Mass Stabilization as Phase Plateau: An Observational Test in the Galactic Center

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Abstract

We propose an observational test of mass stabilization interpreted as a low-frequency phase-delay plateau in the Galactic Center. Rather than replacing collider-scale symmetry breaking mechanisms, we examine whether mass admits a dynamical realization as stabilized group delay in strong-gravity modulation spectra. Four discriminants are identified: (i) low-frequency plateau, (ii) ω^{-2} tail, (iii) environmental modulation, (iv) multi-band invariance.

1 Observational Principle

We treat the modulation frequency ω (QPO/periodic variability) rather than the photon carrier frequency.

$$X_{\mathrm{obs}}(\omega) = H(\omega;\mu)\, X_{\mathrm{src}}(\omega) \tag{1}$$

$$\phi(\omega;\mu) = \arg H(\omega;\mu) \tag{2}$$

$$\tau(\omega;\mu) = -\,\partial_\omega \phi(\omega;\mu) \tag{3}$$

Lag is identified as excess phase delay beyond GR+plasma propagation models.

2 Target Systems

Primary target: Sgr A* NIR flares (VLTI/GRAVITY).

Typical modulation timescale:

$$T \sim 20\text{–}60\,\mathrm{min}, \qquad \omega_0 \sim \frac{2\pi}{T}$$

For $M_{\mathrm{SgrA*}} \approx 4.3 \times 10^6 M_\odot$,

$$t_g = \frac{r_g}{c} \approx 21\,\mathrm{s}$$

3 Implementation Procedure

Step 1 – Spectral Localization

Identify dominant QPO band in $P(\omega)$.

Step 2 – Phase Extraction

$$\phi_{\rm obs}(\omega, t) = \arg X(\omega, t)$$

Phase unwrapping required.

Step 3 – Projection Residual

$$\Delta\phi(\omega) = \phi_{(1)}(\omega) - \phi_{(2)}(\omega)$$

Subtract GR+plasma baseline.

Step 4 – Group Delay

$$\tau(\omega_i) \approx -\frac{\Delta\phi_{i+1} - \Delta\phi_{i-1}}{\omega_{i+1} - \omega_{i-1}}$$

For reference, we adopt a conservative detectability threshold of order 1 s in plateau amplitude, used as the reference level in Fig. 1.

4 Lag Parameter Model

$$\boxed{\tau(\omega) = \tau_0(\mu)\frac{\Lambda_{\rm lag}^2}{\Lambda_{\rm lag}^2 + \omega^2}} \tag{4}$$

The predicted structure consists of a plateau regime, a transition region, and a power-law decay tail. The QPO band is expected to probe the crossover between these regimes, where discriminability is maximal.

Expected structure:

$$\tau(\omega) \sim \begin{cases} \tau_0 & (\omega \ll \Lambda_{\rm lag}) \\ \omega^{-2} & (\omega \gg \Lambda_{\rm lag}) \end{cases}$$

5 Independent Parameter Consistency

Independent measurements:

- τ_0 from phase slope
- γ from linewidth/coherence time
- $m_{\rm lag}$ from pole or kinematic proxy

Consistency test:

$$\boxed{m_{{\rm lag},\alpha}^2(\mu) = -\frac{\gamma_\alpha(\mu)}{\tau_\alpha(0;\mu)}} \tag{5}$$

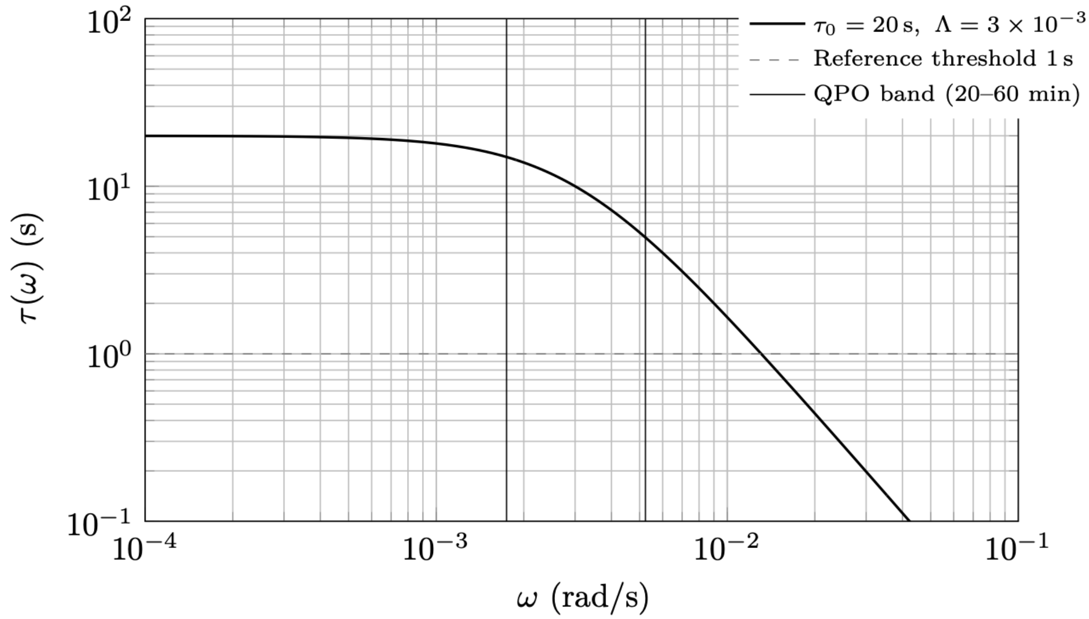

Figure 1: Lag spectrum in modulation frequency ω (not photon frequency). The model predicts a low-frequency plateau of order $\tau_0 \sim O(t_g)$ and an ω^{-2} decay at high frequency. The shaded vertical region indicates the QPO band (20–60 min), which lies near the transition regime. The dashed line marks a conservative detectability threshold of order 1 s.

6 Cut-Rate Inference

$$\Delta\kappa(\mu) \propto -m_{\mathrm{lag}}^2(\mu)\, \Delta\tau_0(\mu) \tag{6}$$

7 Discriminants

Model validated only if all four hold:

1. Low-frequency plateau
2. ω^{-2} high-frequency tail
3. Environmental dependence of τ_0
4. Multi-band invariance of Λ_{lag}

8 Conclusion

If confirmed, mass admits an observational realization as stabilized phase delay at the gravitational timescale. If falsified, lag-based mass generation is excluded at the tested scale. The test is decisive at the gravitational timescale.