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Are Cosmic Rays still a valuable probe of Lorentz Invariance Violations in the Auger era?

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In the last years a general consensus has emerged that ultra-high energy cosmic ray (UHECR) data can serve as a powerful probe of the validity of special relativity. This applies in particular to the propagation of cosmic rays from their sources to Earth through diffuse extragalactic background radiation, which is responsible for energy suppressions due to pion photoproduction by UHE protons (the Greisen-Zatsepin-Kuzmin limit) and photodisintegration of UHE nuclei (the Gerasimova-Rozental' limit). A suppression in the flux of UHECRs at energies above 40 EeV – as expected from these interactions – has been established experimentally beyond any doubt by current experiments. However, such an observation is still not conclusive on the origin of the suppression. In particular, data from the Pierre Auger Observatory can be interpreted in a scenario in which the suppression is due to the maximum acceleration energy at the sources rather than to interactions in the background radiation. In this scenario, UHECR data can no longer yield bounds on Lorentz invariance violations which increase the thresholds for interactions of nuclei on background photons, in particular through modification of the dispersion relations. Here we argue in turn that the study of UHECRs still represents a unique opportunity to test Lorentz invariance, by discussing the possibility of deriving limits on violation parameters from UHECR phenomena other than propagation. In particular we study the modifications of the shower development in the atmosphere due to the possible inhibition of the decay of unstable particles, especially neutral pions.

Collaboration

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