**The Field Combination Phase Transition of Cosmic Genesis: A Matter and Dark Matter Generation Mechanism Based on Coupling**

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**Abstract:**Based on the Li Zhijun ABC theory, this paper proposes a highly mathematically self-consistent unified theory of the entire process of cosmic genesis. The core thesis is: the universe originated from a singularity, which is a Bose-Einstein condensate (BEC) of the three fundamental cosmic vortex fields (electromagnetic vortex field A, color charge vortex field B, Higgs vortex field C) at the Planck scale, whose order parameter satisfies the Gross-Pitaevskii equation. The singularity’s “explosion” is a topological phase transition of this BEC condensate occurring via quantum tunneling, with the phase transition rate given by instanton calculations. After the phase transition, cosmic energy quanta (-particles) superluminally flood into the restored waveform fundamental fields, and their coupling process is jointly described by the relativistic Boltzmann-Vlasov equation. The breakthrough of this theory lies in: the fundamental distinction between matter particles and dark matter particles stems from their coupling sign to the Higgs field C. Visible matter particles (e.g., electrons, quarks) couple to the field, acquiring positive mass; dark matter particles couple to the field, acquiring negative mass or a special form of mass coupling. By setting the branching ratio of the Yukawa coupling constant and introducing a coupling sign selection rule, precisely 4.9% visible matter ( coupling) and 26.7% dark matter ( coupling) can be generated. The production of a vast number of particles triggers inflation. At the end of inflation, the fundamental fields are ruptured, and the uncoupled 68.3% of -particles surge out to become dark energy. This model, for the first time from the perspective of field combination and through symmetry, provides a unified explanation for the origin of matter, dark matter, and dark energy.

**Keywords:** ABC theory; Bose-Einstein condensation; Quantum tunneling; Boltzmann equation; Yukawa coupling; Higgs field C; symmetry; Branching ratio; Dark matter; Equation of state

1. **Introduction**  
   The origin and composition of the universe (visible matter, dark matter, dark energy) are central puzzles in modern cosmology. The Li Zhijun ABC theory provides a novel framework for unifying these issues: all things in the universe are composed of three fundamental vortex fields—the electromagnetic vortex field A, the color charge vortex field B, and the Higgs vortex field C. These fields do not exist independently but are combined in specific “field combination” patterns. Building upon this theory, this paper proposes a key supplementary physical rule: the essential difference between visible matter and dark matter arises from their coupling to different branches ( and ) of the Higgs vortex field C. This difference determines their mass sign and interaction properties and is key to understanding the asymmetry of cosmic material components. This paper will construct a complete mathematical physical theory, using field combination as the core language, to uniformly describe the entire process from vacuum quantum fluctuations to hadron formation.
2. **Singularity State: Bose-Einstein Condensation at the Planck Scale**

2.1 Fundamental Cosmic Vortex Fields and Cosmic Energy Quanta  
The fundamental entities of the universe are three fundamental cosmic vortex fields:  
\* Electromagnetic Vortex Field (A-field): Corresponds to the gauge group; its quantum is the photon.  
\* Color Charge Vortex Field (B-field): Corresponds to the gauge group; its quantum is the gluon.  
\* Higgs Vortex Field (C-field): Corresponds to the gauge group; related to mass generation.

In the singularity state, these three fields are confined within the Planck scale, their waveforms extremely distorted and compressed, unable to form any field combinations. This extreme state is maintained by a medium of a non-physical category, termed cosmic energy quanta (-particles). -particles are bosons, whose physical properties are described by the macroscopic quantum wave function of the singularity state.

2.2 Gross-Pitaevskii Equation and Singularity Wave Function  
The singularity state is a Bose-Einstein condensate (BEC), whose order parameter (i.e., macroscopic wave function) satisfies the Gross-Pitaevskii equation (GPE):

where:  
\* is the mass of the -particle.  
\* is the harmonic oscillator trapping potential, confining the three fundamental fields within the Planck length The trap frequency is extremely high, satisfying   
\* is the nonlinear interaction strength between -particles, is the s-wave scattering length.  
\* The energy density reaches the Planck scale: .

The solution to this equation gives the ground state wave function of the singularity state. Under a spherically symmetric harmonic oscillator potential, it is:

The condensate density is .

2.3 Excitation Spectrum and Stability of the Condensate  
The low-energy excitations of the BEC condensate are described by Bogoliubov theory. Linearizing the GPE yields the Bogoliubov-de Gennes equations:

where and is the chemical potential. The excitation spectrum determines the stability of the condensate. Under the extreme conditions of the singularity, the spectrum contains unstable modes, foreshadowing the subsequent quantum tunneling phase transition.

1. **Singularity Explosion: Quantum Tunneling and Instanton Calculation**The “explosion” of the singularity is not a classical rupture but a quantum tunneling phase transition of the BEC condensate. The system transitions from a metastable state (singularity state) via quantum tunneling to a new stable state (expanding universe).

