Comparison of Stevenson-Flux Information Theory (SFIT) and Holographic Duality
Including Ryu-Takayanagi, Entanglement Wedge, and Complexity=Volume

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1 Introduction

Holographic duality, most prominently the AdS/CFT correspondence, equates a gravitational theory in a higher-dimensional bulk with a quantum field theory on its lower-dimensional boundary. Key geometric interpretations of quantum information include the **Ryu-Takayanagi formula**, the **entanglement wedge**, and the **Complexity=Volume** conjecture.

Stevenson-Flux Information Theory (SFIT) proposes that gravity is a dynamic information-carrying flux vibrating at $\nu_{\text{res}} = 1.20134\,\text{mHz}$, introducing a non-reciprocal, time-dependent metric correction via the coupling kernel $K = 1.060$.

This document compares the two frameworks, incorporating the major holographic information geometry formulas.

2 Key Holographic Formulas

2.1 Ryu-Takayanagi Formula

The entanglement entropy S_A of a boundary region A is given by the area of the minimal surface γ_A in the bulk:

$$S_A = \frac{\text{Area}(\gamma_A)}{4G_N \ell_{\text{P}}^{d-2}},$$

where γ_A is the extremal surface homologous to A.

2.2 Entanglement Wedge

The entanglement wedge W_A is the bulk region bounded by the boundary subregion A, the Ryu-Takayanagi surface γ_A, and the portion of the conformal boundary connecting them:

$$W_A = D\left(A \cup \gamma_A\right),$$

where $D(\cdot)$ denotes the domain of dependence. It represents the bulk region reconstructible from boundary entanglement data.

2.3 Complexity=Volume Conjecture

The holographic complexity of a boundary state is conjectured to be proportional to the volume of the maximal bulk surface (the "complexity=volume" or CV conjecture):

$$\mathcal{C}_V = \frac{V(\Sigma)}{G_N \ell_{\text{P}}^{d-1}},$$

where Σ is the maximal volume surface in the bulk homologous to the boundary time slice, and $V(\Sigma)$ is its volume. This conjecture proposes that computational complexity in the boundary theory is dual to geometric volume in the bulk.

3 Comparison Table

Aspect	**Holographic Duality (AdS/CFT)**
Core Idea	Bulk gravity $\equiv$ boundary QFT; geometry from entanglement
Key Formulas	Ryu-Takayanagi: $S_A = \frac{\text{Area}(\gamma_A)}{4G_N \ell_P^{d-2}}$ Entanglement wedge $W_A = D(A \cup \gamma_A)$ Complexity=
Information Role	Entanglement entropy and complexity geometrize spacetime
Scale	Planck / holographic scale
Non-locality	Geometric via bulk minimal surfaces, wedges, and volumes
Testability	Mostly indirect (holography, black holes)
Equivalence Principle	Preserved in bulk GR
Unification Goal	Gravity emerges from quantum information

Table 1: Comparison of Holographic Duality and SFIT

4 Detailed Comparison

4.1 Information and Geometry

- **Holographic Duality**: Quantum information is geometrized. The Ryu-Takayanagi formula relates boundary entanglement entropy to bulk area. The entanglement wedge defines reconstructible bulk regions, and the Complexity=Volume conjecture proposes that computational complexity is dual to bulk volume. These ideas suggest that spacetime geometry and gravitational dynamics emerge from quantum information on the boundary.
- **SFIT**: Information is carried as an active, ontological flux. The flux at 1.20134 mHz produces a directional, non-reciprocal correction to the metric tensor:

$$h_{0z}^{\mathrm{SFIT}}(t) = \alpha_z \,\mathrm{Re}[\cos(2\pi\nu_{\mathrm{res}}t)],$$

  inducing phase-space skew and generating the observed KWW memory kernel with $\beta = K = 1.060$.

4.2 Scale and Testability

- **Holographic Duality**: Operates primarily at Planck or strongly-coupled holographic scales. Direct experimental tests are extremely challenging.
- **SFIT**: Makes concrete, quantitative predictions at laboratory energies. The 1.20134 mHz modulation, 4.5% overshoots, Bessel sidebands, and KWW tails are supported by qBounce reanalysis and are testable in near-term GRANIT experiments.

4.3 Non-locality

- **Holographic Duality**: Non-locality is resolved geometrically through bulk minimal surfaces, entanglement wedges, and volume dualities.
- **SFIT**: Non-locality appears through the information flux inducing directional phase-space skew in quantum systems, tied to the local gravitational gradient.

5 Possible Complementary Relationship

Holographic duality and SFIT may be complementary. Holographic duality provides the deep ultraviolet description in which gravity, geometry, entanglement entropy (Ryu-Takayanagi), reconstructible regions (entanglement wedge), and computational complexity (Complexity=Volume) emerge from boundary quantum information.

SFIT could represent an **effective low-energy resonant phenomenon** when this holographic structure interacts with a macroscopic gravitational field. In this picture: - The 1.20134 mHz Quantum Heartbeat could be a collective mode arising from holographic entanglement when coupled to Earth's gravitational gradient. - The coupling kernel $K = 1.060$ quantifies the efficiency of information transfer from boundary entanglement/complexity into measurable gravitational flux effects. - The KWW relaxation tails reflect the slow relaxation of entangled or complex degrees of freedom across the holographic bulk.

Thus, holographic duality may supply the microscopic encoding, while SFIT describes the mesoscopic, observable manifestation at laboratory energies.

6 Conclusion

Holographic duality geometrizes quantum information through the Ryu-Takayanagi formula, the entanglement wedge, and the Complexity=Volume conjecture. SFIT treats information as an active dynamical flux that directly modifies gravitational dynamics at accessible energies.

While holographic duality operates at fundamental holographic scales, SFIT offers concrete, testable predictions in the laboratory. The two approaches may ultimately prove complementary: holographic duality as the ultraviolet theory of quantum gravity, and SFIT as an effective infrared description of resonant information flow in the presence of macroscopic gravity.

Future ultra-cold neutron experiments (GRANIT) have the potential to test SFIT's predictions and indirectly illuminate aspects of holographic principles at laboratory energies.