On Origin of Universe

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September 8, 2025

Abstract

We propose a framework connecting Wheeler's "It from Bit" paradigm with modern developments in AdS/CFT, emphasizing the fundamental role of the event horizon in cosmological evolution. We argue that the pure quantum state on the horizon generates spacetime and curvature, separating the bulk universe from the external void. Curvature is always directed toward the void, suggesting a duality between the universe and black holes when eversion inside out. This duality motivates the **Inside–Out Equivalence Principle (IOEP)**, under which all dynamical laws in the bulk must remain invariant under O(3) rotations and inversion symmetry. Applying this principle, we reformulate the Einstein field equations without a cosmological constant, yielding predictions for the universe's expansion and black hole evaporation yielding post-heat-death horizon dynamics.

1 Introduction

The nature of spacetime and its origin from quantum information remains one of the deepest puzzles in theoretical physics. Wheeler's "It from Bit" suggests that the fabric of spacetime emerges from underlying quantum information stored on boundaries, particularly horizons [1]. Recent developments in the AdS/CFT correspondence reinforce this view: horizons encode bulk information holographically, connecting boundary quantum states to emergent spacetime geometry [2, 4].

In this work, we explore a novel principle—the **Inside–Out Equivalence Principle (IOEP)**—which identifies a duality between black holes and the universe. Whereas a black hole absorbs external bulk toward its interior void, on opposite way that the universe absorbs interior bulk toward its exterior void. The IOEP formalizes this duality and imposes symmetry constraints on dynamical laws.

2 Horizon as the Source of Spacetime and Curvature

Let $\mathcal{H}$ denote the event horizon, hosting a pure quantum state $|\Psi_{\mathcal{H}}\rangle$. The holographic encoding implies that all bulk degrees of freedom emerge from $|\Psi_{\mathcal{H}}\rangle$, producing both the local spacetime metric $g_{\mu\nu}$ and curvature $R_{\mu\nu\rho\sigma}$. The horizon separates the **bulk**, containing spacetime and matter, from the **void**, which is non-spacetime.

By construction, the curvature vector $\vec{K}$ points outward toward the void. This directional property leads to a natural "inside-out" duality: flipping the bulk and void corresponds mathematically to an inversion symmetry, mapping a universe with expanding bulk to a black hole with contracting interior.

3 Inside–Out Equivalence Principle (IOEP)

The IOEP asserts that all fundamental dynamical laws in the bulk are invariant under:

1. **O(3) rotations**, representing isotropy of the horizon and bulk.
2. **Inversion symmetry**, exchanging bulk and void.

Formally, for any bulk dynamical operator $\mathcal{O}[g_{\mu\nu}, T_{\mu\nu}]$, the IOEP requires:

$$\mathcal{O}[g_{\mu\nu}, T_{\mu\nu}] = \mathcal{O}[Rg_{\mu\nu}R^T, T_{\mu\nu}] = \mathcal{O}[g^{\text{inv}}_{\mu\nu}, T^{\text{inv}}_{\mu\nu}] \tag{1}$$

for all $R \in O(3)$, where $g^{\text{inv}}_{\mu\nu}$ denotes the metric under inversion. This symmetry constrains the form of the Einstein field equations and other dynamical laws, forbidding a cosmological constant term.

4 Reformulating Einstein's Equations under IOEP

Starting from the classical Einstein field equations without a cosmological constant:

$$G_{\mu\nu} \equiv R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} = 8\pi G T_{\mu\nu}, \tag{2}$$

we demand invariance under O(3) rotations and inversion symmetry. The inversion symmetry effectively exchanges bulk and void, requiring that solutions remain consistent under a map $g_{\mu\nu} \to g^{\text{inv}}_{\mu\nu}$.

Physically, this predicts:

- The universe's **apparent expansion** arises from bulk curvature flowing toward the external void, not from a cosmological constant.
- After heat death, with no net inflow of bulk energy, the horizon begins to **shrink** via quantum evaporation, analogous to black hole Hawking radiation, consistent with the inside-out duality.

5 Cosmological Implications

The IOEP offers solutions to several cosmological puzzles:

1. **Dark energy problem:** The observed accelerated expansion is a manifestation of bulk curvature dynamics rather than a true cosmological constant.
2. **Horizon evolution:** Horizon area grows as bulk accumulates; after heat death, evaporation reduces the horizon size, suggesting a cyclic or decaying universe.
3. **Black hole–universe duality:** The inside-out mapping implies that universal dynamics mirror black hole formation and evaporation, providing a unified description of cosmological and gravitational collapse phenomena.

6 Conclusion

By combining Wheeler's "It from Bit" with insights from AdS/CFT, we highlight the central role of the horizon as a generator of spacetime and curvature. The Inside–Out Equivalence Principle enforces O(3) rotational and inversion symmetry, constraining all bulk dynamics and eliminating the need for a cosmological constant. This framework predicts apparent expansion, post-heat-death horizon evaporation, and a deep duality between black holes and the universe. Future work will explore quantitative models of horizon-induced curvature, bulk dynamics under IOEP, cyclic universe bounces, origin of CMB and testable consequences for early-time cosmology, including primordial gravitational waves, Cosmic Microwave Background fluctuations, etc.

References

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