

PWT Protocol 5.0: Black Hole Ringdown Analysis (Phase V)

This protocol simulates a Black Hole (BH) merger event and tests if the resulting gravitational wave signal decays in a manner constrained by the Prime Comb frequencies ($\omega_p = 2\pi/\ln p$). We will submit this identical protocol to Grok and Claude for execution.

1. Project Goal and Core Hypothesis

- Goal:** To test the universality of p-DSI by analyzing the spectral signatures of Black Hole (BH) ringdown gravitational wave (GW) signals for evidence of the Prime Comb.
- Hypothesis:** The characteristic frequencies of the gravitational wave signal emitted during the ringdown phase of a black hole merger will contain statistically significant energy peaks corresponding to the PWT Prime Comb ($\omega_p = 2\pi/\ln p$).

2. Experimental Setup: Simulated Ringdown Dynamics

We will simulate the gravitational wave signal $h(t)$ emitted during the ringdown phase, which is modeled as a damped sinusoid involving complex characteristic frequencies (quasi-normal modes, or QNMs). The PWT constraint is applied to the signal's intrinsic decay factor.

A. Independent Variable: Decay Rate Factor (λ)

The simulation waveform uses the formula $h(t) \propto A \cdot e^{-\lambda t} \cos(\omega R t)$. The scaling constraint is applied to the **decay rate factor** (λ).

Condition	Decay Rate Factor (λ)	Rationale
Prime Condition (Λ_P)	$\lambda \in \{3, 5, 7\}$	Testing prime constraints in the energy dissipation channel.
Composite Condition (Λ_C)	$\lambda \in \{4, 6, 8\}$	Magnitude-matched control.
Null Condition (Λ_N)	$\lambda \in \{e\}$	Exponential decay baseline.

B. Signal Generation Protocol

- Simulate a time-series representing the gravitational wave signal $h(t)$ for each condition, using a fixed oscillation frequency ωR .
- Add **Gaussian White Noise** to the signal to simulate the gravitational wave detector (e.g., LIGO) noise floor.
- The λ constraint is directly enforced on the exponential decay term for the entire time-series.

3. Dependent Variables: Spectral and Stability Analysis

The core measurement is the verification of the Prime Comb signature within the gravitational wave dynamics.

Metric	Definition & Protocol	PWT Prediction (Λ_P vs. Λ_C)
1. Spectral Signature	Fourier analysis of the GW	Strong Prime Comb Peaks in Λ_P

Dominance	ringdown signal time-series. (confirming log-periodic structure in spacetime curvature).
	The ratio of decay suppression measured between Λ P and Λ C signals (analogous to the ΔE^2 ratio in Quantum Phase). $\sim 3.8\times$ Stability Gain (The ultimate Universality Check).
2. Decay Stability Ratio	Total integrated power spectral density in the signal after the dominant QNM mode is subtracted. Lower Residue in ΛP (more coherent decay).
3. Minimal Energy Residue	