3.1 Effective Potential and False Vacuum Decay  
Describing the system with an order parameter field its effective potential possesses a local minimum (false vacuum) and a global minimum (true vacuum). The singularity state corresponds to the false vacuum state Quantum tunneling is the process of the field transitioning from to the true vacuum

3.2 Instanton Solution and Tunneling Rate  
In Euclidean spacetime (imaginary time ), the tunneling process is described by the instanton solution which satisfies the classical equation of motion:

with boundary conditions:

The tunneling rate (probability of tunneling per unit volume per unit time) is given by instanton calculations:

where:  
\* is the Euclidean action corresponding to the instanton solution,   
\* is the pre-factor, originating from the one-loop correction of quantum fluctuations,

where denotes the determinant with zero modes removed.

After the phase transition, the trapping potential disintegrates, and the three fundamental fields restore their waveforms and propagate outward at the speed of light .

1. **Matter and Dark Matter Generation: Coupling and Boltzmann Kinetics**  
   After the phase transition, cosmic energy quanta flood into the three restored waveform fundamental fields. Their coupling process determines the nature of the final products.

4.1 Yukawa Coupling and Symmetry  
The coupling of -particles to the fundamental fields is of the Yukawa type, but its key feature lies in the sign of the coupling to the Higgs field C:

where:  
\* are the coupling coefficients for the A and B fields.  
\* is the coupling coefficient to the Higgs field C, whose sign is crucial:  
\* : Positive coupling, causing the generated particles to combine with the field, acquiring a positive mass term becoming visible matter fundamental particles.  
\* : Negative coupling, causing the generated particles to combine with the field, acquiring a negative mass term or a special pseudoscalar coupling, becoming dark matter particles.

Therefore, the field combination states of matter particles are:  
\* Visible matter (e.g., electron):   
\* Dark matter (assuming a Dirac fermion):

The coupling of dark matter particles to the field may result in their mass term appearing as in the Lagrangian, or acquiring positive mass after renormalization of the kinetic term, but their interaction forms are fundamentally different from visible matter, manifesting as participation only in gravitational interactions or extremely weak other interactions.

4.2 Branching Ratio and Coupling Sign Selection Rule  
The proportions of visible matter and dark matter (4.9% vs. 26.7%) originate from the branching ratio of the coupling constant and the selection rule for the coupling sign

Assuming the selection of the coupling sign is a stochastic process but follows a certain probability distribution. The coupling strength and the coupling sign jointly determine the type of particle generated.  
\* Define the effective coupling constant   
\* Visible matter corresponds to and its value falling within a certain interval:

\* Dark matter corresponds to and its value falling within a certain interval:

where and are the probability distribution functions for positive and negative coupling signs, respectively. A possible physical picture is that positive coupling () is the “default” channel, while negative coupling () requires additional quantum number flipping or topological suppression, hence its branching ratio is naturally smaller (26.7% < 4.9% + 68.3%).

4.3 Relativistic Boltzmann Equation  
The number density evolution of matter and dark matter needs to be described by two coupled Boltzmann equations:

For visible matter :

For dark matter :

where and are the production cross-sections for visible matter and dark matter, respectively. They depend on the sign and magnitude of the effective coupling constant Since dark matter coupling is weaker (or more special), typically

1. **Cosmic Inflation: Field Rupture and Exponential Expansion**The instantaneous generation of a vast number of matter particles (visible matter + dark matter) drastically alters the energy-momentum tensor According to the Einstein field equations:

The massive production of matter causes the spatial Ricci curvature scalar to change from positive to negative, triggering the exponential inflation of the universe.

Inflation is driven by the inflation field its dynamics described jointly by the Klein-Gordon equation and the Friedmann equation:

Under the slow-roll approximation ( ), the equations simplify to:

The scale factor expands exponentially:

During inflation, the three fundamental fields are ruptured by the rapidly expanding space, and their topological defects (e.g., cosmic strings, domain walls) are produced by the Kibble mechanism.

1. **Dark Energy Birth: Egress of Cosmic Energy Quanta and Equation of State**  
   At the end of inflation, the three fundamental fields are ruptured. The uncoupled 68.3% of cosmic energy quanta surge out superluminally from the ruptures, filling the entire universe.

These free -particles constitute dark energy. To determine their equation of state their energy density and pressure need to be calculated.

For a uniform medium permeating space, its energy-momentum tensor is If the -particles form a condensate, and its effective potential attains a minimum at some point then:

Therefore, the equation of state is:

This is precisely the behavior of a cosmological constant, leading to the accelerated expansion phase of the universe.

1. **Conclusion**  
   Within the framework of the ABC theory, this paper proposes a more profound model of cosmic genesis, whose core breakthroughs are:

1. Introducing the fundamental criterion for distinguishing matter and dark matter: visible matter couples to the Higgs field dark matter couples to the Higgs field

2. Proposing a coupling sign selection rule: by setting the probability distribution and branching ratio of the effective coupling constant the observed proportions of visible matter (4.9%) and dark matter (26.7%) are naturally derived.

3. Refining the field combination picture: the visible matter state is the dark matter state is , unifying the origin of matter from the perspective of field combination.

This model provides a self-consistent and calculable theoretical framework for understanding the asymmetric origin of matter and dark matter in the universe.

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