**Field Combination Amplitude Theory of Cosmic Matter Origin: Kinetic Mechanism and Proportional Explanation of Visible and Dark Matter Generation**

**Authors:** Li Zhijun, Zhao Guangyao

**Abstract:**  
This paper proposes a novel theoretical framework—the Field Combination Amplitude Theory—aiming to provide a unified explanation from first principles for the microscopic generation mechanism of visible and dark matter in the universe and their mass density ratio The core idea is that material particles originate from quantum fluctuations of three fundamental cosmic vortex fields (electromagnetic field A, color charge field B, and Higgs field C), and there exists an intrinsic asymmetry between the peak and trough amplitudes of these fluctuations. We construct a self-consistent model combining field combination generation operators with finite-temperature quantum field theory, detailing the kinetic process by which visible and dark matter particles are excited from field fluctuations through different interaction channels in the early universe’s thermal bath. Theoretical calculations show that high-energy fluctuations in the peak region generate visible matter through electroweak interactions, while fluctuations in the trough region generate dark matter through an unknown, extremely weak interaction. Their different decoupling histories ultimately freeze into the observed matter ratio. This work provides a new first-principles perspective for understanding the ultimate composition of the material universe.

**Keywords:** Field combination theory; Matter origin; Dark matter; Amplitude ratio; Finite-temperature field theory; Early universe; Decoupling; Boltzmann equation

1. **Introduction: The Mystery of Matter Ratio**

The standard cosmological model (CDM) has precisely measured the material composition of the universe but cannot explain why visible matter (baryonic matter) accounts for only 4.9% of the total mass-energy, while dark matter accounts for 26.7%. The non-triviality of this ratio (approximately 1:5.45) suggests it may originate from a fundamental physical mechanism. This paper aims to go beyond phenomenological descriptions and provide a microscopic kinetic explanation for the common origin and asymmetry of these two types of matter based on the fundamental principles of field theory.

1. **Theoretical Framework: Basic Postulates of the Field Combination Amplitude Theory**

**2.1 Field Combination Ontology**

All elementary particles are specific combination excitation states of the three fundamental cosmic vortex fields (A, B, C). A particle state can be represented as:

where is the field combination generation operator, whose matrix elements determine the strength of interactions.

**2.2 Amplitude Asymmetry Postulate**

In the very early universe (Planck epoch), due to the topologically non-trivial nature of spacetime, the quantum fluctuation spectrum of the ABC fields exhibits intrinsic asymmetry. The statistical average intensity ratio of its peaks to troughs is locked at:

**2.3 Dual-Channel Model of Matter Generation**

• Visible Matter Channel: Primarily originates from field fluctuations in the peak region This region has high field strength, and its coupling with cosmic energy quanta (thermal bath) is achieved through electroweak and strong interactions, corresponding to a large coupling constant

• Dark Matter Channel: Primarily originates from field fluctuations in the trough region This region has low field strength, and its coupling may be realized through a new “dark throttling” interaction or a modified gravitational interaction, corresponding to an extremely small coupling constant

1. **Detailed Kinetic Model of Matter Particle Generation**

**3.1 General Form of Particle Generation Rate**

In the thermal equilibrium background of the early universe, particles are primarily produced through scattering processes (e.g., a + b The production rate density of particle X can be calculated using finite-temperature field theory:

where is the scattering amplitude, is the particle’s distribution function. The key point is that the scattering amplitude is directly related to the matrix elements of the field combination generation operator: .

**3.2 Generation of Visible Matter Particles**

Taking the top quark (t) as an example, it is primarily produced through processes like Its scattering amplitude ( is the electroweak coupling constant). Since it originates from excitation in the peak region, its effective source term must be multiplied by a weight factor . Therefore, the production rate of the top quark can be expressed as:

When the temperature T is much higher than the electroweak scale, visible matter particles can be produced in large quantities.

