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Newborn pulsars as ultrahigh energy cosmic accelerators

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Neutron stars are among the few possible astrophysical sources that can confine ultrahigh energy cosmic rays. Meanwhile, they offer plausible sites for heavy nuclei injection. The heavy nuclei can be accelerated to ultrahigh energy by the wind of a fast-spinning newborn pulsar. They then traverse the expanding supernova ejecta surrounding the star. We found that the escape process softens the injected cosmic ray spectrum, and produces a series of interaction products which display a transition from light to heavy in the chemical composition, explaining the feature seen by the Auger Observatory. In addition, we show that by assuming proper injection composition, the integrated cosmic ray flux from the pulsar population can fit both the observed energy spectrum and Xmax, RMS-Xmax measurements. As a counterpart, the Galactic pulsars can contribute significantly to high energy cosmic rays between 10**16 and 10**18 eV. This contribution can bridge the gap between predictions of cosmic rays produced by other Galactic sources, e.g., supernova remnants and the observed spectrum and composition just below the ankle. As a smoking gun of the pulsar sources, high energy neutrinos produced in the source region have a unique spectrum distinctive from cosmogenic neutrinos. We show that detectability of these neutrinos are consistent with current detection upper limits and may be seen by another 4-year of IceCube operation.

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