Probing Quantum Gravity with Energy-Resolved Timing of Gamma-Ray Bursts and Pulsars

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Abstract

Quantum-gravity theories predict that spacetime may deviate from the smooth description of general relativity near the Planck scale, potentially producing tiny energy-dependent delays in high-energy photons. We present an energy-resolved timing method to test Lorentz Invariance Violation using gamma-ray bursts and pulsars. The method models the observed time lag as the sum of an intrinsic emission delay and a possible propagation-induced delay. Applied to 42 Fermi GRBs with known redshift, observed by Fermi/GBM and Fermi/LAT, the analysis yields EQG,1> 0.25 EPl at 95% confidence level for a linear subluminal LIV correction. Applied to 60 pulsars observed by Fermi/LAT, MAGIC, and H.E.S.S., the same framework gives EQG,1> 0.17 EPl (at 95% confidence level for a linear subluminal LIV correction). The consistency between cosmological GRBs and local pulsars supports the robustness of the method and its ability to disentangle intrinsic source effects from possible quantum-gravity-induced propagation delays.

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