**Quantum Transport of Electrons in Conductors: A Low-Energy Diffuse State Conduction Model Based on ABC Field Combination Theory**

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**Abstract:**Based on Li Zhijun’s ABC field combination theory, this paper proposes an innovative theoretical framework for the electron transport mechanism in conductors. The core argument is that conduction electrons in metallic conductors are specific coupling states of the electromagnetic vortex field A, the color charge vortex field B, and the Higgs vortex field C, forming a “low-energy density diffuse state.” Their high conductivity originates from the extremely long de Broglie wavelength and highly dispersed wave function of this quantum state, which drastically reduces the scattering matrix elements with local scattering centers, resulting in extremely long mean free paths. This paper constructs a generalized quantum transport equation incorporating the effective mass tensor and the periodic C-field background potential , rigorously derives the eigen solutions of the electron wave function (Bloch waves), and calculates their interaction matrix elements with scattering potentials. The theory predicts that in ultra-pure low-temperature conductors, the electron mean free path can reach macroscopic scales, which is highly consistent with experimental results.

**Keywords:** ABC field theory; Quantum transport; Low-energy diffuse state; Bloch waves; Effective mass; Scattering matrix elements

1. **Introduction**

Metallic conductivity is a fundamental problem in condensed matter physics. Although the traditional free electron gas model successfully phenomenologically describes Ohm’s law, it fails to explain from the quantum mechanical foundation why electrons can almost unimpededly traverse periodic crystal lattices. Based on Li Zhijun’s ABC field combination theory, we propose that conduction electrons are specific field combination states, and their excellent conductivity originates from the characteristics of the low-energy density diffuse state.

1. **ABC Field Combination Theory Framework**

**2.1 Fundamental Particles as Field Coupling States**

Any fundamental particle is a specific coupling state of three vortex fields:

Where:  
\* A-field (electromagnetic vortex): Characterizes electromagnetic wave properties

* B-field (color charge vortex): Provides charge and color charge attributes, maintaining field coupling stability
* C-field (Higgs vortex): Couples with the mass generation mechanism, determining particle inertia

Conduction electrons can be expressed as:

where is the color singlet state, ensuring no participation in strong interactions.

**2.2 Effective Mass and C-Field Coupling**

The motion of electrons in a lattice is described by the generalized Ginzburg-Landau equation:

The effective mass tensor originates from the coupling between the field and the lattice C-field background, and is a periodic function of spatial position.

1. **Formation and Characteristics of the Low-Energy Diffuse State**

**3.1 Bloch Wave Solutions**

For a perfect crystal, the eigen solutions of the equation are Bloch waves:

where is a function with the same periodicity as the lattice.

**3.2 Diffuse State Characteristics**

Near the bottom of the energy band, the electron effective mass is determined by the band curvature. The near the Fermi level is typically small, resulting in a de Broglie wavelength:

comparable to the lattice constant, forming a low-energy density diffuse state.

The energy density distribution:

shows uniform spatial energy distribution with low density.

1. **Conduction Mechanism: Weak Scattering and Long Mean Free Path**

**4.1 Scattering Matrix Element Calculation**

Resistance originates from the interaction between electrons and local scattering potentials . The scattering matrix element:

Since the Bloch wave amplitude is approximately constant within the range of the scattering potential:

This integral value is very small.

**4.2 Scattering Rate and Mean Free Path**

Scattering rate:

where is the normalization volume.

Mean free path:

The more dispersed the wave function (low-energy diffuse state), the longer the mean free path.

1. **Theoretical Predictions and Experimental Verification**

In ultra-pure metals and at extremely low temperatures:  
\* Phonon scattering is suppressed

* Impurity concentration is extremely low
* Electron wave function coherence is well maintained

The theory predicts that the mean free path can reach millimeter or even centimeter scales, completely consistent with experimental results of ultra-pure single crystal metals at low temperatures.

1. **Conclusion**

Based on the ABC field combination theory, we have demonstrated:  
1. Conduction electrons are low-energy density diffuse states coupled with periodic C-field backgrounds  
2. Dispersed wave functions lead to extremely small interaction matrix elements with local scattering potentials  
3. The inverse square relationship of scattering rate naturally derives macroscopic-scale mean free paths

This paper is based on the ABC field combination theory, where the A-field is the electromagnetic vortex field, the B-field is the color charge vortex field, and the C-field is the Higgs vortex field. All fundamental particles are specific coupling states of these three fields. This model provides profound physical imagery for understanding electron conduction and unifies condensed matter physics with fundamental particle field theory.

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