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Investigating the Lorentz Invariance Violation effect using different cosmological backgrounds

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Abstract

Familiar concepts in physics, such as Lorentz symmetry, are expected to be broken at energies approaching the Planck energy scale as predicted by several quantum-gravity theories. However, such very large energies are unreachable by current experiments on Earth. Current and future Cherenkov telescope facilities may have the capability to measure the accumulated deformation from Lorentz symmetry for photons traveling over large distances via energy-dependent time delays. One of the best natural laboratories to test Lorentz Invariance Violation~(LIV) signatures are Gamma-ray bursts~(GRBs). The calculation of time delays due to the LIV effect depends on the cosmic expansion history. In most of the previous works calculating time lags due to the LIV effect, the standard $Lambda$CDM (or concordance) cosmological model is assumed. In this paper, we investigate whether the LIV signature is significantly different when assuming alternatives to the $Lambda$CDM cosmological model. Specifically, we consider cosmological models with a non-trivial dark-energy equation of state ($w neq -1$), such as the standard Chevallier-Polarski-Linder~(CPL) parameterization, the quadratic parameterization of the dark-energy equation of state, and the Pade parameterizations. We find that the relative difference in the predicted time lags is small, of the order of at most a few percent, and thus likely smaller than the systematic errors of possible measurements currently or in the near future.

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