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Fundamental problems in the field of UHE extragalactic particles

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Three fundamental problems in the field of UHE astrophysical particles are reviewed.
UHE particles are observed at energies higher than 1×10^{20}eV, with 3×10^{20}eV as the highest energy. In principle, in cosmology there are the reliable mechanisms of particle production with energies much higher than 10^{20}eV (e.g. Topological Defects or Super Heavy Dark Matter), but this production most probably cannot explain the observational data. It is widely argued nowadays that traditional acceleration, e.g. acceleration by relativistic shocks, cannot provide the observed highest energies.
The other fundamental problem is propagation of protons and nuclei in extragalactic space. This problem is studied thoroughly theoretically with prediction of spectral features, dip and GZK cutoff, for protons, which are observed in data of HiRes and Telescope Array, but contradict to mass composition measured by of Auger.
The third fundamental problem is cosmogenic neutrinos, produced by interaction of UHE protons and nuclei with background radiation CMB and EBL. Neutrinos detected by IceCube in 2010 - 2012 do not correspond to standard predictions, and detection of cosmogenic neutrinos probably expects the future space detector JEM-EUSO.

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