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Searches for Lorentz Invariance Violation at the Pierre Auger Observatory

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Lorentz symmetry requires the space-time structure to be the same for all observers, but, on the other hand, various quantum gravity theories suggest that it may be violated when approaching the Planck scale. Even a small violation of Lorentz Invariance (LI) could easily affect the Ultra High Energy Cosmic Rays (UHECRs) propagation on a cosmological scale. Moreover, at the extreme energies, like those available in the collisions of UHECRs in the atmosphere, one should also expect a change in the interactions and, therefore, in the development of extensive air showers. In this work, Lorentz Invariance Violation (LIV) has been introduced as a perturbation term in the single particle dispersion relation considering a phenomenological approach. As a result, the kinematics of the interactions in the extragalactic propagation and in the shower development in the atmosphere is affected. The unprecedented statistics and data quality collected by the Pierre Auger Observatory in the EeV range are used to explore LIV scenarios. In particular, LIV effects have been tested by comparing the energy spectrum and the composition of cosmic rays determined with the Pierre Auger Observatory with the predictions from simulations including LIV. Also the impact of LIV on the resulting upper limits on the photon flux has been studied. Finally, the effects on the development of extensive air-showers in the atmosphere are studied. In particular, the change in the energy-momentum relation leads to a modification of the energy threshold of particle decays, which allows for hadronic interactions of neutral pions that contribute to the growth of the hadronic cascade. As a consequence, an increase in the number of muons and a decrease in their intrinsic fluctuations are expected. In this contribution, limits on LIV parameters have been derived and presented considering the muon fluctuation measurements from the Pierre Auger Observatory.

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