Field Composition Dynamics of Neutrino-Photon Conversion: A Two-Step Mediation Model Based on ABC Theory  
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Abstract:  
Based on Li Zhijun’s ABC (Electromagnetic–Color Charge–Higgs) vortex field theory, this paper proposes a novel mechanism for neutrino-to-photon conversion—the Two-Step Mediation Model. This model addresses two core challenges in fermion-boson conversion: statistical discontinuity and color charge field annihilation. We demonstrate that neutrino (ν) to photon (γ) conversion does not occur directly but proceeds through an intermediate fermion-pair state X with zero net B-field in two steps: First, the color charge field component of the neutrino annihilates with an anti-color charge field, achieving B-field neutralization, described by the effective vertex . Second, the energy of the intermediate state is mapped to electromagnetic field excitations via nonlinear coupling, completing the statistical transition, with the Lagrangian . This paper constructs a complete effective field theory description, derives a rigorous expression for the conversion probability , and reveals the resonant nature of external field enhancement effects. This model provides a theoretical foundation for detecting neutrinos in strong-field environments and predicts testable experimental signals.

Keywords: ABC theory; neutrino-photon conversion; field composition dynamics; statistical transition; color charge neutralization; two-step mediation model

1. Introduction

Neutrino-photon conversion (e.g., is a cutting-edge topic at the intersection of particle physics, astrophysics, and cosmology. It holds significant importance for understanding the intrinsic properties of elementary particles, the evolution of the early universe, and exploring new physics beyond the Standard Model. However, this seemingly simple conversion process faces two major theoretical challenges:

1.1Statistical Obstacle: According to the spin-statistics theorem, fermions (half-integer spin, e.g., neutrinos) and bosons (integer spin, e.g., photons) follow fundamentally different quantum statistics. Direct conversion between them violates basic symmetry principles, leading to theoretical inconsistency.

1.2Field Structure Obstacle: In Li Zhijun’s ABC (Electromagnetic–Color Charge–Higgs) vortex field theory [1], elementary particles are viewed as composite vortices of three fundamental fields (A, B, and C fields). Neutrinos, as fermions, contain non-zero color charge vortex field (B-field) components in their field composition, while photons, as gauge bosons, have zero B-field. Thus, from a field composition perspective, conversion requires a non-zero B-field to vanish, which is forbidden in standard field theory.

To overcome these difficulties, this paper proposes a “Two-Step Mediation Model” based on ABC theory. The core idea is that neutrino-to-photon conversion does not occur instantaneously but proceeds through a special intermediate state in two steps. This intermediate state elegantly resolves the dual contradictions of statistics and field structure. This paper elaborates on the dynamical mechanism of this model, constructs its effective field theory, calculates the conversion probability, and explores its physical implications and experimental predictions, providing a new theoretical foundation and experimental approach for this mysterious process.

1. ABC Theory and the Two-Step Mediation Model

2.1 Fundamentals of ABC Field Theory

ABC theory posits that fundamental interactions in the universe originate from three primordial fields: the electromagnetic field (A-field), color charge field (B-field), and Higgs field (C-field). Fermions (e.g., neutrinos ν) and bosons (e.g., photons γ) can be represented as vortex excitations of these fields. In the ABC framework, the neutrino field operator can be formally written as:

where is a composite function whose expansion necessarily includes B-field components, i.e., The photon field operator is solely composed of the A-field:

Clearly, This fundamental difference in field structure is the root cause of the difficulty in conversion.

2.2 Two-Step Mediation Model

To address these challenges, we propose that the conversion process occurs in two steps through an intermediate state X:

Step 1: Color Charge Neutralization and B-Field Zeroing  
Under specific conditions (e.g., strong external fields), the neutrino ν can excite a fermion pair X, consisting of a particle x and its antiparticle Crucially, x and carry B-field components of equal magnitude but opposite signs. Thus, the intermediate state has a total B-field of zero:

The physical essence of this step is the “stripping” and annihilation of the B-field component within the neutrino through pair production. The effective interaction Lagrangian for this process is:

where is an effective coupling constant related to ABC theory. This process remains a fermion-to-fermion pair conversion, avoiding violation of the spin-statistics theorem.

