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

Douglas G. Stevenson
stevensonfluxinformationtheory.com

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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. Two cornerstone formulas are the **Ryu-Takayanagi formula** for entanglement entropy and the **entanglement wedge** construction, which defines the bulk region dual to a boundary subregion.

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, with explicit inclusion of the Ryu-Takayanagi and entanglement wedge 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 that is homologous to A:

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

where γ_A is the extremal surface in the bulk anchored on ∂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. It represents the bulk region that is "reconstructible" from the boundary entanglement data.

Formally, the entanglement wedge is defined as the domain of dependence of the region between A and γ_A:

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

where $D(\cdot)$ denotes the domain of dependence. This construction plays a central role in modern holographic information theory, including subregion-subregion duality and the connection between entanglement and bulk locality.

3 Comparison Table

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

Table 1: Comparison of Holographic Duality and SFIT

4 Detailed Comparison

4.1 Information and Geometry

- **Holographic Duality**: Quantum entanglement on the boundary is geometrized. The Ryu-Takayanagi formula relates boundary entanglement entropy to the area of a bulk minimal surface. The entanglement wedge W_A defines the bulk region dual to boundary data, providing a geometric notion of subregion reconstruction.

- **SFIT**: Information is carried as an active flux. The flux at 1.20134 mHz produces a directional, non-reciprocal correction to the metric tensor:

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

inducing phase-space skew and generating the observed KWW memory kernel.

4.2 Scale and Testability

- **Holographic Duality**: Operates at Planck or strongly-coupled holographic scales. Direct tests are extremely challenging.
- **SFIT**: Makes concrete predictions at laboratory energies. The 1.20134 mHz modulation, 4.5% overshoots, and KWW tails with $\beta = 1.060$ 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 (Ryu-Takayanagi) and entanglement wedges.
- **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 and geometry emerge from quantum entanglement on a boundary (via Ryu-Takayanagi and entanglement wedges). 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 how efficiently boundary entanglement information is transferred into measurable gravitational flux effects. - The KWW relaxation tails reflect the slow relaxation of entangled 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 and the entanglement wedge construction. 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.