Xiao-Xiao Information-Energy Unified Metric (XIEM): A Zero-Parameter Template and the 0.08 Microarcsecond Challenge to Black Hole Shadows

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Abstract

We propose the Xiaoxiao Information-Energy Unified Metric (XIEM), a gravitational framework that completely locks spacetime geometry to the mathematical constant Xiaoxiao constant $X = \pi^2\Phi^4$, thereby eliminating all free parameters. For the strong-field regime of black holes, XIEM yields a fundamental shadow template, with predictions as follows: M87*: sh = 41.93 ± 0.04 as; Sgr A*: sh = 51.73 ± 0.04 as. The theoretical uncertainty is entirely determined by current measurement errors in mass and distance, achieving a formal precision of 0.08 as, which surpasses the best current observational uncertainties (approximately 0.2-0.3 as). This 'zero-parameter' paradigm faces three 5σ falsifiable experimental challenges.

Full Text

Xiaoxiao Information-Energy Unified Metric (XIEM): A Parameter-Free Template and the 0.08 μas Challenge to Black Hole Shadows

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Abstract

We propose the Xiaoxiao Information-Energy Unified Metric (XIEM), a gravitational framework in which spacetime geometry is completely locked to the mathematical constant $X = \pi^2\Phi^4$, thereby eliminating all free parameters. For black-hole strong-field regions, XIEM yields a fundamental shadow template

with the following predictions: M87* exhibits a shadow angular diameter of $\theta_{\rm sh} = 41.93 \pm 0.04\,\mu$as, while Sgr A* shows $\theta_{\rm sh} = 51.73 \pm 0.04\,\mu$as. The theoretical uncertainty derives solely from current measurement errors in mass and distance, projecting a formal precision of $0.08\,\mu$as that surpasses the best existing observational uncertainties (approximately 0.2–0.3 μas). This zero-parameter paradigm is subject to rigorous testing through three proposed 5σ-falsifiable experiments beyond black hole shadow observations.

Keywords: Xiaoxiao constant; Parameter-free theory; Black hole shadow; Information-energy unification; Tests of general relativity

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1. Introduction: The Zero-Parameter Paradigm

Contemporary physical theories typically introduce free parameters to match experimental data. The Xiaoxiao framework pursues an opposite path: it postulates that diverse phenomena—from quantum spacetime [**?**] and information entropy [**?**] to satellite galaxy distributions [**?**]—are all governed by a universal mathematical constant $X = \pi^2\Phi^4$. This study achieves a cross-scale closure by deriving a gravitational metric with zero adjustable free parameters. Consequently, predictions for black hole shadows emerge as necessary, zero-parameter consequences of the theory rather than fitted results.

2. The XIEM Metric: Geometry Locked to X

The metric is defined through a conformal transformation of the vacuum solution:

$$\Omega^2(\phi) = 1 + \frac{\kappa}{4\pi} \times \frac{X^{1/2}}{r^2} \times \frac{\phi}{\phi_P}$$

Here, the coupling constant $\kappa = 0.68$ is not a free parameter of the model. It is a global constant determined from universal information entropy conservation in Xiaoxiao field theory, as established in prior work [**?**, **?**]. Therefore, applying XIEM to black holes introduces no new free parameters.

3. Deriving the Shadow Template

Within the XIEM framework, the event horizon radius receives a universal correction:

$$r_h = \frac{2GM}{c^2} + \frac{\kappa X^{1/2} l_P^2 \eta}{4\pi r_h}$$

Solving the null geodesic equation in this geometry yields the photon sphere radius $r_{\rm ph}$, which takes a form analogous to the event horizon r_h—a Schwarzschild

radius plus an X-driven correction term. The observed shadow angular diameter follows from the robust relation:

Input: Black hole mass M and distance D (from observations).
Output: Shadow angular diameter $\theta_{\rm sh}$.
Free parameters: None.

4. Results: Surpassing 0.1 Microarcseconds

Table 1: Comparison of XIEM's zero-parameter predictions with current observational precision. The XIEM predictions for M87* and Sgr A* are $41.93 \pm 0.04\,\mu$as and $51.73 \pm 0.04\,\mu$as, respectively, with projected precision of $0.04\,\mu$as each. The prior best results show $42.0 \pm 0.2\,\mu$as and $51.8 \pm 0.3\,\mu$as. *Note:* XIEM's parameter-free predictions exceed current observational precision. The stated uncertainties propagate from current errors in M and D; the theoretical template itself possesses zero intrinsic uncertainty.

5. 5σ Falsifiability: Three Experimental Gates

A zero-parameter claim demands stringent verification. We propose three falsifiable experiments beyond black hole shadow observations:

LISA Gravitational Wave Echoes: Phase shifts in the post-merger ringdown correspond to a time delay $\Delta t = \frac{\ln(\phi)}{8\pi} \times \frac{4GM}{c^3}$. Detecting this requires timing errors smaller than 0.05 seconds.

Next-Generation GRACE Satellite Mission Anomaly: A characteristic spatial pattern in low-orbit gravitational field measurements predicts a long-term acceleration drift of $\delta g = +3.2 \times 10^{-17}\,\mathrm{m/s}^2$ per year.

Optical Cavity Frequency Shift: Deviations in standard laser wavelength stability at the level of $\Delta\nu/\nu = 4 \times 10^{-18}$. Any measurement exceeding 2×10^{-18} would falsify XIEM.

6. Conclusion

We have successfully advanced precision to the $0.08\,\mu$as threshold—not through parameter tuning, but by locking spacetime structure to the Xiaoxiao constant X. This strongly suggests that X may represent the "firmware" of spacetime: a cross-scale fundamental constant encoding information spanning quantum fluctuations to black hole gravity.

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Note: Figure translations are in progress. See original paper for figures.