Field Combination Dynamics of Neutrino-Photon Conversion: A Two-Step Mediator Model Based on the ABC Theory

**Authors:** Li, Zhijun and Zhao, Guangyao

**Abstract:**  
Based on Li Zhijun’s ABC (Electromagnetic-Color-Higgs) vortex field theory, this paper proposes a novel mechanism for neutrino-to-photon conversion—the two-step mediator model. This model resolves two fundamental challenges in fermion-boson conversion: the abrupt change in statistics and the annihilation of the color charge field. We demonstrate that the conversion from a neutrino (ν) to a photon (γ) is not direct but occurs in two steps via a fermionic pair intermediate state |X⟩ with a zero net B-field. In the first step, the color charge component of the neutrino field annihilates with an anti-color charge field, resulting in the nullification of the B-field. In the second step, the energy of the intermediate state is mapped to an electromagnetic field excitation through non-linear coupling, completing the statistical transition. This paper constructs a complete effective field theory description, calculates a rigorous expression for the conversion probability, and reveals the resonant nature of the external-field enhancement effect. This model provides a theoretical cornerstone for detecting neutrinos in strong-field environments and predicts testable experimental signatures.

**Keywords:** ABC theory; neutrino-photon conversion; field combination dynamics; statistical transition; color charge neutralization; two-step mediator model

**1. Introduction**

The conversion between neutrinos and photons (e.g., is a frontier problem in particle physics, holding significant implications for understanding the fundamental nature of particles, cosmology, and the search for new physics. However, this process faces two major theoretical challenges:  
1) **Statistical Obstacle:** A direct conversion between a fermion and a boson violates the spin-statistics theorem.  
2) **Field Structure Obstacle:** The field composite of a neutrino contains a non-zero color charge vortex field (B-field) component, whereas the photon’s B-field is zero.

This paper, based on Professor Li Zhijun’s ABC theory, proposes a two-step mediator model that perfectly resolves the aforementioned contradictions. The core idea is that the conversion proceeds through a virtual fermionic pair intermediate state, accomplishing color charge neutralization and the statistical transition sequentially.

**2. The ABC Theory Framework and Particle Field Composites**

**2.1 Field Composite Representation**

In the ABC theory, elementary particles are excited states of specific combinations of the electromagnetic vortex field (A), the color charge vortex field (B), and the Higgs vortex field (C).

• **Neutrino (fermion) state:**

Its field operator satisfies the anti-commutation relation: .

• **Photon (boson) state:**

Its field operator satisfies the commutation relation: .

**2.2 The Conversion Dilemma**

A direct conversion faces:

1. **Operator Conflict:** An anti-commuting operator cannot directly generate a commuting operator.  
2. **Field Structure Conflict:** A non-zero B-field component, , cannot directly transition to the identity .

**3. The Two-Step Mediator Model**

We propose the following conversion pathway:

where is a fermionic pair intermediate state with a zero net B-field.

**3.1 Step 1: Color Charge Neutralization (B-field Annihilation)**

**Physical Process:** The neutrino’s color charge field annihilates with the anti-neutrino’s anti-color charge field .

**Effective Hamiltonian:**

**Final State:** A fermionic pair state with a zero net B-field is produced, satisfying .  
At this stage, the statistics remain unchanged; is still a fermionic state.

**3.2 Step 2: Statistical Transition (A-field Excitation)**

**Physical Process:** The intermediate state injects its energy into the electromagnetic field via non-linear coupling, exciting a photon.

**Effective Hamiltonian:**

where is an external electric field or a quantum fluctuation.

**Final State:** , successfully achieving the statistical transition.

**4. Mathematical Formulation of the Conversion Probability**

The amplitude for the entire process is:

where is the propagator of the intermediate state .

The conversion probability is:

where is the decay width of the intermediate state. This expression naturally explains the extremely low conversion probability, as it is a higher-order process involving the propagation of a virtual state.

**5. Resonant Interpretation of External-Field Enhancement**

A strong external field () enhances through three mechanisms:  
1. **Coupling Enhancement:** The coupling constants are proportional to .  
2. **Energy Matching:** The external field can polarize the vacuum, suppressing the energy and reducing the energy denominator .  
3. **Resonant Enhancement:** When , a resonance occurs, significantly amplifying the probability.

Therefore, the macroscopic scaling laws, such as or , originate from this microscopic resonant enhancement mechanism.

**6. Model Implications and Experimental Predictions**

**6.1 Testable Predictions**

1. **Threshold Effect:** A critical field strength exists, above which the conversion becomes significant ().

where is the effective magnetic moment.

1. **Energy Spectrum Signature:** The energy spectrum of the outgoing photons should exhibit a sharp peak structure, corresponding to the resonant energy of the intermediate state .
2. **Polarization Correlation:** The polarization direction of the outgoing photons should be correlated with the direction of the external field, originating from the coupling.

**6.2 Proposed Experimental Scheme**

1. **Strong-Field Environment:** Create an environment with T using high-power lasers, high-current accelerators, or pulsed magnets.
2. **Signal Detection:** Place high-sensitivity photon detectors (e.g., superconducting nanowire single-photon detectors) at the center of the strong-field region to search for anisotropic, mono-energetic X/γ-ray signals.
3. **Coincidence Measurement:** Utilize timing information from a neutrino source (reactor, accelerator) to perform coincidence measurements to suppress background noise.

**7. Discussion and Outlook**

**7.1 Theoretical Significance**

The two-step mediator model, for the first time within the ABC framework:  
1. Provides a unified solution to the challenges of statistics and field structure in particle conversion.  
2. Reveals the microscopic resonant mechanism behind external-field enhancement.  
3. Decomposes a complex conversion process into a clear physical picture.

**7.2 Potential Applications**

1. **Neutrino Detection:** Offers a novel approach for neutrino detection based on strong-field conversion.
2. **Particle Manipulation:** Provides a theoretical possibility for manipulating particle properties (such as statistics) in a laboratory setting.
3. **Cosmology:** Presents a model for understanding particle conversions in extreme astrophysical environments, such as the early universe or neutron star mergers.

**8. Conclusion**

This paper introduces a two-step mediator model for neutrino-photon conversion based on the ABC theory. The key conclusions are as follows:  
1. The conversion must proceed in two steps via a fermionic pair intermediate state with a zero net B-field.  
2. The first step achieves color charge neutralization (B-field annihilation), while the second step completes the statistical transition (energy mapping).  
3. The extremely low conversion probability is attributed to it being a higher-order process that relies heavily on resonant enhancement provided by an external field.  
4. The model predicts testable signatures, including a threshold effect, a resonant energy spectrum, and polarization correlation, which provide clear directions for experimental verification.

This model furnishes a new theoretical foundation and experimental pathway for exploring the fundamental nature and interactions of particles.

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