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Large and intermediate scale anisotropies of ultra-high-energy cosmic rays with the Pierre Auger Observatory

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The origin of ultra-high-energy cosmic rays (UHECRs) remains one of the most compelling open questions in astroparticle physics. The Pierre Auger Observatory, the world's largest facility for cosmic ray detection, has provided unprecedented data to investigate anisotropies in UHECR arrival directions. At large angular scales, a significant dipolar modulation in right ascension has been observed above 8 EeV, reaching a 6.9σ significance and pointing away from the Galactic Center, strongly supporting an extragalactic origin. At intermediate angular scales, a blind search analysis revealed a localised excess around the Centaurus region within a 27° search window radius. Additionally, a likelihood-based analysis framework has identified correlations between events above 32 EeV and several astrophysical source catalogs. The most significant result corresponds to starburst galaxies, showing a correlation at approximately 3.8σ significance. Similarly, a complementary approach has recently focused on the UHECRs flux along the supergalactic plane, which traces the large-scale distribution of matter in the local Universe. The most significant indication, with a post-trial significance of 3.1σ , is again found in the direction of the Centaurus region, extending previous findings to lower energies. No other significant excesses were observed along other regions of the supergalactic plane, where the data are consistent with isotropy.

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