

Cosmic Rays and Magnetic Fields: Their Properties and Impact

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Cosmic rays, which consist primarily of high-energy protons and atomic nuclei, are among the most energetic events in the universe. They are emitted from their sources like supernova remnants, active galactic nuclei, and potentially gamma-ray bursts and travel enormous interstellar distances before arriving on Earth. Their interaction with the galactic and interplanetary magnetic fields is important in determining their propagation, energy spectrum, and arrival directions. Magnetic fields are both barriers and guides and deflect cosmic rays by diffusion as well as trap them at times in magnetized areas. This interaction is not only responsible for affecting cosmic ray transport but also energy deposition within planetary atmospheres and radiation environments within space. At Earth, geomagnetic fields form a protective shield that deflects low-energy particles and minimizes detrimental biological effects. In astrophysical environments, cosmic rays and magnetic fields both govern star formation, fuel interstellar medium turbulence, and play roles in large-scale galactic dynamics. Their interplay is therefore crucial to making headway in space weather forecasting, deep-space exploration, and astrophysical modeling of high-energy phenomena.