# The Essential Difference Between Cosmic Origin Singularity and Black Hole Singularity: A Zero-Volume Singularity Classification Theory Based on Li Zhijun’s Field Combination Theory

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## Abstract

Based on Li Zhijun’s Field Combination Theory, this paper rigorously demonstrates mathematically that although both the cosmic origin singularity and black hole singularity possess zero-volume characteristics, they are fundamentally different in physical essence and information structure. The core thesis is: the black hole singularity is a Bose-Einstein condensate collapse state () of field combinations () within the physical domain, representing a finite-information zero-volume structure; whereas the cosmic origin singularity is a geometric origin point in the non-physical domain, a pure geometric structure enveloped by Planck-scale vortex fields for which the concept of temperature is undefined. By constructing the field combination tensor and the singularity entropy operator this paper rigorously proves the essential differences between these two types of zero-volume singularities.

**Keywords:** Zero-volume singularity; Field combination theory; Bose-Einstein condensate; Planck scale; Quantum gravity; Information entropy

## 1. Introduction: The Classification Problem of Zero-Volume Singularities

General relativity predicts two types of singularities (black hole singularity and cosmic origin singularity) both possessing zero-volume () geometric characteristics. However, traditional theories cannot explain why two singularities with identical geometric features exhibit completely different physical properties. Li Zhijun’s Field Combination Theory proposes a revolutionary view: zero-volume is merely the surface geometric characteristic of singularities, with their essential difference lying in their internal information structure and field combination states.

## 2. Mathematical Modeling: Field Combination Theory of Zero-Volume Singularities

### 2.1 General Form of the Field Combination Tensor

Any physical entity can be represented as a tensor product of three fundamental fields:

where each field satisfies:

### 2.2 Mathematical Formulation of the Zero-Volume Condition

Both types of singularities satisfy the zero-volume condition:

However, the physical mechanisms achieving zero-volume are entirely different.

### 2.3 Field Combination State of the Black Hole Singularity: Bose-Einstein Condensate

The field combination state of the black hole singularity is:

where indicates complete collapse of the color charge field:

This state obeys Bose-Einstein statistics, with its wave function:

where the normalization condition is:

However, since the density diverges:

### 2.4 Field Combination State of the Cosmic Origin Singularity: Pure Geometric State

The field combination state of the cosmic singularity is:

where the enveloping fields satisfy Planck-scale constraints:

Key difference: The cosmic singularity does not contain any material particles; therefore, the concept of temperature is undefined here. This state cannot be described by conventional physical quantities but is defined by geometric boundary conditions:

## 3. Information Entropy and Thermodynamic Characterization

### 3.1 Finite Entropy of the Black Hole Singularity

Although the black hole singularity has zero volume, its information capacity is finite. Its entropy is given by the Bekenstein-Hawking formula:

where the horizon area is . The entropy density diverges:

but the total entropy remains finite.

### 3.2 Infinite Entropy and Absence of Temperature in the Cosmic Singularity

The information capacity of the cosmic singularity is infinite:

However, the concept of temperature fails here because:

Reason: Temperature is a statistical concept related to the thermal motion of material particles, whereas the cosmic singularity contains no material particles and is a pure geometric boundary.

### 3.3 Mathematical Proof of Entropy Density Comparison

Define the entropy density operator:

For the black hole singularity:

For the cosmic singularity:

## 4. Field Equations and Singularity Structure

### 4.1 Field Equations of the Black Hole Singularity

The black hole singularity satisfies the modified Einstein field equations:

where the stress-energy tensor is:

Although the integrated mass is finite:

### 4.2 Failure of Field Equations at the Cosmic Singularity

Field equations completely fail at the cosmic singularity:

with a faster divergence rate:

## 5. Characterization of Quantum Effects

### 5.1 Quantum Effects of the Black Hole Singularity

The black hole singularity still exhibits quantum fluctuations:

The Hawking temperature is finite:

### 5.2 Failure of Quantum Properties at the Cosmic Singularity

Quantum principles fail at the cosmic singularity:

The concept of temperature is undefined:

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Reason: No material particles, no thermal motion, no statistical system.

## 6. Theoretical Predictions and Verification

### 6.1 Testable Predictions

1. Black hole information conservation: The black hole singularity should obey quantum unitarity.
2. Untraceable cosmic origin: Spacetime before the Big Bang is undefined.
3. Applicability of the temperature concept: Only the black hole singularity possesses the attribute of temperature.

### 6.2 Observational Verification Schemes

Using next-generation gravitational wave detectors (Einstein Telescope, LISA) and 21 cm cosmology, the following can be verified:  
\* Quantum effect signatures of black hole singularities  
\* Geometric boundary effects of cosmic singularities

## 7. Conclusion

This paper rigorously proves:  
1. Zero-volume is not the essential characteristic of singularities; although both have , their physical essences are entirely different.  
2. The black hole singularity is a physical-domain condensate with finite information, possessing the concept of temperature.  
3. The cosmic singularity is a non-physical-domain geometric boundary with infinite information, lacking the concept of temperature.

This discovery provides a new direction for quantum gravity theory: instead of pursuing the “elimination of singularities,” we need to correctly understand the classification and essence of singularities.

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