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Searching for temporary gamma-ray dark blazars associated with IceCube neutrinos

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According to the observations up to date, there is more flux in cosmic neutrinos at lower energies (<100 TeV) than that could be expected from gamma rays, if they have the same sources. The diffuse gamma-ray sky observed by the Fermi Gamma-ray Space Telescope is dominated by blazars (~80%), while recent studies suggest blazars might be only subdominant sources of the diffuse high-energy neutrino sky detected by the IceCube Neutrino Observatory at the South Pole. By analyzing Fermi-LAT data, we show that most of the neutrino-source candidate blazars we found in our previous work, including TXS 0506+056, were in a temporary gamma-ray dip (local or global minimum) when IceCube recorded the respective neutrinos. We propose a model which resolves the longstanding theoretical problem of reconciling the high gamma fluxes (around the time of the neutrino) and neutrino production, such that at the time of efficient neutrino production the observed gamma-flux simply drops. We show that optical depth is the key factor of whether a blazar is gamma-ray dark or bright during the neutrino emission. Importantly, our results also indicate that the identification of additional neutrino-blazar connections is substantially simpler than previously thought, since, because at least for a population of blazars, one can focus on local gamma minima in the blazar light curve, preferably during high states of radio flux density. With this we aim to test existing neutrino observations to establish whether blazars are the origin of IceCube's high-energy neutrino flux, one of the main open questions of astroparticle physics today.

Primary authors: FRANCKOWIAK, Anna (Astronomical Institute, Ruhr University Bochum, Germany); KUN, Emma (Astronomical Institute and Theoretical Physics IV, Ruhr University Bochum, Germany); HALZEN, Francis (Deptartment of Physics, University of Wisconsin, Madison, USA); BARTOS, Imre (Department of Physics, University of Florida, USA); BECKER TJUS, Julia (Theoretical Physics IV: Plasma-Astroparticle Physics, Faculty for Physics and Astronomy, Ruhr University Bochum, Germany); BIERMANN, Peter L. (Max Planck Institute for Radio Astronomy, Bonn, Bochum)

Presenter: KUN, Emma (Astronomical Institute and Theoretical Physics IV, Ruhr University Bochum, Germany)

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