Ultra high energy particles in the universe

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Particles near 10^{20} eV are the most energetic particles known to us in the universe, also called ultra high energy cosmic rays. Their observations have led us to build the largest detector systems in the world, in the South the Auger air-shower array, and in the North the Telescope Array. With these and earlier arrays events have been detected of an energy up to $3 \, 10^{20}$ eV, which is a macroscopic energy. There have been two predictions: one that due to interaction with the microwave background the spectrum should show a turnoff near $5 \, 10^{19}$ eV (1966); this has been confirmed by two experiments, HiRes and Auger (2007, 2008). Second, that active galactic nuclei, probably radio galaxies, should be the accelerators, based on the non-thermal optical spectra of knots and hot spots in radio galaxies (1987); this is now tentatively confirmed by Auger (2007, 2008), but contradicted by HiRes (2008). I will go through some fundamental problems with the predictions, which teach us about active galactic nuclei. Apart from differentiating various remaining options, such as gamma ray bursts, how to generate these particles, and their source population, there is one major difficulty: the lack of understanding of the cosmological web of magnetic fields, which may influence the propagation of high energy particles; here it is especially important to understand the role of our local cosmic neighborhood and a possible galactic magnetic wind. I propose, that magnetic scattering leads to a steep distribution function of scattering angles of the deviation from a straight line path for the arriving particles. I will discuss the observational and theoretical limits for an exemplary set of models, the predictions like chemical abundances, that result from these models, and how present and future observations will test our conclusions, especially with the Telescope Array (TA), the Auger Array, the neutrino observatory IceCube, the TeV Cherenkov γ-ray telescopes, and the future space observatory EUSO. We face a number of exciting challenges for particle physics, cosmology, astronomy, and our deep understanding of matter.