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Constraints on Axions from Cosmic Distance Measurements

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Axion couplings to photons could induce photon-axion conversion in the presence of magnetic fields in the Universe. This conversion could impact various cosmic distance measurements, such as luminosity distances to type Ia supernovae and angular distances to galaxy clusters, in different ways. In this paper we consider different combinations of the most up-to-date distance measurements to constrain the axion-photon coupling. Employing the conservative cell magnetic field model for the magnetic fields in the intergalactic medium (IGM) and ignoring the conversion in the intracluster medium (ICM), we find the upper bounds on axion-photon couplings to be around 5×10^{-12} (nG/B) $\sqrt{\mathrm{Mpc}/s}$ GeV^{-1} for axion masses m_a below 10^{-13} eV, where B is the strength of the IGM magnetic field, and s is the comoving size of the magnetic domains. When including the conversion in the ICM, the upper bound is lowered and could reach 5×10^{-13} GeV^{-1} for $m_a < 5 \times 10^{-12}$ eV. While this stronger bound depends on the ICM modeling, it is independent of the strength of the IGM magnetic field, for which there is no direct evidence yet. These constraints could be placed on firmer footing with an enhanced understanding and control of the astrophysical uncertainties associated with the IGM and ICM. All the bounds are determined by the shape of the Hubble rate as a function of redshift reconstructable from various distance measurements, and insensitive to today's Hubble rate, of which there is a tension between early and late cosmological measurements.

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