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Ultra-high-energy Cosmic Rays: Recent Results and Future Plans FRANK SCHROEDER, University of Delaware — The origin of ultra-high-energy cosmic rays remains one of the big questions of astroparticle physics. Too rare for direct measurements in space, these cosmic rays are observed indirectly by particle cascades they induce when impinging the atmosphere. Modern ground-based experiments, such as the Pierre Auger Observatory and the Telescope Array, combine several detection techniques for these air showers, in particular, arrays of particle detectors and fluorescence telescopes. Recently, several arrays, such as IceTop and Auger, are also adding radio antennas to further increase the measurement accuracy. Moreover, balloon and space missions have the potential to provide unprecedented statistics at the highest energies. With recent observations of the cosmic-ray energy spectrum, mass composition, and a weak anisotropy in their arrival directions, we were able to restrict scenarios for their origin. Galactic cosmic rays seem to reach energies up to around 10^{18} eV and extragalactic sources beyond 10^{20} eV. Further progress requires, on the one hand, higher statistics and measurement accuracy for cosmic-ray protons and nuclei, and, on the other hand, multi-messenger techniques aiming for a direct discovery of cosmic-ray sources by photons and neutrinos.

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