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Modeling multiwavelength emission from the blazar TXS 0506+056

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The MAGIC collaboration has recently analyzed data from a long-term multiwavelength campaign of the γ-ray blazar TXS 0506+056. In December 2018, it was flaring in the very-high-energy (VHE; $E > 100$ GeV) γ-ray band, but no simultaneous neutrino event was detected. We explore prospects for detecting γ-rays and neutrinos of hadronic origin, produced both inside and outside the jet of TXS 0506+056, while coherently modeling the observed spectral energy distribution (SED) and neutrino flux upper limits. We constrain the neutrino flux through the restriction from observed X-ray flux on the secondary radiation due to hadronic cascade. We propagate the escaping ultra-high-energy cosmic rays (UHECRs; $E \geq 0.1$ EeV) in a random, turbulent extragalactic magnetic field (EGMF). The leptonic emission from the jet dominates the GeV range, whereas the cascade emission from CR interactions in the jet contributes substantially to the X-ray and VHE range. The line-of-sight cosmogenic γ rays from UHECRs produce a hardening in the VHE range of the SED. Neutrino signal from the jet showed little or no variability during the MAGIC campaign. Therefore, we infer that the correlation between VHE γ rays and neutrino flare is minimal. The luminosity in CRs limits the cosmogenic γ-ray flux, which, in turn, bounds the RMS value of the EGMF to $\geq 10^{-5}$ nG. The cosmogenic neutrino flux is lower than the IceCube-Gen2 detection potential for 10 yrs of observation. VHE γ-ray variability should arise from an increased activity inside the jet. Upcoming γ-ray imaging telescopes, such as the CTA, will be able to constrain the cosmogenic γ-ray component in the SED of TXS 0506+056. Detecting a steady flux at multi-TeV energies will validate blazars as unambiguous sources of UHECRs.

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