

Whispers from the Dark Universe - Particles & Fields in the Gravitational Wave Era

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WHISPERS FROM THE DARK UNIVERSE – PARTICLES & FIELDS IN THE GRAVITATIONAL WAVE ERA

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Cosmic Last Scattering as an Axion Dark Matter Detector

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Isotropic Birefringence —all-sky rotation of linear polarization —of the cosmic microwave background (CMB) can be sourced by axion-like particle dark matter. We predict distinct signals from oscillating ultra-light axion dark matter present at recombination as well as locally. Using Planck CMB upper limits while incorporating allowed axion fractions of dark matter, we find strong constraints on the axion-photon coupling which can improve over CAST limits by up to 5 and 2 orders, respectively, for recombination and local dark matter axions. Forecast constraints (Simons Observatory, LiteBIRD, CMB-S4, & CMB-HD) tighten further by 1-2 orders, extending to higher axion mass.

Improving hints of a detection (currently at $\sim 3\sigma$) of isotropic CMB birefringence from a re-analysis of Planck and WMAP data are considered, in light of our new axion birefringence signals. Certain regions of coupling-mass parameter space for ultra-light axion dark matter could explain this detection, if confirmed. We also present constraints from searches in the Planck data for time-oscillation of the birefringence.

CMB birefringence constraints scale only weakly with ultra-light axion fraction of dark matter. They remain unaffected by uncertainties common in other astrophysical axion probes: strength and spectrum of magnetic fields, assumed over-density of ALPs in structures and the source's intrinsic polarization orientation.

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