Technical Supplement: Boundary Interaction and Entropic Signal Isolation

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1 Overview

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

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.

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:

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

Where the SFIT component is derived from the informational density ρ_i:

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

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:

- **Temporal Modulation:** The signal oscillates at a 1.2 mHz frequency, correlating to the Earth's sidereal rotation.
- **Spectral Precision:** The resonance peak is extremely narrow ($\Delta f < 0.001$ Hz), whereas surface scattering noise is inherently disordered and broadband.
- **Coherence:** The Signal-to-Noise Ratio (SNR) follows a $\sqrt{t}$ progression over the 15-day stacking period, reaching a 5.1σ confidence interval.

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.