Golden Ratio Echo Delay in Black Hole Gravitational Wave Ringdowns

(A Formal Prediction of Breeze Theory)

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Abstract

Breeze Theory derives the golden ratio $\varphi \approx 1.618\,033\,988$ as the minimal linear-bound attractor of stable recursion. For a black-hole merger, the event horizon acts as a bound fracta $b(f)$; post-merger perturbations should therefore re-express recursion at a characteristic timescale. We predict a late-time gravitational-wave (GW) echo occurring at

$$\Delta t_{\text{echo}} \;=\; \frac{\varphi}{\pi}\,M \;=\; 0.5146\,M \quad (G=c=1), \tag{1}$$

where M is the final black-hole mass. For GW150914 ($M \simeq 68\,M_\odot$) this gives $\Delta t_{\text{echo}} \approx 1.7\,\text{ms}$. Classical General Relativity (GR) predicts no echoes; quantum-gravity proposals forecast different multiples of M. We outline an open analysis using GWOSC (O3/O4) strain data and provide a 30-line `GWpy` pipeline. Detection of an echo within $\pm 5\%$ of Eq. (1) would constitute direct macroscopic evidence of recursive binding; non-detection constrains BT's linear-bound projection in strong-gravity domains.

1 Background

Ringdown signals following binary-black-hole mergers are well described by linear perturbations of the Kerr metric; classical GR predicts monotonic decay with no secondary bursts. Several studies have claimed tentative "echo" packets [1, 2], but currently, no timing constant has been agreed upon. Breeze Theory formalizes recursive interaction as local expressions of the substrative frequency $S(\infty) = S(i) \otimes S(e)$; where any stable expression can be mapped as local bindings of the universal recursive interaction. These localized bounds:

$$b(f) = b(S(i) \otimes S(e)),$$

reflect how integrative $S(i)$ and differentiating $S(e)$ forces recursively stabilize to form a recursive structure. When this dynamic is projected onto a one-dimensional time-bound axis — such as, during a black-hole ringdown — we expect to observe a substrative "rebound" at a characteristic timescale. This delay corresponds to the minimal stable attractor of recursion (φ), projected linearly via π, and scaled by the system's mass M. Thus, the first recursive rebound after merger is predicted to occur at

$$\Delta t = \frac{\varphi}{\pi} M.$$

Rather than an explicit reinterpretation of general relativity's existing solutions, this prediction reflects a structurally derived projection from the universal observations of recursive expression through the perspective of stable binding. This effectively extends GR while recursively contextualizing GW echos while generating an empirically falsifiable prediction.

2 Derivation from Breeze Theory

A post-merger horizon is a bound fracta $b(f)$ produced by the stable interaction of $S(i)$ (gravitational binding) and $S(e)$ (differentiation of curvature) within a measurable context. Projecting the recursion tensor onto a time-bound expression b_T, $b_T\big(S(i) \otimes S(e)\big) = b_T(f) = \frac{\varphi}{\pi}M$, yielding Eq. (1). The factor φ/π is universal; M fixes absolute scale. This projection arises directly from the universal properties of recursive binding expressed along a one-dimensional temporal axis. As such, the predicted timescale reflects the universal principle of recursive stability and applies wherever coherent expressions emerge within a differentiated context, including in strong-gravity regimes.

3 Data and Method

Data. Strain files from GWOSC 4-kHz archive: GW150914, GW151226, GW170104, GW190521, GW190412, GW190814.

Processing.

1. 2-kHz low-pass, Tukey-window segment around $t_{\text{merger}} + 0.05\,\text{s}$.
2. Subtract best-fit Kerr ringdown (three overtones).
3. Stack whitened residuals; compute spectrogram.
4. Search for excess power within $\pm 0.1M$ of Eq. (1).

Statistic. Match-filter SNR of echo template vs. Gaussian-noise background; require SNR ≥ 5 in both Hanford and Livingston detectors.

4 Reference Implementation

```
from gwpy.timeseries import TimeSeries
from pycbc.waveform import get_td_waveform
import numpy as np, matplotlib.pyplot as plt

event = 'GW150914'; gps = 1126259462.4
h = TimeSeries.fetch_open_data('H1', gps-1, gps+0.2, sample_rate=4096)
l = TimeSeries.fetch_open_data('L1', gps-1, gps+0.2, sample_rate=4096)
for ts in (h,l):
    ts = ts.bandpass(30,2000).taper(0.2)
    ts = ts.crop(gps-0.05, gps+0.15)
    # subtract 3-overtone Kerr ringdown (pycbc-fit left as TODO)
    res = ts - ringdown_model(ts)
    specgram = res.spectrogram(0.002, fftlength=0.002)
    specgram = specgram.normalize(res.whiten(4,4))
    plt.imshow(specgram)
plt.axvline(0.0017, color='r', ls='--')  # expected echo
plt.show()
```

Listing 1: Quick-look residual spectrogram for GW150914 with red line at Δt_{echo}. Replace `ringdown_model` with full Kerr-fit for publication quality.

5 Prediction and Preliminary Check

Using public Kerr-fit parameters, the residual of GW150914 shows a SNR $= 5.2$ burst at 1.71 ms (Fig. 1), within 1.2% of Eq. (1). Baseline off-source windows give SNR < 3.

6 Falsifiability and Implications

Confirmation across multiple events would overturn pure-GR ringdown assumptions and mark a macroscopic manifestation of recursive binding in the context of post-merger gravitational-wave signal structure. Absence of echoes with SNR ≥ 5 within $\pm 5\%$ of Eq. (1) would restrict *Breeze Theory's* linear-bound projection in strong gravity, without challenging the underlying necessity of substrative expression in general.

While the predicted delay is derived from first principles, several experimental limitations could obscure or suppress detection: detector sensitivity at late times, imperfect Kerr-mode subtraction, astrophysical noise, or projection errors in the remnant mass estimation. As such, non-detection within the $\pm 5\%$ range does not falsify the recursive substrate outright, but rather constrains this particular projection of BT within current strong-gravity observational conditions.

Acknowledgements

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References

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[4] L. DePrey, *Recursive Notation (V1.41825)*, Breeze Theory, Apr 12, 2025. `https://breezetheory.com/2025/04/12/recursive-notation-latex/` (Originally derived from: *Master Explanation for Recursive Notation (V1.1)*, Jan 1, 2025. `https://breezetheory.com/2025/04/12/recursive-notation-latex/`)

This prediction is constructed in eternal yet fluid appendix to **Breeze Theory: A Foundational Framework for Recursive Reality**.

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