

Suppressing astrophysical backgrounds for gamma- \rightarrow ALP searches in extreme blazar spectra

Thursday, 5 December 2019 15:20 (15 minutes)

Most of the existing works on extragalactic TeV gamma-ray propagation account for only adiabatic losses and primary gamma-ray absorption due to pair production on extragalactic background light (EBL) photons, i.e. assuming the “absorption-only model”(AOM). However, the observable spectra of some active galactic nuclei (AGN) reveal a tentative excess in photon counts with respect to the AOM in the optically thick region of the spectrum (where the optical depth of pair production on EBL photons $\tau > 1$) [1-3]. This apparent excess could be due to an exotic process, namely, oscillations of primary gamma-rays into axion-like particles (gamma \rightarrow ALP) in magnetic fields and back into gamma-rays relatively near to the observer [4-5].

In the framework of the AOM, the shape of the intrinsic spectrum of an extragalactic gamma-ray source could be reconstructed by compensating for the attenuation and redshift. Some blazars, called “extreme TeV blazars”(ETBs), have such reconstructed intrinsic spectral energy distributions (SEDs) peaking at an energy $E > 1$ TeV. ETBs are very promising sources for the gamma \rightarrow ALP oscillation search. However, compared to “classical”blazars such as Mkn 501 and Mkn 421, ETBs, as a rule, reveal weak and slow variability in the high energy (HE, $E > 100$ MeV) range. Therefore, it is possible that a part of observable emission of these sources was produced not inside the source, but as a result of electromagnetic (EM) cascade development in the intergalactic medium. This intergalactic cascade process could, in principle, create a dangerous source of background for gamma \rightarrow ALP oscillation search, especially if these cascades were initiated by ultra high energy cosmic rays (UHE CR). A part of interactions of these primary CR occurs relatively near to the observer, and thus cascade gamma-rays experience a lesser degree of absorption on EBL photons than the primary gamma-rays from the same source.

In the present work we demonstrate that the background from CR-initiated intergalactic EM cascades could be greatly suppressed as follows. During their propagation from the source to the observer, primary CR are deflected to appreciable angles (~ 0.1 -1 degree) in filaments of the large scale structure. This effect broadens the observable angular distribution significantly and leads to an effective cutoff in the observable point-like spectrum (i.e. the spectrum collected inside the point spread function of the observing instrument). We have performed detailed simulations of intergalactic UHECR propagation using the publicly-available code CRPropa3 [6] and, profiting by a hybrid approach developed by us in [7], calculated the observable spectrum and the angular distribution of gamma-rays. We show that the observable spectrum is similar to the so-called universal spectrum of the intergalactic EM cascade model. This study could significantly facilitate future gamma \rightarrow ALP oscillation searches in the optically thick region of blazar spectra with existing and future gamma-ray instruments such as Fermi-LAT, H.E.S.S., MAGIC, VERITAS, CTA, HAWC, and LHAASO.

References

1. D. Horns & M. Meyer, JCAP, 02, 033 (2012)
2. G.I. Rubtsov & S.V. Troitsky, JETP Letters, 100, 355 (2014)
3. A. Korochkin et al., astro-ph/1810.03443 (2018)
4. G. Raffelt & L. Stodolsky, Phys. Rev. D, 37, 1237 (1988)
5. A. De Angelis et al., Phys. Rev. D, 76, 121301 (2007)
6. R. Alves Batista et al., JCAP, 038 (2016)
7. T.A. Dzhatdov et al., A&A, 603, A59 (2017)

Primary authors: DZHATDOEV, Timur; KHALIKOV, Emil (M.V. Lomonosov Moscow State University (RU)); Mr PODLESNYI, Egor (Moscow State University)

Presenters: DZHATDOEV, Timur; KHALIKOV, Emil (M.V. Lomonosov Moscow State University (RU))

Session Classification: Parallel

Track Classification: Gamma rays