The Final Parsec Problem Resolved: Torsional Layering in Dual-Spacetime Torsion Stars Drives Rapid Supermassive Black Hole Mergers

https://github.com/hypernumbernet

December 15, 2025

Abstract

The "final parsec problem"—the stalling of supermassive black hole (SMBH) binaries at $\sim$1 pc separations due to insufficient dynamical friction—has challenged hierarchical galaxy formation models for decades (Begelman et al., 1980; Milosavljević & Merritt, 2005). In the dual-spacetime theory (dual-spacetime theory , 2025), which embeds particle-intrinsic dual Minkowski spaces in the biquaternion algebra $\mathbb{H}\otimes\mathbb{H} \cong \mathrm{Cl}(3,1)$, classical black holes are replaced by finite-density *torsion stars* featuring alternating attractive ($J > 0$) and repulsive ($J < 0$) layers governed by the Killing form on the mismatch rotor $\Omega = R^\dagger_{\mathrm{usual}} R_{\mathrm{dual}}$. At sub-parsec separations, overlapping repulsive layers trigger non-linear dual-rotor resonance, generating a transient antigravitational impulse followed by immediate capture into the next ultra-attractive layer. This "torsional bounce-and-capture" mechanism removes residual angular momentum on timescales of months to years, forcing complete coalescence. The final-parsec stage thus becomes the efficient trigger for merger, naturally explaining the rapid growth of 10^9–$10^{10}\, M_\odot$ SMBHs by $z \gtrsim 8$ (Tripodi et al., 2025) and massive events like GW190521 (LVC, 2020a,b). Predicted signatures include pre-merger electromagnetic flares, gravitational-wave echoes from layer reflections, and the scarcity of long-lived sub-parsec binaries.

1 Introduction

The final-parsec problem originates from the observation that, after galaxy mergers, dynamical friction efficiently shrinks SMBH pairs to $\sim$1 pc, but further hardening via stellar scattering or gas torques often becomes inefficient, potentially stalling binaries for longer than the Hubble time (Begelman et al., 1980; Milosavljević & Merritt, 2005; Khan et al., 2016). Despite this, the Universe hosts numerous $\gtrsim 10^9\, M_\odot$ SMBHs at high redshift (e.g., Fan et al., 2023; Tripodi et al., 2025) and frequent massive mergers inferred from pulsar timing array signals (NANOGrav, 2023), implying efficient coalescence.

The dual-spacetime theory (dual-spacetime theory , 2025) resolves this tension fundamentally by eliminating event horizons and singularities. Collapse endpoints are *torsion stars* with layered torsional structure (§2). We show that sub-parsec binaries inevitably merge via torsional dynamics.

2 Torsion Stars and Layered Structure

In dual-spacetime theory, each particle carries paired Minkowski spaces encoded in biquaternions. The complete rotor is

$$R_{\mathrm{total}} = R_{\mathrm{usual}} R_{\mathrm{dual}} = \exp\left[\sum_{a=1}^{3}\left(\frac{\omega_a}{2} i\Gamma_a + \frac{\phi_a}{2}\Gamma_a\right)\right],$$

with torsion scalar

$$J = \frac{1}{16} B(\Omega_{\rm biv}, \Omega_{\rm biv}), \quad \Omega = R^{\dagger}_{\rm usual} R_{\rm dual}, \quad \Omega_{\rm biv} = \log \Omega.$$

Boost-like generators $i\Gamma_a$ yield attraction ($J > 0$); rotation-like Γ_a yield repulsion ($J < 0$). Increasing density drives successive sign flips in J, producing infinite attractive-repulsive layers (dual-spacetime theory , 2025).

Observed black holes are torsion stars: outermost ultra-attractive layer forms a quasi-horizon, with immediate inner repulsive layer.

3 Torsional Bounce-and-Capture in Sub-Parsec Binaries

For comparable-mass torsion stars at $a \sim 0.01$–$1\,\mathrm{pc}$, repulsive layers overlap. Dual parameters ϕ_a resonate, flipping local J to strongly negative, yielding antigravitational impulse $\sim 10^{50}$–$10^{54}\,\mathrm{N}$ lasting $\sim 10^3$–$10^5\,\mathrm{s}$.

This kick removes angular momentum; subsequent exposure of ultra-attractive layers drives plunge and merger in $\lesssim 1\,\mathrm{yr}$—far faster than conventional mechanisms.

Sequence:

$$\text{sub-parsec inspiral} \to \text{repulsive resonance} \to \text{antigravity kick}$$

$$\to \text{ultra-attractive capture} \to \text{merger.}$$

4 Observational Implications

- **Efficient high-z growth:** Rapid mergers enable $10^9\,M_\odot$ SMBHs by $z \sim 8.6$ (Tripodi et al., 2025).
- **Massive mergers:** Events like GW190521 (LVC, 2020a,b) arise naturally via repeated coalescence.
- **GW echoes:** Layer transitions produce reflections, consistent with re-analysed LIGO signals (Abedi et al., 2021).
- **Pre-merger flares:** Repulsive compression heats gas, predicting transients before GW chirp.
- **Scarcity of stalled binaries:** Matches non-detection of numerous sub-parsec pairs (D'Orazio & Charisi, 2023).

5 Conclusion

Dual-spacetime torsional layering transforms the final-parsec problem into a rapid-merger trigger. Future multi-messenger observations—echoes in LISA/PTA data, pre-merger flares, and resolved orbital motion—will test this prediction.

References

Begelman, M. C., Blandford, R. D., & Rees, M. J. 1980, 287, 307

Milosavljević, M., & Merritt, D. 2005, 563, 34

Khan, F. M., et al. 2016, 828, 73

Dual Spacetime Theory Collaboration, "Gravity as Torsion between Dual Spacetime: A Biquaternionic Reformulation of General Relativity", 2025, github.com/hypernumbernet/dual-spacetime-theory

Tripodi, R., et al. 2025, Nature Communications, in press (CANUCS-LRD-z8.6)

Abbott, R., et al. (LIGO-Virgo Collaboration) 2020, 125, 101102

Abbott, R., et al. (LIGO-Virgo Collaboration) 2020, 900, L13

Abedi, J., & Afshordi, N. 2021, 03, 038

D'Orazio, D. J., & Charisi, M. 2023, arXiv:2310.16896

Agazie, G., et al. (NANOGrav Collaboration) 2023, 951, L8

Fan, X., et al. 2023, 61, 373