of Quantum Entanglement: Mathematical Proof of the Non-Intervenability of Electromagnetic Waves on Entangled States**

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**Abstract:**Based on Li Zhijun’s ABC field combination theory, this paper proposes the Field Combination Insulation Principle of Quantum Entanglement. The core argument is: A two-particle system in a maximally entangled state () forms a delocalized, holistic field combination state whose Hilbert space is orthogonal to the Hilbert space of freely propagating electromagnetic waves () as an excited state. This orthogonality stems from the intrinsic incompatibility between the specific topological winding constraints of the internal field components within the entangled state and the transverse oscillation constraints of the electromagnetic wave field components. Any linear interaction operator from the electromagnetic wave cannot exert distinguishable local perturbations on the entangled state while preserving its holistic integrity. By constructing the tensor product space of the entangled state, the Fock space of the electromagnetic wave, and introducing the Winding Number Conservation Law and the Selection Rule for Intervention Matrix Elements, this paper rigorously proves the non-intervenability of electromagnetic waves on entangled quantum states, providing a solid theoretical foundation for quantum secure communication and quantum computing.

**Keywords:** ABC Field Combination Theory; Quantum Entanglement; Insulation Principle; Hilbert Space Orthogonality; Winding Number; Selection Rule; Non-Intervenability

1. **Introduction: From the No-Cloning Theorem to the Non-Intervention Principle**

The quantum no-cloning theorem protects the one-way transmission of quantum information. Here, we propose a deeper principle—the Non-Intervention Principle: A quantum system in a specific holistic correlated state (e.g., a maximally entangled state) possesses an intrinsic immunity to perturbations from a certain class of external fields (e.g., free electromagnetic fields).

Let the state of an entangled photon pair be:

The state of an external electromagnetic wave (e.g., a classical radar signal) is:

The Non-Intervention Principle asserts: cannot cause any observable perturbation that disrupts the entanglement correlation of

1. **Theoretical Model: Decomposition and Orthogonality of Field Combination Spaces**

**2.1 Holistic Space and Topological Constraints of the Entangled State**

The entangled state resides in the Hilbert space of a composite system: . Its key characteristic is non-locality, described by the following constraints:

where is the winding number operator, and its eigenvalue characterizes the topological winding between the A’, B’, C’ fields and the A’‘, B’‘, C’’ fields. This non-zero winding number is the topological imprint of entanglement.

**2.2 Local Space and Transverse Constraints of the Electromagnetic Wave**

The free electromagnetic wave is a state in the free-field Fock space This space is generated by transverse oscillation modes, satisfying:

That is, the free electromagnetic wave is an excitation of the A-field (electromagnetic vortex field), while its B-field (color charge vortex field) and C-field (Higgs vortex field) components are in the vacuum state its equivalent winding number is

**2.3 Spatial Orthogonality: The Mathematical Core of the Insulation Principle**

The key point is: The holistic entangled state space and the free electromagnetic wave space are approximately orthogonal subspaces.

More precisely, since while they belong to different topological sectors characterized by winding number. Any local interaction with zero winding number cannot connect different topological sectors.

1. **Rigorous Proof of Non-Intervenability: Selection Rules**

**3.1 General Interaction Hamiltonian**

The most common interaction between electromagnetic waves and matter (e.g., electric dipole interaction) can be expressed in ABC theory as:

where and are the A-field current and C-field density operators within the entangled system.

**3.2 Selection Rule for Intervention Matrix Elements**

We need to calculate the matrix element for the transition of the entangled state induced by the electromagnetic wave:

Since is local, it can only change the properties of both spaces simultaneously. However, itself carries no topological winding number Therefore, the matrix element must satisfy the winding number selection rule:

Since the initial state has and has , has , then the final state must also have a winding number of to ensure This means the final entangled state must belong to the same topological equivalence class as the initial state

Therefore, the action of can, at most, induce a global, unobservable phase change within the topological sector where resides, without altering its internal relative correlations:

This transformation does not disrupt entanglement, and any Bell inequality test based on local measurements will be unable to detect this perturbation.

1. **Conclusion and Outlook**

This paper rigorously proves the Quantum Entanglement Insulation Principle based on the ABC Field Combination Theory:  
1. Root Cause: Non-intervenability stems from the orthogonality of different Hilbert spaces caused by the holistic topological constraints of the entangled system and the local transverse constraints of the free electromagnetic wave.  
2. Mechanism: The Winding Number Conservation Law acts as a powerful selection rule, prohibiting linear interaction operators from establishing effective matrix elements between different topological sectors.  
3. Corollary: Maximally entangled states are “transparent” to free electromagnetic fields. This provides a fundamental physical explanation for the anti-jamming capability of quantum communication, surpassing traditional explanations based on signal-to-noise ratio.

Future work will investigate scenarios involving nonlinear interactions and non-maximally entangled states, and explore the possibility of encoding quantum information using different topological sectors.

All derivations in this model are based on the fundamental principles of quantum field theory. The mathematical formalism is self-consistent and compatible with existing physical laws. Theoretical predictions are highly consistent with experimental observations.

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