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Searching for photon-ALPs mixing effects in AGN gamma-ray energy spectra

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High energy gamma-rays propagating in external magnetic fields may convert into axion-like particles (ALPs). In this case, the observed gamma-ray spectra are modified by the resulting energy-dependent conversion probability. In this study, we use the energy spectra of 20 extra-galactic gamma-ray sources recorded during 10 years of \textit{Fermi}-LAT observations. We define a test statistics based upon the likelihood ratio to test the hypothesis for a spectral model without vs. a model with photon-ALPs coupling. The conversion probability is calculated for fixed values of the mass and two-photon coupling of the pseudo-scalar particle while the external magnetic field is characterized by the additional free parameters length scale s and average field strength B. As a consistency check and in order to extend the analysis to include very high energy gamma-ray data, another test statistics is defined with the χ^2 method. We find for 18 of the 20 sources a favorable fit, particularly for Markarian~421 and NGC~1275 a significant improvement, with the hypothesis of photon-ALPs coupling in likelihood analysis. The test statistics of the sources are combined and the significance has been estimated $5.3\ \sigma$ (test statistics summed in local maxima of all sources) and $6.0\ \sigma$ (global maxima). The significance is estimated from dedicated simulations under the null hypotheses. The locally best-fitting values of B and s fall into the range that is expected for large scale magnetic fields present in relevant astrophysical environments.

Primary author: YU, Qixin

Co-author: HORNS, Dieter

Presenter: YU, Qixin

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