Gravitational Radiation Demarcation: Wheeler–Feynman Absorber Damping, Radio Timing Standards, and Interferometer Template Filtering

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Abstract

Gravitational radiation is widely cited as the definitive experimental verification of General Relativity's autonomous transverse-traceless vacuum metric excitations ($h_{\mu\nu}^{\mathrm{TT}}$). In this paper, we establish a rigorous physical and epistemological demarcation between two fundamentally distinct classes of gravitational observables: 1. **Direct Radio Timing Standards:** The secular orbital period decay of relativistic binary pulsars (e.g., PSR B1913+16, $\dot P_b \approx -2.40 \times 10^{-12}\,\text{s/s}$); 2. **Interferometer Matched-Filter Strain Catalogues:** Kilometer-scale laser strain measurements (LIGO–Virgo–KAGRA) cross-correlated against pre-computed General Relativistic numerical waveform templates ($h \sim 10^{-21}$).

We demonstrate that the observed orbital energy loss of binary pulsars does not necessitate autonomous vacuum radiative degrees of freedom propagating to spatial infinity. Within a Wheeler–Feynman absorber cosmology on a closed $S^3(R)$ container, the secular decay is accounted for by the conservative Burke–Thorne radiation reaction potential: [\Phi_{\text{reac}}(\mathbf{x}, t) = \frac{G}{5 c^5} x^j x^k Q_{jk}^{(5)}(t),] whose orbit average identically reproduces the Einstein quadrupole energy loss rate: [\langle \dot E \rangle = -\frac{G}{5 c^5} \left\langle \dddot Q_{jk}^{\mathrm{TF}} \dddot Q_{jk}^{\mathrm{TF}} \right\rangle,] matching the Peters quadrupole rate at full strength without free fields. We show that scalar-only radiation falls short of the observed binary pulsar decay by a factor of $5.93\times$ ($1/6$ of Peters), confirming that the damping interaction must be spin-2 tensor in structure.

Finally, we formalize the framework's governing two-sided demarcation rule, `PASS_RAD_LIGO_PURSUE_NOT_PRESUME`: catalogue detections are not an axiomatic proof that autonomous vacuum gravitons exist, while methodological critiques of matched-filter noise baselines do not license the retirement of tensor damping.

1. Introduction: The Epistemological Bifurcation in Gravitational Wave Physics

Modern gravitational wave physics rests upon two distinct empirical foundations that are frequently conflated: 1. **The Indirect Classical Observable (Taylor & Hulse 1974):** High-precision radio arrival times measuring the cumulative orbital phase shift of binary neutron stars over four decades. 2. **The Direct Laboratory Observable (LIGO 2015–Present):** Picometer-scale differential arm length variations ($\Delta L \sim 10^{-18}\,\text{m}$) extracted from noisy interferometer data via matched-filter template banks.

In General Relativity, both observables are interpreted as manifestations of a single entity: propagating transverse-traceless ripples of the spacetime metric ($h_{\mu\nu}^{\mathrm{TT}}$) carrying energy away into asymptotically flat vacuum.

However, in a closed cosmological container such as the CPT vacuum resonator $S^3(R)$, there is no spatial infinity ($\mathscr{I}^+$). Energy cannot escape to an infinite sink. In this paper, we examine whether binary pulsar decay requires autonomous radiative vacuum degrees of freedom, or whether it represents direct non-local Wheeler–Feynman absorber damping between compact sources.

2. Radio Timing Standards: The Peters Rate and the Scalar Shortfall

The primary empirical constraint on gravitational radiation is the orbital period decay of the Hulse–Taylor binary pulsar PSR B1913+16: [\dot P_b = (-2.40 \pm 0.05) \times 10^{-12}\,\text{s/s}.]

For an eccentric binary system with masses m_1, m_2, semi-major axis a, and eccentricity e, the quadrupole energy loss rate derived by Peters and Mathews (1963) is: [\left\langle \frac{\mathrm{d}E}{\mathrm{d}t} \right\rangle = -\frac{32}{5} \frac{G^4 m_1^2 m_2^2 (m_1 + m_2)}{c^5 a^5} \frac{1 + \frac{73}{24} e^2 + \frac{37}{96} e^4}{(1 - e^2)^{7/2}}.]

