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Cosmic rays beyond the boundary of the heliosphere

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In August of 2012 the Voyager 1 space probe has left the solar-wind bubble of ionized gas we call the heliosphere and entered the denser and colder environment of the interstellar cloud surrounding the solar system. Energetic charged particles underwent dramatic changes past the heliopause: the heliospheric ions disappeared completely, while the galactic cosmic rays were for the first time measured in their unmodulated state. The interstellar medium is almost entirely devoid of turbulent magnetic fluctuations, and the transport of cosmic rays is governed by a large-scale geometry of the magnetic field. We discuss observations of heliospheric ions, including anomalous cosmic rays, near the heliopause transition, and propose interpretations of the measured intensities and pitch-angle distributions based on gradient drift in a weakly nonuniform magnetic field. The heliopause transition appears to be permeated by magnetic flux tubes connected to the interstellar space and facilitating particle escape. The two Flux tube crossings by the spacecraft allowed an indirect measurement of the plasma radial velocity near the heliopause. We also discuss galactic cosmic ray transport properties and their anisotropies in the outer heliosheath.

Collaboration

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