**Field Combination Theory Interpretation of Neutrino Penetrability: Weak Scattering Mechanism of Low-Energy-Density Diffuse States**

**Authors:** Li Zhijun, Zhao Guangyao

**Abstract:**Based on Li Zhijun’s ABC field combination theory, this paper proposes a new theoretical interpretation for the ultra-high penetrability of neutrinos. The core argument is that neutrino penetrability does not originate from its “tiny volume”, but rather from its extremely small scattering matrix elements when interacting with matter as a low-energy-density diffuse state. The energy density distribution function of the neutrino field combination state is highly dispersed in space, causing the coupling matrix element to approach zero when interacting with the localized states of atomic nuclei. This paper constructs the quantum wave function of the neutrino field combination state, calculates its scattering cross-section with atomic nuclei, and derives the mathematical expression of neutrino penetration probability from first principles, perfectly explaining why neutrinos can almost unimpededly penetrate entire planets. This theory provides profound physical imagery and a rigorous mathematical framework for understanding the weak interactions between neutrinos and matter.

**Keywords:** ABC Field Theory; Neutrino Penetration; Low-Energy-Density Diffuse State; Scattering Matrix Element; Weak Interaction; Quantum Wave Function

1. **Introduction**

The ability of neutrinos to easily penetrate macroscopic objects such as Earth has long been a puzzling phenomenon in quantum physics. Traditional explanations often attribute this to the “tiny volume” of neutrinos, but such classical metaphors cannot meet the requirements of modern quantum field theory. Based on Li Zhijun’s ABC field combination theory, this paper proposes that neutrino penetrability originates from its special quantum state property: low-energy-density diffuse state. This state has an extremely large spatial extension range but extremely low energy density, resulting in minimal interaction probability with matter.

1. **Field Combination State Representation of Neutrinos**

In the ABC field combination theory, neutrinos can be represented as:

Where:  
\* : Characterizes the chirality and weak charge properties of neutrinos  
\* : Color singlet, ensuring no participation in strong interactions  
\* : Endows it with extremely low mass by weak coupling with the Higgs field

The quantum wave function of neutrinos can be written as:

where V is the normalization volume, reflecting the dispersion characteristics of the wave function in space.

1. **Energy Density Distribution and Diffuse State Characteristics**

The energy density distribution function of neutrinos is:

Due to the extremely small mass of neutrinos and the dispersion of the wave function over a huge spatial range , its energy density approaches zero. This is the physical essence of the low-energy-density diffuse state.

1. **Scattering Matrix Elements and Penetration Mechanism**

The interaction between neutrinos and atomic nuclei occurs through weak force, with scattering probability determined by the matrix element:

Expanding the wave function:

Since the neutrino wave function is approximately constant at the atomic nucleus scale:

The weak interaction Hamiltonian is a short-range force, significantly non-zero only within the atomic nucleus . Therefore, the integration region is extremely small:

The scattering cross-section is:

1. **Calculation and Interpretation of Penetration Probability**

The survival probability of neutrinos passing through matter of thickness L is:

where n is the number density of the target matter.

Since is extremely small , even for L = Earth diameter :

This indicates that neutrinos almost certainly penetrate Earth without interaction.

1. **Conclusion**

Based on the ABC field combination theory, this paper demonstrates that the ultra-high penetrability of neutrinos originates from the characteristics of their low-energy-density diffuse state:  
1. Extremely small mass leads to extremely long de Broglie wavelength  
2. Wave function is highly dispersed in space with extremely low energy density  
3. Scattering matrix elements for interactions with atomic nuclei are extremely small  
4. Scattering cross-section is minimum, with penetration probability approaching 100%

This theory not only explains neutrino penetrability but also provides a general framework for studying interactions between other quantum states and matter, which is of great significance for understanding the nature of fundamental particles.

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