10th International Conference on Gravitation and Cosmology: New Horizons and Singularities in Gravity (ICGC 2023)



Contribution ID: 242

Type: Poster

Axion dark matter and helical electromagnetic fields

Primordial electromagnetic fields can strongly affect the cosmic evolution of axions and vice versa. We show that if helical electromagnetic fields are coherently produced in the early universe, their remnants source a field velocity to the coupled axions and enhance the relic abundance of axion dark matter. We discuss the implications for the QCD axion and axion-like particles that are coupled to the SM or hidden gauge groups. For a QCD axion coupled to hidden photons, we find that the conventional window for the axion decay constant $10^8 \, {\rm GeV}$

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 $lesssim 10^{12}\,{\rm GeV}$ can be completely closed due to overproduction of axion dark matter by helical electromagnetic fields as little as $\alpha\,\Delta N_{\rm eff}$

 $gtrsim10^{-12}$, where α is the gauge coupling and $\Delta N_{\rm eff}$ is the effective extra relativistic degrees of freedom of the hidden photons.

Email

rajeev.jain.k@gmail.com

Affiliation

Dept. of Physics, IISc Bangalore

Author: Dr JAIN, Rajeev Kumar

Presenter: Dr JAIN, Rajeev Kumar

Session Classification: Cosmology

Track Classification: Cosmology