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Photon-Axion mixing as a cosmic magnetometer

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Abstract :

Axion-like particles (ALPs) are a candidate component of dark matter and are ubiquitous in both high-energy theories and in extensions of the standard model. Additionally, ALPs exhibit the ability to mix with photons in the presence of an electromagnetic field which makes them also interesting for astrophysical studies.In this work we calculate the probability of the ALP-photon transition for a variety of astrophysical cases and we derive the main physical characteristics of the magnetic field in cosmic structures showing ALP-photon mixing. Importantly these interactions give rise to characteristic energies, where photons entering the magnetic field with these particular energies leave as photons only. We discuss the possibility of using such characteristic energies as probes of cosmic structure and of using ALP-photon spectra to constrain both the ALP particle properties as well as those of the host magnetic field. We make specific reference to propagation in an intra-cluster magnetic field and in the inter-galactic magnetic field by using the emission of powerful active galactic nuclei (AGNs): the radio-galaxy NGC1275 at the centre of the Perseus cluster and the distant blazar PKS1830-210 at z=2.507. Using the available Fermi-LAT observations for these two sources we show that the available data on the spectral energy distribution of NGC1275 can set stronger constraints on the intra-cluster magnetic field parameters in Perseus cluster in the region $B < 1$ μG and $d < 10$ kpc than those attained from previous Faraday rotation studies (for ALP-photon couplings close to the CAST limit). The limits obtained on the inter-galactic magnetic field from the spectrum of PKS1830-210 are similarly more constraining in the region $B < 10^{-3}$ μG and $d < 1$ Mpc for similar couplings.We finally stress that the ALP-photon mixing process also has the to potential imprint information about the structure of cosmic magnetic fields upon the ALP induced polarisation spectrum of photons passing through the field. This property is also shown to survive in realistic turbulence models and to gain the power to align polarisations towards a characteristic configuration in such cases.

Award :

Yes

Level :

PhD

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Paper :

No

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