# Research on the Mutual Exclusion Mechanism of Wave-Particle Duality of Elementary Particles Based on the Li Zhijun-Zhao Guangyao Field Combination Theory

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## Abstract

The observational mutual exclusion of wave-particle duality is one of the fundamental puzzles in quantum mechanics. Based on the Li Zhijun-Zhao Guangyao field combination theory, this paper proposes that the essence of elementary particles is described by the coupling of three vortex fields: the electromagnetic vortex field A (wave nature), the color charge vortex field B (color charge and electric charge properties), and the Higgs vortex field C (mass and particle nature). By constructing a dynamic coupling model of the ABC fields, this paper reveals the deep-seated mechanism behind the impossibility of simultaneously observing wave and particle properties—the mutual collapse effect of the A and C fields. The theory indicates that observational acts disrupt the dynamic balance of the ABC fields, causing the manifestation of one field at the cost of the collapse of the other. This framework provides a new path for unifying quantum mechanics and field theory.

## Keywords

Wave-particle duality; Field combination theory; Vortex field; Mutual collapse; Quantum measurement; Double-slit experiment

## I. Introduction: The Observational Dilemma of Wave-Particle Duality

In the double-slit experiment, observing the particle path (particle nature) causes the interference pattern (wave nature) to disappear. This phenomenon is attributed to the “complementarity principle” in the Copenhagen interpretation but has always lacked a dynamical explanation. The Li Zhijun-Zhao Guangyao field combination theory breaks through traditional frameworks by proposing that the essence of elementary particles is a superposition of three vortex fields:

* A-field (electromagnetic vortex field): Responsible for wave nature, excited by changing magnetic fields, with closed and source-free electric field lines, corresponding to the propagation behavior of electromagnetic waves.
* B-field (color charge vortex field): Carries color charge and electric charge properties, acts as a coupling intermediary between the A and C fields, and maintains the overall symmetry of the fields.
* C-field (Higgs vortex field): Confers mass and locality to particles, corresponding to particle nature, and relates to mass generation in the Higgs mechanism.

The coupled state of the ABC fields determines the behavior of particles, while observational acts disrupt their dynamic balance, triggering collapse.

## II. Framework of the ABC Field Combination Theory

### 1. Mathematical Expression of Fields and Coupling Mechanism

The total field function is expressed as:

Where:

* The A-field satisfies the vortex electric field equation in Maxwell’s equations: , describing non-conservative vortex electric fields.
* The C-field is related to the Higgs field, satisfies a Klein-Gordon-like equation, and embodies mass terms and locality.
* The B-field, as a gauge field, regulates the interaction between A and C through color charge degrees of freedom, with its operator form incorporating symmetry.

The coupling term between the A and C fields satisfies the commutation relation . This non-commutativity prevents them from being precisely observed simultaneously.

### 2. Dynamical Mechanism of Observational Mutual Exclusion

* When the A-field dominates: The particle is in a wave state. The vortex characteristics of the A-field cause phase coherence in the wave function (e.g., double-slit interference), while the C-field is suppressed to its minimum potential energy.
* When the C-field dominates: The particle is in a particle state. The Higgs mechanism manifests mass, enhancing particle locality, and the phase coherence of the A-field is destroyed.

Observational acts are equivalent to introducing an external perturbation operator . When its intensity exceeds the critical value , it triggers a reallocation of the ABC fields:

* If the observation target is the A-field (wave nature), the B-field transfers coupling energy to the C-field, causing the C-field to collapse.
* If the observation target is the C-field (particle nature), the vortex structure of the A-field is destroyed, and wave nature disappears.

Mathematical essence: The mutual exclusion of the A and C fields stems from the energy-time uncertainty relation. The A-field corresponds to high-frequency vibrations (e.g., electromagnetic wave cycles), while the C-field corresponds to rest energy (). The energy injection required for observation disrupts the original balance.

## III. Experimental Verification: Reinterpretation of the Double-Slit Experiment

Taking the electron double-slit experiment as an example:

1. No observation : The ABC fields are in equilibrium. The vortex electric field lines of the A-field extend closedly, and the electron wave function undergoes coherent superposition after passing through the slits, manifesting an interference pattern.
2. Path observation : The interaction with the observation device (e.g., a detector) activates the C-field. The B-field transfers energy from the A-field to the C-field, causing the collapse of the A-field’s vortex structure and the disappearance of the interference pattern. The electron now behaves as a localized particle.
3. Weak measurement attempt: If the observational field intensity is close to but below , some characteristics of the A-field can be partially retained while obtaining limited information about the C-field. This is consistent with recent weak measurement experimental results.

## IV. Theoretical Extensions and Physical Significance

1. Quantum measurement problem: The ABC field model treats wave function collapse as a dynamic process of field energy reallocation, avoiding controversies such as “consciousness involvement.”
2. Implications for superconductivity applications: In copper-based superconducting materials, the competition between the A-field (wave nature of electron pairs) and the C-field (locality of Cooper pairs) may explain pseudogap phase behavior.
3. Unification in particle physics: The B-field, as a carrier of color charge, can connect quantum chromodynamics (QCD) with the electroweak unification theory, providing a field-theoretic supplement to the “Standard Model.”

## V. Conclusion

The Li Zhijun-Zhao Guangyao field combination theory, through the coupling and mutual exclusion of the ABC vortex fields, reveals the essence of wave-particle duality: The mutual exclusion of wave and particle properties is not a principled limitation but a natural outcome of field dynamics under observation. Future work will focus on the quantization of the ABC fields and the validation of field collapse thresholds through ultra-cold atom simulations.

## References

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