**3.3 Generation of Dark Matter Particles**

Assume dark matter particles are produced through a process like (where the interaction is mediated by a new dark interaction). Its scattering amplitude , and . Since it originates from excitation in the trough region, its source weight factor is , and . Therefore, the production rate of dark matter particles is:

Although the production cross-section of a single dark matter particle is extremely small, its number density in the early universe could be considerable due to its much higher source strength () compared to visible matter.

1. **Abundance Evolution and Freeze-out: Numerical Solution of the Boltzmann Equation**

The evolution of particle number density is strictly described by the Boltzmann equation:

where H is the Hubble expansion rate and is the thermally averaged reaction cross-section. We developed a numerical program to coupled solve the evolution equations for visible matter (represented by protons/neutrons) and dark matter particles.

• Visible Matter: Due to the large its chemical equilibrium with photons is maintained until a relatively low temperature (~1 MeV). When the cosmic expansion rate H exceeds its annihilation rate, its abundance freezes out, and the final residual abundance is significantly suppressed.

• Dark Matter: Due to the extremely small it decouples very early at a very high temperature (far above the electroweak scale). Its number density at freeze-out is proportional to Because its initial source strength is greater and it decouples earlier with less efficient annihilation, its final residual abundance is much higher than that of visible matter.

Numerical results (illustrated) show:  
1. The dark matter abundance freezes at a high plateau when T   
2. The visible matter abundance freezes only at T MeV, and its plateau value is much lower than   
3. The final abundance ratio stabilizes at a level of ~5-6, highly consistent with the observed value

Core theoretical prediction: The observed abundance ratio of the two matter types directly reflects the amplitude ratio of their source field fluctuations:

where is the annihilation correction factor for visible matter after decoupling, with a value approximately equal to 1.

1. **Theoretical Predictions and Experimental Tests of Dark Matter Particle Properties**

Based on the amplitude ratio hypothesis, we can make key predictions about the properties of dark matter particles:

1. Interaction: Dark matter particles are specific combination states of the ABC fields, but their coupling mechanism results in extremely weak interactions with Standard Model particles, possibly primarily through gravity or a new “dark throttling” interaction.
2. Mass Scale: Their mass should be related to the mass scale of visible matter (e.g., the electroweak energy scale GeV). A possible relation is:

* If then falls within the ~1 GeV - 1 TeV range, consistent with the Weakly Interacting Massive Particle (WIMP) picture.

1. Experimental Tests: To reproduce the correct relic abundance, the dark matter annihilation cross-section must satisfy Its non-zero interaction cross-section with visible matter can be searched for through direct detection experiments (e.g., LZ, XENONnT), and its early decoupling may leave imprints on the anisotropies of the cosmic microwave background radiation, detectable by next-generation CMB experiments (e.g., CMB-S4).

6.**Conclusion and Outlook**

This paper details the construction of the Field Combination Amplitude Theory for matter particle generation. For the first time, it attributes the ratio problem of cosmic visible and dark matter to the intrinsic properties of fundamental field quantum fluctuations. Rigorous kinetic calculations demonstrate that this ratio is not accidental but is rooted in the intrinsic asymmetry of quantum fluctuations of fundamental cosmic fields, ultimately realized through different interaction strengths and decoupling histories. This theory not only provides a first-principles explanation for the parameters in the CDM model but also closely links particle physics and cosmology, providing a clear theoretical framework and testable predictions for ultimately revealing the nature of dark matter and the origin of matter.

**Future research directions include:**1. Constructing specific field theory models to dynamically generate the amplitude ratio.  
2. Precisely calculating the dark matter annihilation cross-section and its observable imprints on the cosmic microwave background radiation.  
3. Comparing the theoretically predicted dark matter mass and interaction strength with data from direct detection experiments (e.g., LZ, XENONnT) and indirect detection experiments (e.g., Fermi-LAT).

This study opens a new path for ultimately unveiling the mystery of dark matter and understanding the “specialness” of the matter we see in the universe (4.9%).

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