2.1 The Scalar Radiation Shortfall

In alternative scalar-tensor theories or pure dilatonic models, radiative emission is mediated by a scalar field ϕ. The scalar dipole moment vanishes identically for identical masses, leaving scalar quadrupole radiation.

Calculating the scalar quadrupole emission rate: [\dot E_{\text{scalar}} = -\frac{G}{30 c^5} \left\langle \dddot Q_{jk} \dddot Q_{jk} \right\rangle = \frac{1}{6} \dot E_{\text{Peters}}.] The scalar rate suffers a **$5.93\times$ shortfall** relative to the observed pulsar timing. Binary pulsar timing decisively rejects scalar-only radiation: any viable damping mechanism must possess full spin-2 tensor structure.

3. Wheeler–Feynman Absorber Damping via the Burke–Thorne Potential

In classical electrodynamics, Wheeler and Feynman (1945) proved that radiative damping $\mathbf{F}_{\text{rad}} = \frac{2 e^2}{3 c^3} \mathbf{\dddot x}$ arises without independent vacuum radiation fields when time-symmetric (half-retarded plus half-advanced) potentials interact with a complete absorber.

Applying this absorber principle to 4D bulk elasticity on $S^3(R)$, the gravitational damping experienced by a localized source is given by the Burke–Thorne radiation reaction potential (Burke 1971, Thorne 1969): [\Phi_{\text{reac}}(\mathbf{x}, t) = \frac{G}{5 c^5} x^j x^k \frac{\mathrm{d}^5 Q_{jk}^{\mathrm{TF}}(t)}{\mathrm{d}t^5},] where Q_{jk}^{TF} is the trace-free quadrupole moment of the system.

3.1 Equivalence to the Peters Rate

The force per unit mass exerted by the Burke–Thorne potential on the binary components is: [\mathbf{a}*{\text{reac}} = -\nabla \Phi*{\text{reac}} = -\frac{2 G}{5 c^5} x^k Q_{jk}^{(5)}(t).] Taking the orbital time-average over a complete period P_b: [\langle \dot E \rangle = \left\langle \sum m \mathbf{v} \cdot \mathbf{a}*{\text{reac}} \right\rangle = -\frac{G}{5 c^5} \left\langle \dddot Q*{jk}^{\mathrm{TF}} \dddot Q_{jk}^{\mathrm{TF}} \right\rangle.] This reproduces the Peters rate identically at 100% strength.

Key Physical Finding: Binary pulsar timing confirms the existence of spin-2 tensor damping at the Peters rate, but does *not* prove that autonomous graviton wavepackets propagate as independent ontological entities through empty vacuum.

4. The LIGO Matched-Filter Demarcation

Interferometers measure the differential strain: [h = \frac{\Delta L}{L} \sim 10^{-21}, \quad \text{with } L = 4000\,\text{m} \implies \Delta L \sim 4 \times 10^{-18}\,\text{m}.] Because raw strain noise exceeds the signal amplitude by multiple orders of magnitude, detection relies upon matched-filter cross-correlation: [\rho = \frac{\langle s | h_{\text{template}} \rangle}{\sqrt{\langle h_{\text{template}} | h_{\text{template}} \rangle}}.]

4.1 The Two-Sided Demarcation Rule: `PASS_RAD_LIGO_PURSUE_NOT_PRESUME`

Within the CPT framework, this methodology is governed by the two-sided rule (§0bn567): 1. **Side 1 (Do Not Presume):** A catalog of matched-filter template detections is not a proof of autonomous vacuum degrees of freedom, is not a licence to fit CPT framework coefficients to numerical relativity chirp banks, and does not constitute a CPT identity. 2. **Side 2 (Do Not Retire):** Methodological critiques of interferometer noise baselines (e.g., residual phase correlations between Hanford and Livingston) do not prove that interferometers are blind, do not license the retirement of transverse-traceless antennas, and do not reopen scalar-only radiation.

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5. Conclusion & Framework Architecture

The CPT framework adopts an epistemologically balanced posture: * **Binary pulsar timing** is retained as primary empirical data, fully explained by Burke–Thorne absorber damping on the compact container. * **Interferometer catalogues** are classified as matched-filter template searches whose interpretation remains conditional on the assumed spin-2 vacuum channel.

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