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

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1 Introduction

Holographic duality, most prominently the AdS/CFT correspondence, states that a gravitational theory in a higher-dimensional bulk is equivalent to a quantum field theory on its lower-dimensional boundary[cite: 29]. A cornerstone of this duality is the **Ryu-Takayanagi formula**, which geometrizes quantum entanglement entropy[cite: 29].

Stevenson-Flux Information Theory (SFIT) proposes that gravity is a dynamic information-carrying flux vibrating at $\nu_{\text{res}} = 1.20134$ mHz, introducing a non-reciprocal, time-dependent metric correction via the coupling kernel $K = 1.060$ [4].

This document compares the two frameworks, with explicit inclusion of the Ryu-Takayanagi formula[cite: 29].

2 Ryu-Takayanagi Formula

In holographic duality, 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 [1, 3]:

$$S_A = \frac{\text{Area}(\gamma_A)}{4G_N l_P^{d-2}}, \tag{1}$$

where:

- γ_A is the minimal (extremal) surface in the bulk anchored on the boundary of region A [1].
- G_N is Newton's constant in the bulk [1].
- l_P is the Planck length in the bulk spacetime dimension $d+1$[cite: 29].

This formula establishes a direct geometric interpretation of quantum entanglement: entanglement entropy on the boundary is proportional to the area of a bulk surface [3].

3 Comparison Table

Table 1: Comparison of Holographic Duality and SFIT[cite: 29]

Aspect	**Holographic Duality (AdS/CFT)**	**SFIT**
Core Idea	Bulk gravity = boundary QFT; geometry from entanglement	Gravity as dynamic information flux
Key Formula	$S_A = \frac{\text{Area}(\gamma_A)}{4G_N l_P^{d-2}}$ (Ryu-Takayanagi)	$h_{0z}^{\text{SFIT}}(t) = \alpha_z \,\text{Re}[\cos(2\pi\nu_{\text{res}}t)]$
Information Role	Entanglement entropy geometrizes spacetime	Ontological information carried by active flux
Scale	Planck / holographic scale	Laboratory / UCN scale
Non-locality	Geometric via bulk minimal surfaces / ER bridges	Directional phase-space skew via gravitational gradient
Testability	Mostly indirect (holography, black holes)	Direct: qBounce (14.28σ), GRANIT
Equivalence Principle	Preserved in bulk GR	Preserved in adiabatic limits; dynamic response violates
Unification Goal	Gravity emerges from quantum information	Gravity–QM bridge via active flux

4 Detailed Comparison

4.1 Information and Geometry

- **Holographic Duality:** Quantum entanglement on the boundary is geometrized via the Ryu-Takayanagi formula [1]. The bulk spacetime geometry encodes boundary entanglement entropy [3]. ER=EPR extends this idea by identifying entanglement with Einstein-Rosen bridges[cite: 29].
- **SFIT:** Information is carried as an active, ontological flux[cite: 29]. The flux at 1.20134 mHz produces a directional, non-reciprocal correction to the metric tensor[cite: 29]:

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

  with amplitude $\alpha \approx 0.00122$[cite: 29]. This flux induces phase-space skew in the quantum wave function and generates the observed KWW memory kernel [9].

4.2 Scale and Testability

- **Holographic Duality:** Operates at Planck or strongly-coupled holographic scales [2]. Direct experimental tests are extremely difficult [2].
- **SFIT:** Makes concrete predictions at laboratory energies[cite: 29]. The 1.20134 mHz modulation, 4.5% overshoots, Bessel sidebands, and KWW tails with $\beta = 1.060$ are supported by qBounce reanalysis and are testable in near-term GRANIT experiments[cite: 29].

4.3 Non-locality

- **Holographic Duality:** Non-locality of entanglement is resolved geometrically through bulk minimal surfaces (Ryu-Takayanagi) or wormholes (ER=EPR)[cite: 29].
- **SFIT:** Non-locality appears through the information flux inducing a directional phase-space skew in quantum systems [5]. The flux is tied to the local gravitational gradient [5].

5 Possible Complementary Relationship

SFIT and holographic duality may be complementary rather than competing frameworks [8]. Holographic duality provides the deep ultraviolet description where gravity and spacetime geometry emerge from quantum entanglement on a boundary (via Ryu-Takayanagi) [1, 8]. SFIT could represent an **effective low-energy resonant phenomenon** when this holographic structure interacts with a macroscopic gravitational field [8].

In this view:

- The 1.20134 mHz Quantum Heartbeat could be a collective mode arising from holographic entanglement when coupled to Earth's gravitational gradient [6].
- The coupling kernel $K = 1.060$ quantifies the efficiency of information transfer from boundary entanglement into measurable gravitational flux effects[cite: 29].
- The KWW relaxation tails reflect the slow relaxation of entangled degrees of freedom across the holographic bulk [7].

Thus, holographic duality may supply the microscopic encoding, while SFIT describes the mesoscopic, observable manifestation at laboratory energies [8].

6 Conclusion

Holographic duality geometrizes quantum information through the Ryu-Takayanagi formula and related constructions, proposing that spacetime emerges from entanglement [1]. SFIT treats information as an active dynamical flux that directly modifies gravitational dynamics at accessible energies[cite: 29].

While holographic duality operates at fundamental scales, SFIT offers concrete, testable predictions in the laboratory [2]. 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 [8].

Future ultra-cold neutron experiments (GRANIT) have the potential to test SFIT's predictions and indirectly illuminate aspects of holographic principles at laboratory energies[cite: 29].

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