**The Chromo-Dynamic Self-Consistency Principle of Hadron Formation: Coherent Fusion Mechanism of Colorless Gluon Field Combinations and Quark Field Combinations**

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**Abstract:**Based on Li Zhijun’s ABC field-composition theory, this paper reveals the complete chromo-dynamic self-consistent mechanism of hadron (proton, neutron) formation. The core argument is: The color neutrality of hadrons originates from the internal gluon field combination first forming a colorless state by itself, and this colorless gluon field combination then coherently fuses with the quark field combination, ultimately leading to overall color neutralization. This paper demonstrates that the stable configurations of protons (uud) and neutrons (udd) must satisfy the “gluon field combination colorless state first” principle, where the color charge components of the three gluons must satisfy By introducing the gluon colorless state projection operator and the overall color singlet fusion operator the rigorous mathematical form of the hadron wavefunction is constructed. This model indicates that hadron formation is a hierarchical, self-consistent wave-dynamic process: the formation of a colorless gluon field is the prerequisite for the quark field to achieve color neutralization.

Keywords: ABC field-composition theory; Color singlet; Gluon colorless state; Wavefunction coherent fusion; Hierarchical projection; Self-consistency principle

1. **Introduction: The Self-Consistency Problem of Color Neutralization**

How is the color neutrality of hadrons (e.g., protons, neutrons) achieved? Traditional theory attributes it to the zero sum of quark color algebra. Li Zhijun’s theory proposes a more profound and self-consistent view: The overall color neutrality of a hadron is the inevitable result of its internal gluon field combination first forming a colorless state by itself, and this colorless state then coherently fuses with the quark field combination. This is a two-step, self-consistent wave-dynamic process.

1. **Theoretical Framework: The Principle of Hierarchical Color Neutralization**

**2.1 The Principle of Gluon Field Combination Colorless State First**

The primary condition for hadron formation is that the gluon field combination it contains must itself form a color singlet (colorless state). For a hadron containing three gluons, this condition is:

where is the gluon colorless state projection operator. Its mathematical form is:

This operator requires that the color charge indices of the three gluons must form a closed chain of color charge-anticolor charge pairs, e.g., so that the net color charge expectation value of the gluon part is strictly zero:

**2.2 Overall Color Singlet Fusion Operator**

After the gluon field combination itself forms a colorless state, its fusion with the quark field combination is achieved by the overall color singlet fusion operator :

This operator ensures that after the coherent fusion of the quark field combination’s color charge with the colorless gluon field combination, the overall color charge expectation value remains zero.

1. **Application: Self-Consistent Constitution of Protons and Neutrons**

**3.1 Self-Consistent Constitution of the Proton (uud)**

The proton’s wavefunction is a specific coherent superposition of its components satisfying the “gluon colorless state first” principle:

Self-Consistent Fusion Process:  
1. Gluon field combination forms a colorless state by itself:

The color charges of the three gluons form a closed chain: whose net color charge is zero.  
2. Coherent fusion of quark field combination with the colorless gluon field:  
\* Quarks provide color charge:   
\* The colorless gluon field as a whole, has a color charge expectation value of zero and undergoes coherent superposition with the quark field combination.  
\* Under the action of the fusion operator the quark color charge coherently cancels out with the colorless gluon field, resulting in an overall color charge of zero.

**3.2 Self-Consistent Constitution of the Neutron (udd)**

The neutron’s wavefunction also follows this principle:

Self-Consistent Fusion Process:  
1. Gluon field combination forms a colorless state by itself:

The color charges of the three gluons are all in color singlet form (color charge-anticolor charge pairs), and their net color charge is zero.  
2. Coherent fusion of quark field combination with the colorless gluon field:  
\* Quarks provide color charge:   
\* The colorless gluon field as a whole, undergoes coherent superposition with the quark field combination.  
\* Under the action of the fusion operator the quark color charge coherently cancels out with the colorless gluon field, resulting in an overall color charge of zero.

1. **Mathematical Expression: Hierarchical Projection and Fusion Equations**

The formation of the hadron wavefunction is described by the following hierarchical projection equation:

Its dynamics satisfy the nonlinear Schrödinger equation with projection:

Here, the nonlinear term embodies the modulating effect of the colorless gluon field on the quark field wave, which is key to maintaining the stability of the overall coherent fusion.

1. **Conclusion**

This paper establishes the chromo-dynamic self-consistency principle of hadron formation, drawing the following conclusions:  
1. Core Mechanism: The color neutrality of hadrons follows the “gluon field combination colorless state first” principle, which is the prerequisite and self-consistency foundation for achieving overall color neutralization.  
2. Hierarchical Fusion: Hadron formation is a hierarchical wave-dynamic process: first, the gluon field combination itself forms a colorless wave packet; then, this colorless wave packet coherently fuses with the quark field combination.  
3. Mathematical Essence: This process is jointly described by the hierarchical projection operator and the fusion operator and its dynamics are governed by a nonlinear Schrödinger equation with projection.  
4. Revolution in Physical Picture: Gluons within hadrons are not mere “force carriers” but are coherent field components that actively participate in color neutralization and first form a colorless state themselves. This picture provides a more profound and self-consistent wave-dynamic framework for understanding color confinement.

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