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The Irreducible Axion Background

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Searches for dark matter decaying into photons constrain its lifetime to be many orders of magnitude larger than the age of the Universe. A corollary statement is that the abundance of any particle that can decay into photons over cosmological timescales is constrained to be much smaller than the cold dark-matter density. We show that an irreducible freeze-in contribution to the relic density of axions is in violation of that statement in a large portion of the parameter space. This allows us to set stringent constraints on axions in the mass range 100 eV – 100 MeV. At 10 keV our constraint on a photophilic axion is almost three orders of magnitude stronger than the bounds established using horizontal branch stars; at 100 keV our constraint on a photophobic axion coupled to electrons is almost four orders of magnitude stronger than present results. Although we focus on axions, our argument is more general and can be extended to, for instance, sterile neutrinos.

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