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Ultrahigh-energy cosmic-ray interactions as the origin of VHE gamma-rays from BL Lacs

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We explain the observed multiwavelength photon spectrum of a number of BL Lac objects detected at very high energy (VHE, $E > 30$ GeV), using a lepto-hadronic emission model. The one-zone leptonic emission is employed to fit the synchrotron peak. Subsequently, the SSC spectrum is calculated, such that it extends up to the highest energy possible for the jet parameters considered. The data points beyond this energy, and also in the entire VHE range are well explained using a hadronic emission model. The ultrahigh-energy cosmic rays (UHECRs, $E > 0.1$ EeV) escaping from the source interact with the extragalactic background light (EBL) during propagation over cosmological distances to initiate electromagnetic cascade down to ~ 1 GeV energies. The resulting photon spectrum peaks at ~ 1 TeV energies. We consider a random turbulent extragalactic magnetic field (EGMF) with a Kolmogorov power spectrum to find the survival rate of UHECRs within 0.1 degrees of the direction of propagation in which the observer is situated. We restrict ourselves to an RMS value of EGMF, $B_{\rm rms} \sim 10^{-5}$ nG, for a significant contribution to the photon spectral energy distribution (SED) from UHECR interactions. We found that UHECR interactions on the EBL and secondary cascade emission can fit gamma-ray data from the BL Lacs we considered at the highest energies. The required luminosity in UHECRs and corresponding jet power are below the Eddington luminosities of the super-massive black holes in these BL Lacs.

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Ultrahigh-energy cosmic rays, Blazars, Gamma-rays, Extragalactic magnetic fields

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Theoretical Results

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