PeV-EeV Neutrinos From γ-Ray Blazars Due To Ultra-High-Energy Cosmic-Ray Propagation

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The IceCube neutrino observatory in Antarctica has established the existence of a diffuse flux of astrophysical neutrinos (from $\sim$ 10 TeV to a few PeV). The isotropic nature of the flux indicates the candidate sources to be of extragalactic origin. A general correlation between the sources of high-energy γ-ray sources with IceCube neutrinos is expected since hadronic interactions are the crucial precursors of both messengers at such high energies. Blazars dominate the extragalactic γ-ray sky. Cosmic rays accelerated in the jet are not cooled efficiently and can escape the source. They can also undergo pion production interactions inside the jet emission region with photons from synchrotron or IC spectrum, producing high-energy neutrinos. However, neutrinos originating from inside the blazar jets cannot account for more than $\sim$ 30% of the diffuse flux. We study ultrahigh-energy cosmic-ray contribution to the diffuse flux through photopion interactions on cosmic background photons. The extragalactic background light, consisting of IR/UV/optical photons require a proton energy threshold of $E_{\rm th}^{p,\pi} \approx 10^{17}$ eV for pion production. The latter can yield PeV neutrinos. We analyze the total contribution from resolved and unresolved blazars by using a luminosity-dependent density evolution of blazars, and find $\approx$ 10% of the diffuse flux upper limit at 6 PeV can be explained by this process. By including the unresolved sources, the neutrino flux increases by a factor of two at a few PeV. The latest Fermi-LAT 4LAC catalog sheds light on the redshift distribution of the diffuse neutrino flux for resolved γ-ray blazars.

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