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Sensitivity of Auger and JEM-EUSO to Ensemble Fluctuations in the Ultra-High Energy Cosmic Ray Flux

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The flux and nuclear composition of ultra-high energy cosmic rays depend on the cosmic distribution of their sources. Data from cosmic ray observatories are yet inconclusive about their exact location or distribution, but provide a measure for the average local density of these emitters. Due to the discreteness of the emitters the flux and nuclear composition is expected to show ensemble fluctuations on top of the statistical variations, i.e. "cosmic variance." This effect is strongest for the most energetic cosmic rays due to the limited propagation distance in the cosmic radiation background and is hence a local phenomenon. For the statistical analysis of cosmic ray emission models it is important to quantify the possible level of this variance. In this work we study the sensitivity of the Pierre Auger Observatory and the JEM-EUSO space mission to ensemble fluctuations on the assumption of uniform distribution of sources, with local source density $\sim 10^{-5}$ Mpc^{-3}. We show that if the Auger experimental performance is in line with design expectations, then after 15 years of data collection (i.e. by 2020) the experiment will attain sensitivity to observe spectral fluctuations in the cosmic ray energy spectrum at Earth relative to the overall power-law fit if the nearest source(s) are at 3 Mpc. We also show that with data taken until 2025 the Auger experiment will become sensitive to ensemble fluctuations if the nearest sources are 10 Mpc away. Finally, we demonstrate that in only one year of observation JEM-EUSO will be able to probe ensemble fluctuations if the nearest sources are at 3 Mpc, and that after 3 years orbiting the Earth this pathfinder mission will become sensitive to ensemble fluctuations if the nearest sources are 10 Mpc away. The study of spectral fluctuations from the local source distributions are complementary but independent of on-going cosmic ray anisotropy studies.

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