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Semi-relativistic hypernova as sources of PeV neutrinos

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We argue that the excess of sub-PeV/PeV neutrinos recently reported by IceCube could plausibly originate through pion-production processes in the same sources responsible for cosmic rays (CRs) with energy above the second knee around 10^{18}eV. The pion production efficiency for escaping CRs that produce PeV neutrinos is required to be >0.1 in such sources. On the basis of current data, we identify semi-relativistic hypernova remnants as possible sources that satisfy the requirements. By virtue of their fast ejecta, such objects can accelerate protons to EeV energies, which in turn can interact with the dense surrounding medium during propagation in their host galaxies to produce sufficient high-energy neutrinos via proton–proton (pp) collisions. Their accompanying gamma ray flux can remain below the diffuse isotropic gamma ray background observed by the Fermi Large Area Telescope (LAT). In order to test this scenario and discriminate from alternatives, the density of target protons/nuclei and the residence time of CRs in the interacting region are crucial uncertainties that need to be clarified. As long as the neutrinos and EeV CRs originate from the same source class, detection of >~10PeV neutrinos may be expected within 5-10 years' operation of IceCube. Together with further observations in the PeV range, the neutrinos can help in revealing the currently unknown sources of EeV CRs.

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