The Quantum Origin of Electric Charge: An ABC Theoretical Model Based on Branch Coupling of the Color Charge Vortex Field.

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Abstract:  
Based on Li Zhijun’s ABC theory, this paper proposes a fundamental explanation for the quantization of electric charge. The core thesis is that the electric charge of elementary particles is not an intrinsic property but rather a topological quantum number emerging from the coupling between cosmic energons (or fundamental fermions) and specific branches of the color charge vortex field . We demonstrate that the color charge field comprises three orthogonal branch components (red, green, blue), each carrying a fundamental charge unit of . A particle coupling to one branch of the positive color charge field acquires a charge of ; coupling to two branches yields . Correspondingly, coupling to branches of the negative color charge field yields negative charges. The sign of the charge is determined by the overall sign of the coupled color charge field ( or ), while the magnitude is determined by the number of coupled branches. We construct a field operator algebra describing this coupling mechanism, derive the commutation relations between the charge operator and the color charge field branch operators , and rigorously prove that the resulting charge values necessarily satisfy (). This model provides, for the first time, a natural explanation for charge quantization from the topological properties of field theory, offering a novel foundation for understanding the Standard Model of particle physics.

Keywords: ABC theory; Charge quantization; Color charge field branches; Coupling mechanism; Topological quantum number; Fractional charge

1. Introduction: The Puzzle of Charge Quantization

The quantization of electric charge () is an experimental fact, but the Standard Model attributes it to representations of the gauge group without explaining its deeper origin. Why is the fundamental unit of charge ? Why do quarks carry fractional charges? Li Zhijun’s ABC theory provides a new perspective: charge is a direct manifestation of the interaction between particles and the geometric structure of the universe’s fundamental fields.

1. Theoretical Framework: Branch Structure of the Color Charge Field

2.1 Mathematical Representation of the Color Charge Field

In the ABC theory, the color charge vortex field is a composite field containing three orthogonal branch components. We represent it as a three-component field:

where correspond to the red (R), green (G), and blue (B) branches, respectively. Each branch is an independent vortex field.

There exist two types of color charge fields:

* Positive color charge field : Its branches are denoted .
* Negative color charge field : Its branches are denoted .

2.2 Branch Coupling and the Charge Operator

We introduce a charge-generating operator acting on the field combination state of a particle. The key hypothesis is that this operator’s expectation value is proportional to the color charge field branch operators .

For a fundamental fermion (e.g., a quark), its field combination state is:

where is its quantum state on the color charge field branches.

The effect of the charge operator acting on the color charge field part is defined as:

This implies that coupling to one branch of the positive color charge field yields an eigencharge of ; coupling to one branch of the negative color charge field yields .

1. Algebraic Derivation of Charge Quantization

3.1 Superposition Principle for Multi-Branch Coupling

If a particle couples to multiple branches simultaneously, its total charge is the linear superposition of contributions from each branch. Since the branches are orthogonal, the coupled state is their direct product.

For example, a particle coupling to both and has a color charge field state:

The charge operator acts on it:

By definition, acts only on the corresponding branch, and due to orthogonality, cross terms vanish. Thus:

The total charge is .

3.2 General Charge Formula

Generalizing, if a particle couples to branches of and branches of , its total charge is:

where , and (since there are only three independent branches).

Thus, all possible charge values are:

This perfectly explains the existence of fractional charges and why charges are integer multiples of .

1. Specific Charge Assignments for Particles

According to the above formula, we can assign color charge field coupling patterns to all known particles:

| **Particle** | **Color Charge Field Coupling Pattern** |  |  | **Calculated** | **Actual** |
| --- | --- | --- | --- | --- | --- |
| Up quark (u) | Couples to | 2 | 0 |  |  |
| Down quark (d) | Couples to | 0 | 1 |  |  |
| Electron () | No coupling to color field | 0 | 3 |  |  |
| Positron () | No coupling to color field | 3 | 0 |  |  |
| Proton () | Indirect coupling via gluons, net color singlet | 0 | 0 | 0 |  |
| Neutron () | Indirect coupling via gluons, net color singlet | 0 | 0 | 0 | 0 |

Note: For electrons and composite particles (e.g., protons), the overall system manifests as a color singlet (), but their charge is determined by the algebraic sum of the charges of their underlying constituent quarks. This indicates that our charge-generating operator primarily acts on the color charge field components of fundamental fermions (quarks). The charge mechanism for leptons may require additional assumptions (e.g., coupling to a special “leptonic color” branch).

1. Relationship to the Standard Model

In the Standard Model, charge is given by , where is the weak hypercharge and is the third component of weak isospin. In the ABC theory, the weak hypercharge might be proportional to the difference in the number of coupled color charge field branches , i.e.,

while might be related to another internal degree of freedom. This offers a possibility to derive the Gell-Mann–Nishijima formula from more fundamental geometric principles.

1. Conclusion

Based on the ABC theory, this paper proposes a novel mechanism for charge quantization:

1. Origin of Charge: Charge is a topological quantum number arising from the coupling of fundamental fermions to specific branches of the color charge field .
2. Charge Quantization: Because the number of branches is integer, and each branch contributes a fixed charge quantity , the charge must be an integer multiple of .
3. Sign of Charge: Determined by the type of color charge field coupled to ( or ).
4. Explanation of Fractions: Naturally explains the fractional charges of quarks.

This model profoundly connects the fundamental physical quantity of charge to the geometric structure and topological properties of the universe’s fundamental fields, representing a critical step towards a unified understanding of elementary particle properties.

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