Contribution ID: **58** Type: **Poster**

Ultra high energy cosmic rays in large-scale astrophysical structures: neutron production and implications for cosmic ray confinement and escape

Tuesday, January 28, 2025 4:40 PM (1h 20m)

Cosmic rays are often modeled as charged particles. This allows their non-ballistic propagation in magnetized structures to be captured. In certain situations, a neutral cosmic ray component can arise. For example, cosmic ray neutrons are produced in considerable numbers through hadronic pp and p-gamma interactions. At ultrahigh energies, the decay timescales of these neutrons is dilated, allowing them to traverse distances on the scale of galactic and cosmological structures. Unlike charged cosmic rays, neutrons are not deflected by magnetic fields. They propagate ballistically at the speed of light in straight lines. The presence of a neutral baryonic cosmic ray component formed in galaxies, clusters and cosmological filaments can facilitate the escape and leakage of cosmic rays from magnetic structures that would otherwise confine them. We show that, by allowing confinement breaking, the formation of cosmic-ray neutrons by high-energy hadronic interactions in large scale astrophysical structures can modify the exchange of ultra high-energy particles across magnetic interfaces between galaxies, clusters, cosmological filaments and voids.

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Session Classification: Poster Presentation