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Implications of the KM3NeT Ultrahigh-energy Event on Neutrino Self-interactions

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Neutrino self-interactions (νSI) mediated by light bosonic particles can produce characteristic spectral dips in astrophysical neutrino fluxes, thereby modifying the expected energy spectrum. The high-energy astrophysical neutrino spectrum has been extensively used to probe νSI models through these distinctive features. The recent detection of the ultrahigh-energy event KM3-230213A offers a new opportunity to explore νSI phenomenology at extreme energies. In this work, we investigate two implications of this observation under the assumption that the event originates from a diffuse power-law spectrum. First, we find that νSI induces spectral distortions that can mildly alleviate tensions between the KM3-230213A detection and the previous non-observation of PeV-scale neutrinos in IceCube data. Second, we derive new constraints on the νSI coupling strength for mediator masses around 100 MeV. Our analysis shows that neutrino telescopes can surpass existing collider constraints in this mass range. In the near future, IceCube-Gen2 is expected to substantially enhance the sensitivity to νSI over a broader range of parameter space.

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