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Neff constraint on portal interaction with hidden sectors

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Measurement of the effective number of neutrino species, $N_{\rm eff}$, by future cosmic microwave background (CMB) experiments is expected to be sensitive enough to rule out new relativistic particles that were in equilibrium with the Standard model (SM) plasma, if the measured $N_{\rm eff}$ value is consistent with the SM value of 3.044. Consequently, the interaction between the new relativistic particles and SM particles will then be strongly constrained. For a given confidence interval around the SM $N_{\rm eff}$ value, we show a straightforward way to compute the $N_{\rm eff}$ constraints on renormalizeable portal interactions between the new relativistic particles and the SM particles. These $N_{\rm eff}$ constraints can be orders of magnitude larger than collider constraints for future CMB measurements. We demonstrate our result on a model with gauged $B - L$ symmetry with right-handed neutrinos and a model with millicharged particles and dark photon as examples. We also show that CMB-S4 $N_{\rm eff}$ measurements have the potential to rule out extended millicharged particle models that resolve the EDGES 21 cm anomaly. Finally, we find that $N_{\rm eff}$ constraints on renormalizeable portal couplings remain largely unchanged even if the new relativistic particles are part of a larger hidden sector.

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