

# Cosmic Millicharge Background and Reheating Probes

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We demonstrate that the searches for dark sector particles can provide probes of reheating scenarios, focusing on the cosmic millicharge background produced in the early universe. We discuss two types of millicharge particles (mCPs): either with, or without, an accompanying dark photon. These two types of mCPs have distinct theoretical motivations and cosmological signatures. We discuss constraints from the overproduction and mCP-baryon interactions of the mCP without an accompanying dark photon, with different reheating temperatures. We also consider the  $\Delta N_{\text{eff}}$  constraints on the mCPs from kinetic mixing, varying the reheating temperature. The regions of interest in which the accelerator and other experiments can probe the reheating scenarios are identified in this paper for both scenarios. These probes can potentially allow us to set an upper bound on the reheating temperature down to  $\sim 10$  MeV, much lower than the previously considered upper bound from inflationary cosmology at around  $\sim 10^{16}$  GeV. In addition, we derive a new “distinguishability condition”, in which the two mCP scenarios may be differentiated by combining cosmological and theoretical considerations.

Finally, we discuss the implications of dedicated mCP searches and future CMB-S4 observations.

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