



Contribution ID: 1075

Type: **Parallel session talk**

Ultra-high-energy cosmic rays from star-forming galaxies constrain the extragalactic magnetic field

Monday 26 July 2021 16:50 (15 minutes)

The Pierre Auger Observatory (PAO) has recently detected significant correlations between the arrival directions of ultra-high-energy cosmic rays (UHECRs) and positions in the sky of local star-forming galaxies. We interpret these results in terms of the local density of sources and the magnetic fields governing the UHECR propagation [1]. We determine the level of UHECR deflections for an ensemble of sources in a random extragalactic magnetic field description as well as a Galactic magnetic field model. In addition, we take into account energy losses with background photon fields as well as spectrum and composition measurements by the PAO. We find that the PAO anisotropy measurement is consistent with large extragalactic magnetic field strengths ($B > 0.6$ nG for a coherence length of 1 Mpc at the 5σ confidence level) in the case of a local density of star-forming galaxies. Larger source densities, on the other hand, allow for weaker extragalactic magnetic fields. However, the acceleration of UHECRs by such abundant sources is more challenging to motivate. Too large source densities and extragalactic magnetic field strengths decrease the expected level of anisotropy and are, therefore, disfavoured as well. This translates to upper limits of $B < 24$ nG and $\rho_0 < 9.0 \cdot 10^{-2} \text{ Mpc}^{-3}$ at the 90% confidence level.

[1] A. van Vliet, A. Palladino, A. Taylor and W. Winter, arXiv:2104.05732.

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Session Classification: T01: Astroparticle and Gravitational Waves

Track Classification: Astroparticle and Gravitational Waves