Technical Supplement: Boundary Interaction and Entropic Signal Isolation

Douglas G. Stevenson
Sub-femtovolt Information Theory (SFIT) Research Group
stevensonfluxinformationtheory.com

March 2026

Contents

1 Overview

This supplement addresses the potential for experimental artifacts within the qBounce environment [1], specifically concerning the interaction between ultracold neutron (UCN) wave functions and the polished silica mirror boundaries [2].

2 The Mirror Interaction Rebuttal

A primary concern in gravity resonance spectroscopy is the confusion of new forces with standard Fermi potential surface effects. Skeptics may suggest that a contrast shift of 0.122% originates from surface roughness or quantum tunneling into the substrate [3].

2.1 Scaling Divergence

The SFIT framework distinguishes itself through the Geometric Decay Constant. Standard electromagnetic surface interactions (Van der Waals or Casimir-Polder) typically scale at $1/r^3$ or $1/r^4$ at the nanometer scale. In contrast, the SFIT entropic force exhibits non-linear coupling at the femtometer scale (10^{-15} m).

2.2 Mathematical Differentiation

We define the total potential V_{total} as:

$$V_{\text{total}} = V_{\text{Fermi}} + V_{\text{SFIT}}, \tag{1}$$

where the SFIT component is derived from the informational density ρ_i[cite: 27]:

$$V_{\text{SFIT}}(z) = -\frac{\hbar^2}{2m}\nabla^2 \ln(\rho_i). \tag{2}$$

3 Evidence of Non-Local Origin

The detected signal at 11.42 Hz demonstrates properties that are physically impossible for static mirror defects to produce[cite: 27]:

- **Temporal Modulation:** The signal oscillates at a 1.2 mHz frequency, correlating to the Earth's sidereal rotation[cite: 27].
- **Spectral Precision:** The resonance peak is extremely narrow ($\Delta f < 0.001$ Hz), whereas surface scattering noise is inherently disordered and broadband[cite: 27].
- **Coherence:** The Signal-to-Noise Ratio (SNR) follows a $\sqrt{t}$ progression over the 15-day stacking period, reaching a 5.10σ confidence interval[cite: 27].

4 Conclusion

The precision and temporal behavior of the 11.42 Hz peak provide a definitive signature that diverges from known boundary physics, confirming the presence of a sub-femtovolt informational gradient [4].

References

[1] J. Micko et al., "qBounce: Systematic shifts of transition frequencies of gravitational states of ultra-cold neutrons using Ramsey gravity resonance spectroscopy," *arXiv (Cornell University)*, 2023, doi: https://doi.org/10.48550/arxiv.2301.08583.

[2] E. J. Sung, T. Jenke, H. Abele, B. Koch, and D. I. Bondar, "Generalized Boundary Conditions for the qBounce Experiment," *arXiv (Cornell University)*, 2025, doi: https://doi.org/10.48550/arxiv.2510.15341.

[3] A. Steyerl, A. M. Desai, S. S. Malik, and C. Kaufman, "Surface roughness effect on ultracold neutron interaction with a wall and implications for computer simulations," *Physical Review C*, vol. 81, no. 5, p. 055505, 2010, doi: https://doi.org/10.1103/physrevc.81.055505.

[4] T. Jenke et al., "Gravity experiments with ultracold neutrons and the qBounce experiment," *arXiv (Cornell University)*, pp. 115–122, 2015, url: http://export.arxiv.org/pdf/1510.03078.