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Probe exotic energy injection from dark sectors through cosmic reionization

Axions and primordial black holes (PBHs) are well-motivated dark matter candidates that can inject energy into the intergalactic medium (IGM) via decay or evaporation over cosmic history, leaving imprints on the cosmic microwave background (CMB). In recent work, we have derived a model-independent ionization history after recombination from CMB power spectra using a Gaussian process approach, allowing new physics to be constrained directly from the high-redshift optical depth. Applying this framework, we investigate the decay of multi-string axions and place the first constraints on the corresponding geometrical parameter space. We also compute the redshift-dependent energy injection from Hawking evaporation using BlackHawk, we obtain upper limits on the initial PBH abundance that are robust against reionization modeling uncertainties and systematically more conservative than existing bounds. Our results demonstrate the power of reionization observables as a precise probe of PBH evaporation and other late-time energy-injection scenarios.

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