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Constraints on the extragalactic magnetic field from UHECR arrival directions

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The expected level of correlations between the position in the sky of the sources of ultra-high-energy cosmic rays (UHECRs) and their actual arrival directions at Earth depends on the strength of the magnetic fields governing their propagation and the density of the sources. We investigate which combinations of magnetic-field setups and source densities can explain the recently observed correlations between star-forming galaxies and UHECR directions. We do this by scanning over the strength and coherence length of the extragalactic magnetic field (EGMF) and over the source density, for a fixed Galactic magnetic field (GMF) model and UHECR spectrum and composition assumptions that fit the measured data of the Pierre Auger Observatory (PAO). Under the assumption that UHECRs are predominantly produced by star-forming galaxies, we find that rather 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. If UHECRs are predominantly produced in sources with an even larger source density than star-forming galaxies, weaker EGMFs are allowed. However, this would mean that UHECRs are accelerated in relatively regular galaxies, which is hard to motivate. Too strong EGMFs, on the other hand, are also disfavoured, leading to an overall upper limit of $B < 22$ nG for a coherence length of 1 Mpc at the 90\% confidence level.

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