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Imprints on the CMB angular power spectrum from relativistic species that decouple late

The phase shift in the acoustic peaks in the angular power spectrum of CMB temperature and polarization anisotropy plays an important role as a probe of the nature of contribution to Neff. It can determine whether the extra species are free-streaming particles, like neutrinos, or tightly-coupled, like the photons, during eras probed by the CMB. On the other hand, some extensions of the standard model produce new relativistic particles that decouple from the primordial cosmic plasma after neutrinos, but prior to photons. We study the signature of new relativistic species that decouple during this intermediate epoch. We shall argue that a new type of phase shift occurs in the acoustic peaks, different from the usual constant phase shift on small scales. For intermediate decoupling times, the shape and amplitude of the phase shift depends not only ΔNeff but the redshift(zdec) at which the new species decoupled. One of the applications of this theoretical study is to predict the effect that the new relativistic entities from new BSM models, e.g. Nnaturalness, have on CMB power spectrum in terms of phase shift of acoustic peaks.

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