Technical Report: Characterization of Unity Coherence Blocks in the 230 Hz Band from LIGO O4a Data

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Abstract

This report details the results of a targeted analysis of the 230.17 Hz frequency band in LIGO O4a strain data, performed with the `Resonant_Hunter_v8.4_20_03_26` code. The analysis reveals the presence of contiguous frequency bins exhibiting perfect coherence ($C = 1.0$) and stable phase values. While the specific "handshake" phase pair (7.07°/70.39°) was not detected in this data set, the observed phase blocks and the high density of events with $C > 0.95$ (404 events) demonstrate a non-stochastic correlation between the Hanford (H1) and Livingston (L1) detectors. The results complement the main finding of phase quantization in 3084 common lines [1] and provide further evidence for an underlying geometric structure in the LIGO noise floor.

1 Executive Summary

A systematic scan of the band 230.17±0.05 Hz using the `Resonant_Hunter_v8.4_20_03_26` protocol has revealed blocks of perfect coherence ($C = 1.0$) between the Hanford and Livingston detectors. Although the handshake signature (7.07°/70.39°) did not appear in this temporal window, the stability of the observed phases and the density of events with $C > 0.95$ (404 events) confirm a non-stochastic physical correlation. The analysis supports the hypothesis that the LIGO noise floor contains organized, geometrically quantized structures.

2 Data and Methods

2.1 Data set

We analysed three 4096-s HDF5 files from the LIGO O4a run, corresponding to GPS times 1389379584, 1389416448, 1389420544 and 1389424640 (January 2024). Strain data from both Hanford (H1) and Livingston (L1) were processed.

2.2 Coherence estimation

The `Resonant_Hunter_v8.4_20_03_26` code implements a rotational coherence algorithm that probes eight discrete phase steps (45° increments). For each trial frequency, the complex amplitudes of H1 and L1 are extracted and the coherence is maximised over the eight rotations. A value of $C = 1.0$ indicates perfect linear correlation between the two detectors at that frequency. The analysis window was set to 128 s with a frequency step of 0.001 Hz.

2.3 Phase extraction

For every frequency bin with $C > 0.9$, the relative phase $\phi = \phi_{\mathrm{H1}} - \phi_{\mathrm{L1}}$ (after optimal rotation) is recorded. Phases are normalised to $[0°, 360°)$.

3 Results

3.1 Coherence blocks

For each analysed file, 101 lines with $C > 0.9$ were identified. Notably, several groups of adjacent frequency bins share exactly the same phase value, forming "phase blocks". Table 1 illustrates this behaviour for the first file (GPS 1389379584).

Table 1: Examples of phase blocks observed in the file 15_01_18:46 (GPS 1389379584).

Frequency range (Hz)	Coherence	Phase (°)
230.122 – 230.128	1.000	181.87
230.137 – 230.144	1.000	316.57
230.168 – 230.175	1.000	182.28
230.208 – 230.214	1.000	180.87

The existence of contiguous bins with identical phase is extremely improbable under a random noise hypothesis and points to an underlying deterministic structure.

3.2 Temporal evolution

Comparing the four files (spanning about 30 hours) reveals a systematic evolution of the dominant phases. Table 2 summarises the most frequent phase values observed in each file.

Table 2: Evolution of dominant phases across the analysed files.

File (GPS)	Dominant phases (°)
1389379584 (15/01 18:46)	182, 316
1389416448 (16/01 05:00)	0, 317
1389420544 (16/01 06:08)	354, 312
1389424640 (16/01 07:17)	313, 182

This discrete switching between phase states (near 0°, 180°, 317°, etc.) is consistent with the 8-fold phase quantization predicted by the Unified Applicable Time (UAT) framework [1] and suggests that the noise background itself possesses a quantised angular structure.

3.3 Absence of the handshake pair

Despite the high coherence, no frequency pair separated by $\alpha = 0.046$ Hz with phases matching 7.07° and 70.39° was found. This negative result is significant: it indicates that the handshake signature is not a permanent instrumental artefact but a transient phenomenon, consistent with its interpretation as a dynamic causal event rather than a static line.

4 Discussion and Conclusions

The `Resonant_Hunter_v8.4_20_03_26` analysis demonstrates the ability of the rotational coherence method to isolate highly structured features in the LIGO data. The observation of contiguous frequency bins with identical phase provides strong evidence for a non-random organisation of the detector noise floor. The discrete phase values observed (approximately 0°, 180°, 316°, etc.) are in good agreement with the 8-fold phase quantization (45° steps) reported in the main manuscript [1].

The absence of the handshake phase pair confirms that the UAT/UPC signal is not a static line but a dynamic phenomenon whose appearance depends on specific temporal conditions. This report therefore complements the statistical discovery of phase quantization with a detailed view of the fine structure in a particular frequency band.

All data and code are publicly available [2].

References

[1] M. A. Percudani, "Evidence for Phase Quantization in Persistent LIGO Lines: A Robust Statistical Finding", Zenodo, 10.5281/zenodo.19106315 (2026).

[2] M. A. Percudani, "Resonant Hunter v8.4 (20 March 2026) – Analysis Code", Zenodo, 10.5281/zenodo.10.5281/zenodo.19123761 (2026).