TeV Particle Astrophysics
TeVPA 2022
August 8-12
Queen's University
Kingston, ON

Contribution ID: **17** Type: **Parallel Talk**

Point sources of ultra-high-energy neutrinos: minimalist predictions for near-future discovery

Tuesday 9 August 2022 14:40 (20 minutes)

The detection of ultra-high-energy neutrinos, with energies above 100 PeV, is requisite to fully understand the high-energy Universe. Their discovery might soon be within reach of upcoming neutrino telescopes, yet in-depth discovery forecasts for their astrophysical sources are largely unavailable. We present a robust framework to compute the statistical significance of source discovery via the detection of neutrino multiplets, i.e., neutrinos clustered around a position in the sky. Our methods are experiment-based—i.e., independent of flux predictions—conservative—i.e., they adopt the maximum allowed background of diffuse neutrinos—and comprehensive—i.e., they account for non-neutrino backgrounds, neutrino attenuation inside the Earth, and the angular response of the detector. We focus on neutrino radio-detection in IceCube-Gen2, via state-of-the-art simulation. To discover a source with 5σ significance, IceCube-Gen2 will need to detect a triplet, at best, and an octuplet, at worst, depending on whether the source is steady-state or transient, and on its position in the sky. The number of discovered sources carries significant information on the properties of the source population, and the discovery of a neutrino multiplet can trigger searches for electromagnetic sources. Our framework is easy to implement and adaptable to other upcoming neutrino telescopes.

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Session Classification: Neutrinos

Track Classification: Extragalactic Sources