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Neutrino Mass from Cosmology: Beyond Two-Point Clustering

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Determining the absolute mass of neutrinos remains a major challenge in cosmology and particle physics. Recent DESI DR1/DR2 results suggest potential deviations from the standard ΛCDM model and indicate that conventional two-point statistics may be insufficient to robustly detect Mν –sparking controversial hints of a negative neutrino mass. To overcome these limitations, we introduce robust, alternative higher-order clustering approaches grounded in cosmic-web analysis based on critical points and persistent homology. These methods capture complex clustering patterns in large-scale surveys and can reveal subtle neutrino signatures missed by traditional two-point analyses. Supported by advanced cosmological simulations, our techniques show great potential in enhancing sensitivity to neutrino effects on the cosmic web. Our methods are particularly relevant for ongoing and upcoming large-volume redshift surveys, including DESI, Euclid, and Rubin-LSST, providing new pathways to directly detect the mass of neutrinos or place reliable and competitive constraints on their total mass and hierarchy.

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