STEPS Students Report

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Context

For very high energy (VHE, $E>100$ *GeV*) gamma-rays and electrons, the Universe is like a huge calorimeter: primary gamma-rays from distant (redshift $z>0.5$) extragalactic sources get absorbed on extragalactic background light (EBL) photons [1-2], producing electron-positron pairs, and these electrons lose energy to secondary (cascade) gamma-rays by means of the inverse Compton (IC) process on cosmic microwave background (CMB) and EBL photons. Observing these cascade photons, one may deduce the total amount of energy stored in extragalactic VHE gamma-rays and electrons. Therefore, the electromagnetic (EM) cascade process on the EBL/CMB has many important implications for astroparticle physics, including cosmic ray physics [3-4], neutrino physics [5-6], and indirect dark matter searches [7]. As well, it was recently pointed out that some blazars located at z=0.1–0.3 may reveal the presence of a cascade component [8], thus providing a chance for the first robust measurement of the extragalactic magnetic field (EGMF) strength.

Aims and methods

The EM cascade process on the CMB/EBL was studied by means of full Monte Carlo simulation. The primary application of this study is the search for signatures of cascade emission in the spectral, angular, and temporal distributions of gamma-rays from blazars using the forthcoming Cherenkov Telescope Array (CTA) detector.

Results

The interaction rates for gamma-rays and electrons depending on energy and redshift were calculated assuming the EBL model [9], separately for interactions with EBL and CMB photons. For all corresponding interaction processes, the distributions of the following quantities were sampled: the free path, the center-of-momentum energy, and the primary energy fraction transferred to the secondary particle. Deflection of cascade electrons while propagating through turbulent EGMF was accounted for. The EGMF structure was calculated according to the CRPropa 1.4 code [10]. The new code ECS 1.0 (from "electromagnetic cascade spectrum") aimed at the simulation of EM cascades on the EBL/CMB in the expanding, magnetized Universe was developed. First results were presented in [11].

Prospects

A detailed refereed paper containing the main results of this work is under preparation. After some additional testing, the ECS 1.0 code will be made publicly available.

References

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