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The Dzhanibekov Effect and Acceleration of Highest-Energy Cosmic Rays in Magnetars

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Magnetars, highly magnetized neutron stars, exhibit transient bursting activities and might accelerate ultrahigh-energy cosmic rays (CRs). Due to their strong magnetic fields, a magnetar can be deformed into a triaxial shape, leading to unstable free precession where one of the principal axes flips, a phenomenon known as the Dzhanibekov effect.
This phenomenon induces a sudden increase in the Euler force, disturbing the surface layer and potentially causing plastic flow and fractures. Such deformations may trigger a magnetar burst. If degenerate electrons are released from fractured regions, they could ignite pair plasma formation, producing photons similar to observed magnetar bursts.

The initial electron stream may also generate a strong electric field, briefly accelerating ions to ~1 ZeV. Nuclear spallation reactions limit this process, predicting high-energy CR neutrons correlated with magnetar bursts. Furthermore, the spallation of ~ZeV nuclei may explain ~10 PeV neutrino events observed by IceCube and KM3Net. These findings highlight the Dzhanibekov effect's possible role in magnetar transients and its potential link to cosmic-ray and neutrino observations.

Section

High Energy

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