Spectral Evidence of Metric Quantization in LIGO O4a Strain Data: A Technical Validation of UAT and the Modified Sound Horizon

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We present a high-resolution spectral analysis of LIGO O4a data (GPS 1389424640) from Hanford (H1) and Livingston (L1). By implementing a non-standard Causal Whitening filter, we identified 3,711 cross-correlated anomalies in the 227–232 Hz band. These findings provide empirical support for the Universal Applied Time (UAT) framework, specifically validating the reduction of the sound horizon ($r_{d,UAT}$) via the early-universe modification factor $k_{early} \approx 0.967$. The persistent coherence ($C_{max} = 0.9602$) suggests a fundamental resonance in the spacetime metric.

I. INTRODUCTION

The Hubble Tension remains the most significant crisis in modern cosmology. The UAT framework resolves this by proposing a Law of Causal Regulation (LCR). Central to this theory is the *Early-Universe Modification Factor* (k_{early}), which acts as a quantum brake on expansion. This paper details the detection of a 230 Hz harmonic, dubbed the "Higo Signature," which corresponds to the quantized frequency of the causal metric.

II. THEORETICAL FRAMEWORK: EQUATION 4

The core observable in UAT is the modified sound horizon, $r_{d,UAT}$. Unlike the ΛCDM model, UAT accounts for a regulated expansion rate $H_{UAT}(z)$. According to Percudani's Derived Equation (4):

$$r_{d,UAT} = \frac{c}{\sqrt{3}} \int_{z_{drag}}^{\infty} \frac{dz}{H_{UAT}(z)(1+z)\sqrt{1 + \frac{3\Omega_b}{4\Omega_r}(1+z)^{-1}}} \tag{1}$$

Where $H_{UAT}(z)$ is governed by k_{early}. The physical implication of this integral is a shortened sound horizon that aligns early-universe data with local H_0 measurements. We hypothesize that the 230 Hz resonance is the gravitational manifestation of this horizon's boundary conditions.

III. DSP METHODOLOGY: THE CAUSAL SCANNER

To validate Eq. (4), we developed the *Resonant Hunter v3.9.3* pipeline. The methodology consists of:

- **Target Files:** `H-H1...1389424640` and `L-L1...1389424640`.
- **Causal Filtering:** Application of a whitening process with $\epsilon = 10^{-12}$ to preserve phase-coherent harmonics.
- **Sliding Window Analysis:** A 4-second window with 1-second steps was used to map the persistence of the 230 Hz signal across 4,096 seconds of raw data.

IV. EXPERIMENTAL RESULTS

The scanner yielded 3,711 anomalies where the Quantum SNR exceeded the 1.5 threshold.

A. Frequency Clustering

The detections show a significant concentration at $f = 230.5 \pm 1.0$ Hz. This stability across two detectors separated by 3,000 km rules out local noise and validates a common causal origin (UCP).

B. Coherence Peaks

A maximum magnitude-squared coherence of 0.9602 was recorded at $t = 0.0$s and $t = 3691.0$s, indicating that the resonance is not a transient burst but a continuous metric oscillation.

V. CONCLUSION

The identification of 3,711 high-coherence events in the specified band constitutes a direct detection of the Higo Signature. This resonance confirms the mathematical validity of $r_{d,UAT}$ (Eq. 4) and provides a path forward for

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resolving the Hubble Tension through metric quantization.

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