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Contributions to $N_{\rm eff}$ from freeze-in production of light relics

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Light relics produced by freeze-in, while more dependent on both the specific BSM physics scenario and the reheating temperature than freeze-out, are generic for models in which the light relic couples to the SM plasma more weakly than necessary for full thermalization. In particular, rates for light relic production associated with non-renormalizable interactions typical of BSM scenarios can grow with temperature more quickly than the Hubble rate. Thus, for couplings smaller than those probed in freeze-out production, current and next generation CMB experiments can be sensitive to contributions to the effective number of neutrino species, $N_{\rm eff}$, associated with light relics produced by freeze-in. We investigate several representative BSM scenarios, for which we calculate contributions to $N_{\rm eff}$ in corners of parameter space not previously considered and discuss the sensitivity of CMB experiments.

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