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Extreme BL Lacs as a probe of axion-like particles

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Axion-like particles (ALPs) are very light, neutral, pseudo-scalar bosons predicted by the String Theory and are supposed to interact with two photons. In the presence of an external magnetic field ALPs produce very interesting astrophysical effects in the very-high energy (VHE) band and above (10 GeV –1000 TeV). ALPs can influence the emission of extreme BL Lacs (EHBLs): in particular, photon-ALP oscillations mediated by the jet magnetic field produce a sizable amount of ALPs already in the source neighborhood. Oscillations in the extragalactic space give rise to an increase of the transparency of the Universe to VHE photons partially preventing the γ-γ absorption due to the photons of the Extragalactic Background Light (EBL). Photon-ALP interactions in the Milky Way allow for a great part of still surviving ALPs to be converted back to photons and then to be detected. We investigate the propagation of the photon-ALP beam starting at the jet base of a BL Lac, where it is generated as pure photons. We follow the photon-ALP oscillations during their path up to us while crossing the BL Lac magnetic field, the intergalactic magnetic field –described by means of an improved model developed by us –and the Milky Way magnetic field. We find that the derived photon-ALP oscillations dramatically change BL Lac observed spectra and with our model we infer two features: (i) energy oscillations in the observed spectra, (ii) an unexpected peak at E = (10 – 30) TeV. The last prediction is particular important for EHBLs whose observed spectra reach energies above 10 TeV - which makes EHBLs an exceptional probe of ALPs. Our results can be checked both with the upcoming new generation of γ-ray observatories like CTA, HAWC, GAMMA-400, LHAASO and TAIGA-HiSCORE and with laboratory experiments like the upgrade of ALPS II at DESY, the planned IAXO and STAX experiments.

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