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Amplifying CMB phase shift with dark matter-radiation interactions

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The peaks of the CMB spectra provide a direct cosmological probe for studying dark sector physics. Specifically, a shift in the peak positions corresponds to a phase shift in the acoustic oscillations of the photon-baryon plasma before recombination, which is sensitive to the propagation behavior of non-photon radiation. It has been established that CMB spectra shift to higher l-modes if the non-photon radiation is self-interacting rather than free-streaming. In this talk, I will show that this phase shift can be further amplified if the non-photon radiation, which includes neutrinos or dark radiation, interacts with dark matter. Using neutrino-dark matter scattering as an example, we numerically calculate the amplified phase shift and offer an analytical interpretation of the result by modelling photon and neutrino perturbations with coupled harmonic oscillators. When the energy density of the interacting radiation exceeds that of the interacting dark matter at matter radiation equality, we find that the phase shift enhancement is proportional to the interacting dark matter abundance but rather insensitive to the abundance of interacting radiation. This additional phase shift emerges as a generic signature of models featuring neutrino-dark matter scattering, or a dark sector with dark matter-radiation interaction.

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