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Probing Lorentz Invariance Violation with Air-Shower Maximum Distributions

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Lorentz invariance violation (LIV) can modify electromagnetic interactions at ultra-high energies and thereby affect the development of extensive air showers (EASs). We study a subluminal photon-sector LIV scenario in which Bethe–Heitler pair production is suppressed. Using LIV-modified EAS simulations, we model the resulting changes in the depth of shower maximum, X_{max} , and reconstructed energy. The predictions are folded with the published Pierre Auger Observatory fluorescence-detector response and compared with the measured X_{max} distributions, allowing the primary composition to vary. Within this simplified analysis, we obtain the 95% confidence-level constraint $M_{\text{LIV}} > 1.5 \times 10^{21}$ GeV, where M_{LIV} is the characteristic LIV energy scale in the photon sector. This result demonstrates the potential of hadron-induced EASs for probing photon-sector LIV.

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