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New physics from the gamma-ray burst GRB 221009A?

Astronomical objects offer unique opportunities to probe physics beyond the Standard Model (SM) since they reach energies exceeding those attainable in laboratories. A striking example is the gamma-ray burst GRB 221009A at redshift $z = 0.151$, detected up to ~15 TeV by LHAASO and even up to ~300 TeV by Carpet. Within the SM, photons above ~10 TeV are mainly absorbed by the extragalactic background light, making the LHAASO detections extremely challenging and the Carpet event impossible. We show that photon–axion-like particle (ALP) oscillations increase the cosmic transparency, thereby naturally accounting for the LHAASO photons but not the Carpet event. Instead, Lorentz-invariance violation (LIV) alters photon dispersion relation explaining the Carpet observation but not the LHAASO photons. Therefore, GRB 221009A provides two distinct hints at new physics. We offer a new self-consistent scenario where photon-ALP oscillations occur in a LIV framework, providing a full explanation of GRB 221009A.

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