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A search for neutron fluxes from Galactic candidate sources using data from the Pierre Auger Observatory

Since neutral particles are not deflected by magnetic fields, they are a valuable tool for studying the sources of ultra-high-energy cosmic rays (UHECRs). It is expected that sources of UHECRs will also produce neutrons through nuclear interactions and photo-pion production near the source. Free neutrons undergo beta decay, traveling a typical distance of $9.2 \times (E/1\,\mathrm{EeV})$ kpc. As a result, neutron fluxes in the EeV energy range could potentially be detected from Galactic sources of UHECRs. Using data from the Surface Detector of the Pierre Auger Observatory, the world's largest cosmic ray detector, we search for neutron fluxes from candidate Galactic sources. Since it is not possible to distinguish between air showers caused by protons or neutrons, we would identify neutron fluxes as excess of cosmic ray events around the direction of a candidate source. We compare the observed signal to the expected background contribution to search for such excesses. Our candidate sources include different classes of astrophysical objects, such as pulsars, microquasars, magnetars, and selected γ-ray sources identified by LHAASO. We also consider two single-element target sets: the Galactic center and the Crab Nebula. We analyze observed cosmic ray events with declination between -90° and $+45^\circ$ and energy starting from 0.1 EeV. While we do not detect any significant excess of events indicating a neutron flux from these candidate sources, we establish upper limits for the neutron fluxes.

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