**The Field Combination Mechanism of Antimatter Production: A Study on High-Energy Collisions and Charge Conjugation Symmetry Based on the ABC Theory**

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Abstract:  
Based on Li Zhijun’s ABC Theory, this paper proposes a complete dynamical model of field combination for antimatter production in high-energy collisions. The core thesis is that the production of antimatter is an eigenstate of ordinary matter field combinations under charge conjugation (C) transformation. Its essence lies in the quantum tunneling or recombination of the coupling mode between cosmic energy quanta and the chromo-charge vortex field ( or ) in high-energy environments. Strictly adhering to the fundamental premise that the down quark (d) couples to one branch of the anti-chromo-charge field (acquiring ), and the up quark (u) couples to two branches of the positive chromo-charge field (acquiring ), we construct a time-dependent field combination Schrödinger equation to describe the collision process. By introducing a Bogoliubov transformation for the chromo-charge field branches, we demonstrate that when the center-of-mass collision energy , the flavor vacuum becomes unstable, leading to the coherent production of particle-antiparticle pairs . Furthermore, we derive the cross-section for the gluon fusion process and detail the cascade recombination process from parton-level anti-quarks to composite anti-hadrons (e.g., antiprotons). This model fully integrates antimatter production into the field combination framework centered on chromo-charge field branch coupling, providing a profound and self-consistent theoretical basis for creating and detecting antimatter in the laboratory.

**Keywords:** ABC Theory; Antimatter Production; Field Combination; Chromo-Charge Field Branch; Down Quark; Up Quark; Gluon Fusion; Bogoliubov Transformation; Hadronization

1. **Introduction:** A Field Combination Perspective on the Antimatter Problem  
   The Standard Model of particle physics successfully predicts the existence of antimatter. Based on Li Zhijun’s ABC Theory, this paper provides a more fundamental physical picture from the perspective of field combination: the production of antimatter is a physical process where the coupling mode between cosmic energy quanta and the chromo-charge vortex field ( or ) undergoes quantum tunneling or recombination at extremely high energies. Its core is the change in the occupation number of chromo-charge field branches.
2. **Theoretical Framework: Quark Field Combinations and Charge Conjugation Transformation**

2.1 Quark Field Combinations and the Origin of Charge (Revised)  
According to the revised ABC Theory:  
\* Up quark (u): Couples to two branches of the positive chromo-charge field (e.g., and ).  
\* Field combination:   
\* Charge calculation:   
\* Chromo-charge: resides in the color triplet state (red-green).  
\* Down quark (d): Couples to one branch of the anti-chromo-charge field (e.g., ).  
\* Field combination:   
\* Charge calculation:   
\* Chromo-charge: resides in the anti-color triplet state (anti-blue).

2.2 Anti-Quark Field Combinations and C Transformation  
The charge conjugation operator acting on a quark field reverses the type of chromo-charge field it couples to () and changes the branch index (color anti-color).  
\* Anti-up quark ():

\* Charge:   
\* Chromo-charge: resides in the anti-color triplet state (anti-red–anti-green).  
\* Anti-down quark ():

\* Charge:   
\* Chromo-charge: resides in the color triplet state (blue).

1. **Dynamics of Antimatter Production in High-Energy Collisions**

3.1 Interaction Hamiltonian  
The primary process for antimatter production in high-energy collisions is gluon fusion , governed by the QCD interaction Hamiltonian:

where the gluon field is the excitation quantum of the chromo-charge field B, with a field combination of . Gluon exchange processes directly rearrange the coupling states of the quark’s chromo-charge field branches.

3.2 Flavor Vacuum Instability and Bogoliubov Transformation  
At extremely high energy densities, chiral symmetry may be temporarily restored, blurring the distinction between “particle” and “antiparticle.” The system’s evolution is described by the time-dependent Schrödinger equation:

The initial state is . When , the flavor vacuum becomes unstable for producing particle-antiparticle pairs . This can be described by a Bogoliubov transformation mixing creation and annihilation operators. For the quark field, this transformation acts on its chromo-charge field branch part:

where is the creation operator for positive particles (coupled to branches), and is the creation operator for antiparticles (coupled to branches). The expectation values of the number operators in the out state are non-zero:

This indicates that new quark-antiquark pairs, with field combination states , are produced from the initial proton state through gluon-mediated recombination of chromo-charge branches.

1. **From Partons to Composite Antimatter: The Cascade Recombination Process  
   High-energy collisions produce high-energy quark-antiquark pairs . These must undergo hadronization to form composite antimatter, such as antiprotons .**

4.1 Field Combination Recombination for Antiprotons  
An antiproton consists of two anti-up quarks and one anti-down quark: .  
\* Anti-up quark (): , with anti-color charge.  
\* Anti-down quark (): , with color charge.

They need to recombine into an overall color singlet state through gluon exchange (excitation of the chromo-charge field B). This field combination recombination process can be expressed as:

The probability of this process, , is described by the fragmentation functions of non-perturbative QCD.

1. **Cross-Section Calculation and Experimental Verification**

5.1 Dominant Process at the Parton Level: Gluon Fusion  
As the core of antimatter production is the flipping and recombination of chromo-charge field branches, the primary process is gluon fusion . Its cross-section depends mainly on the strong coupling constant :

This process is driven by the gluon field strength , which directly alters the coupling state of the quark’s chromo-charge fields.

1. **Conclusion**  
   Based on the revised ABC Theory, this paper constructs a dynamical model of field combination for antimatter production:

1. Origin of Charge: The up quark acquires a charge by coupling to two branches of ; the down quark acquires a charge by coupling to one branch of .

2. Nature of Antimatter: It is the charge conjugation state of ordinary matter field combinations; its production results from the reversal of the chromo-charge field B branch coupling mode ().

3. Production Mechanism: High-energy collisions cause flavor vacuum instability, leading to the coherent production of particle-antiparticle pairs via gluon-mediated Bogoliubov transformation.

4. Recombination Pathway: The produced anti-quarks hadronize via the gluon field medium, recombining into composite antimatter (e.g., antiprotons).

This model elevates antimatter research from the phenomenological level to the level of chromo-charge field branch manipulation, providing a solid theoretical foundation for cutting-edge research in antimatter chemistry, antimatter gravity, and related fields.

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