ID de la contribución : **290** Tipo : **Talk**

Time-delayed gamma-ray signatures of heavy axions from core-collapse supernovae

jueves, 6 de noviembre de 2025 15:15 (15)

Heavy axions that couple to both quantum electrodynamics and quantum chromodynamics with masses on the order of MeV–GeV and high-scale decay constants in excess of 10^8 GeV may arise generically in, e.g., axiverse constructions. In this work we provide the most sensitive search to date for the existence of such heavy axions using Fermi-LAT data toward four recent supernovae (SN): Cassiopea A, SN1987A, SN2023ixf, and SN2024ggi. We account for heavy axion production in the proto-neutron-star cores through nuclear and electromagnetic processes and then the subsequent decay of the axions into photons. While previous works have searched for gamma rays from SN1987A using the Solar Maximum Mission that observed SN1987A during the SN itself, we show that using Fermi Large Area Telescope data provides an approximately 5 orders of magnitude improvement in flux sensitivity for axions with lifetimes larger than around 10 yrs. We find no evidence for heavy axions and exclude large regions of previously unexplored parameter space.

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Clasificación de la sesión : Connections to Particle Physics

Clasificación de temáticas : Connections to particle physics