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Constraints on extragalactic magnetic fields from ultra-high-energy cosmic rays

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Ultra-high-energy cosmic rays (UHECRs) get deflected by extragalactic magnetic fields (EGMFs) when they propagate from their sources to Earth. The spread of UHECRs around their original source position provides a measure for the strength of the EGMFs in between the UHECR sources and Earth. Furthermore, the density of UHECR sources plays an essential role in determining the relative contribution from nearby sources compared with the isotropic background. In Ref. [1], we investigated which combinations of magnetic-field strengths and source densities can explain the correlations between star-forming galaxies and UHECR directions observed by the Pierre Auger Collaboration. We found that, if UHECRs are predominantly produced by star-forming galaxies, relatively strong EGMFs ($B > 0.2$ nG for a coherence length of 1 Mpc at the 5σ confidence level) between the UHECR sources and the Milky Way are necessary to explain the observed correlations. Weaker EGMFs are allowed if UHECRs are predominantly produced in sources with an even larger source density than star-forming galaxies. These findings will be improved and extended upon in Ref. [2], which will include a more direct comparison with publicly-available UHECR arrival-direction data of the Pierre Auger Collaboration.

[1] Van Vliet A., Palladino A., Taylor A. M. and Winter W., 2021, MNRAS, 510, 1289.
[2] AL-Zetoun A., Taylor A. M., Winter W. and Van Vliet A., 2024, in preparation.

Primary authors: Dr AL-ZETOUN, Ala'a (Khalifa University); Dr TAYLOR, Andrew (DESY); WINTER, Walter (DESY); VAN VLIET, Arjen (Khalifa University)

Presenter: VAN VLIET, Arjen (Khalifa University)