The Field-Composition Origin of Entropy: Topological Phase Transition from Fermionic Matter to Bosonic Black Holes

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Abstract: Based on Li Zhijun’s ABC theory, this paper proposes a unified theoretical framework from the perspective of field composition to elucidate the nature of entropy and its evolution during black hole formation. Our research demonstrates that the entropy of an object does not originate from the simple arrangement of its constituent particles but rather reflects the topological degeneracy of its ABC field composition. For ordinary matter, entropy primarily arises from the degeneracy of specific excitation modes (flavor, color) of its chromocharge vortex field B branch; for black holes, entropy is encoded in the macroscopic topological quantum numbers of their overall field composition. We prove that black hole formation constitutes a topological phase transition of field composition—transitioning from a multi-branch excited fermionic field composition (high microscopic entropy) to a single, coherent bosonic field composition (high topological entropy). By constructing a field composition degeneracy operator we derive its relationship with field expectation values and demonstrate the field-theoretic formulation of entropy conservation before and after the phase transition. This model achieves a deep integration of statistical mechanics with quantum field theory, providing a new paradigm for understanding the essence of entropy from microscopic to macroscopic scales.

Keywords: ABC theory; field composition; entropy; topological degeneracy; black holes; chromocharge field; Higgs field; topological phase transition

1. Introduction: The Field-Composition Interpretation of Entropy

Entropy, as a core concept in statistical mechanics, has always been a crucial subject in theoretical physics research. Recently, Li Zhijun’s proposed ABC theory has provided a new perspective for understanding the origin of entropy [1]. This paper proposes based on this theory that entropy is a measure of the intrinsic degeneracy corresponding to specific excitation modes of a system’s field composition. The ABC field composition of an object can exist in multiple degenerate quantum states that are energetically equivalent but differ in the specific configurations of field components. The degeneracy in the entropy definition:

precisely represents the number of these degenerate states. This interpretation provides a unified framework for understanding the origin of entropy from microscopic particles to macroscopic black holes.

1. Theoretical Framework: Field Composition and Degeneracy

2.1 Field-Composition Representation of Objects

Consider a macroscopic object composed of N fermions (e.g., atoms), whose quantum state can be represented as the direct product of the field compositions of all constituent particles:

where the field composition of each particle can be expanded as a superposition of eigenmodes:

2.2 Origin of Entropy: Degeneracy of Field Excitations

Research shows that the entropy of an object mainly originates from the degeneracy of excitation modes within specific branches of the field composition:

* Chromocharge field B branch: A quark’s B field exhibits three degenerate color charge excitation states (red, green, blue), contributing entropy:

\* Higgs field C branch: Yukawa coupling may lead to mass degeneracy

* Electromagnetic field A branch: Degrees of freedom such as charge and spin direction provide additional degeneracy

The total degeneracy of the system is:

The corresponding entropy is:

2.3 Field-Composition Degeneracy Operator

Define the degeneracy operator:

whose eigenvalues correspond to the number of degenerate states that the field composition can occupy under given macroscopic constraints, where identifies the occupation numbers of each field excitation mode.

1. Field Composition of Black Holes: Coherence and Topology

3.1 Field-Composition Representation of Black Holes

According to ABC theory, a black hole is a Bose-Einstein condensate (BEC) formed after the topological phase transition of the chromocharge vortex field B, with its field composition being a coherent global state:

where:  
\* : condensed chromocharge field state, all B field components are phase-coherent

* : total electromagnetic field state, determining charge and angular momentum
* : total Higgs field state, determining mass

3.2 Origin of Black Hole Entropy: Macroscopic Topological Degeneracy

Black hole entropy stems from the topological degeneracy of its overall field composition. For spherically symmetric black holes, the phase of the B-field condensate has different winding numbers on the event horizon:

The number of these topological degenerate states is:

Taking the coherence length we obtain:

Precise topological field theory calculations yield:

Thus the black hole entropy is:

1. Black Hole Formation: Topological Phase Transition of Field Composition

Black hole formation is a topological phase transition of field composition from a fermionic state to a bosonic state:

Before phase transition (star):

Entropy:

After phase transition (black hole):

Entropy:

During the unitary phase transition process, the total information is conserved:

This equality profoundly connects microscopic physics (particle number N, degeneracy with macroscopic geometry (event horizon area A).

1. Mathematical Modeling: Partition Function of Field Composition

Partition function for ordinary matter:

Corresponding entropy:

Partition function for black holes:

Due to energy degeneracy between states with different winding numbers, we obtain:

1. Conclusion and Outlook

This study provides a unified interpretation of the nature of entropy from the perspective of field composition:  
1. Proposes that entropy is a measure of the degeneracy of field composition excitation modes  
2. Reveals that black hole entropy originates from the macroscopic topological degeneracy of the overall field composition  
3. Demonstrates the entropy conservation law during black hole formation

Future research directions include:  
1. Developing quantitative computational tools for field composition degeneracy  
2. Investigating the dynamics of entropy flow during topological phase transitions  
3. Exploring the microscopic mechanisms of topological entropy carried by Hawking radiation

This model elevates the concept of entropy from statistical mechanics to the level of quantum field theory, providing new insights for resolving the black hole information paradox.

References

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