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Probing Lorentz violation in the ultra-high-energy regime using air showers

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Current efforts towards a more fundamental theory beyond the Standard Model of Particle Physics open up a window for deviations from exact Lorentz symmetry. To test Lorentz symmetry, one can take advantage of the extreme energies reached by ultra-high-energy cosmic rays (UHECRs). We use the air showers initiated by UHECRs to study the effects of Lorentz violation (LV), focusing on isotropic, non-birefringent LV in the photon sector. New processes, which are forbidden in case exact Lorentz symmetry holds, can significantly change the shower development, specifically vacuum Cherenkov radiation or photon decay. Based on the average depth of the shower maximum (Xmax) and its shower-to-shower fluctuations, world-leading bounds on the strength of LV have been placed. The next step is to investigate and exploit the impact of LV on shower muons. Including shower observables related to muons is expected to significantly improve the sensitivity of LV searches.

Summary

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