Step 2: Energy Transfer and Statistical Transition  
The intermediate state X is an unstable fermionic system with zero net B-field. It can transfer its energy and momentum entirely to the electromagnetic field A via nonlinear coupling, exciting one or more photons. This process is represented as:

Since X is a bound system with integer total spin, its decay into photons (bosons) does not violate statistics. This step achieves the statistical transition from a fermionic system to a boson. The effective interaction Lagrangian is:

where is a nonlinear coupling coefficient, and is the electromagnetic field tensor. This form indicates that the scalar density of the intermediate state couples to the energy density of the electromagnetic field

In summary, the complete conversion path is:

1. Effective Field Theory and Conversion Probability Calculation

3.1 Total Effective Lagrangian

Combining the two steps, the total effective Lagrangian describing the process is:

Using methods such as path integration, the intermediate field X can be integrated out, yielding a higher-order effective operator directly connecting ν and γ. In the low-energy regime, this operator takes the form:

where is the characteristic mass scale of the intermediate state X.

3.2 Conversion Amplitude and Probability

Based on the above effective Lagrangian, the conversion matrix element for can be calculated. Considering the catalytic role of external fields (e.g., strong magnetic fields which provide necessary momentum and enhance coupling, the conversion amplitude is approximated as:

where is the neutrino spinor wavefunction. Summing over spins and taking the modulus squared, the conversion probability per unit time is:

Here, is the Dirac delta function ensuring energy-momentum conservation and resonance conditions. This expression clearly reveals key features:  
1. The conversion probability is proportional to the square of the product of the two-step coupling coefficients .  
2. The conversion probability is proportional to the square of the external field strength   
 indicating that strong-field environments are crucial for triggering the process.  
3. The function shows that the conversion probability is sharply enhanced when the neutrino energy satisfies specific resonance conditions with the external field and intermediate state parameters.

1. Physical Implications and Experimental Predictions

4.1 Resonant Nature of External Field Enhancement

Our model naturally explains why neutrino-photon conversion can only occur in extreme environments (e.g., neutron star magnetospheres, supernova remnants, high-power laser foci). Strong external fields not only provide the necessary energy but also make it easier to satisfy the energy-momentum conservation condition , leading to resonant amplification. This mechanism is analogous to the resonant enhancement of neutrino oscillations in matter [4].

4.2 Testable Experimental Signals

The model predicts several potential experimental signals:  
1. High-Power Laser Experiments: Future high-energy laser facilities colliding intense neutrino beams with ultra-strong laser pulses. Our model predicts that above a threshold laser intensity (approximately depending on model parameters), single-photon signals highly correlated with the neutrino beam direction and with energies close to the neutrino energy may be detected.  
2. Astrophysical Observations: On neutron star surfaces with ultra-strong magnetic fields, neutrino fluxes may partially convert to photons, contributing to observed non-thermal radiation spectra. Particularly, additional radiation peaks due to resonant effects may appear in certain energy windows.  
3. Connection to Axion Experiments: The process in this model shares experimental similarities with axion-photon conversion a involve searching for photon signals in strong magnetic fields). Thus, data from existing axion detection experiments (e.g., CAST, IAXO) could be reanalyzed to search for signals predicted by this model.

1. Conclusion

This paper successfully constructs a Two-Step Mediation Model for neutrino-photon conversion based on ABC vortex field theory. By introducing an intermediate fermion-pair state with zero net B-field, the model elegantly resolves the theoretical obstacles of statistical discontinuity and color charge field annihilation. We establish a complete effective field theory framework, derive a conversion probability proportional to the square of external field strength, and reveal its resonant enhancement nature. This model not only provides a new perspective for understanding profound connections between particles but also opens up novel, verifiable avenues for detecting neutrinos in laboratory and astrophysical environments. Future high-precision experiments will serve as decisive tests for this model.

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