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Neutrino and gamma-ray emission via neutron beta decay in the jet of NGC 1068

IceCube reported evidence at 4.2σ for neutrino emission from NGC 1068, the first candidate steady source of high-energy astrophysical neutrinos. The measured flux, well constrained between 1.5 and 15 TeV, exceeds the Fermi-LAT and MAGIC gamma-ray limits by more than an order of magnitude, in tension with standard pionic models. We present an independent computational replication of the model of Yasuda et al. (PRL 134, 151005, 2025), in which ^{4}He nuclei accelerated in the jet are photodisintegrated on the ultraviolet field of the accretion disk and the infrared field of the dusty torus, and the released neutrons decay in flight ($n \to p + e^- + \bar{\nu}_e$), producing TeV antineutrinos without an appreciable gamma-ray counterpart. We implement the full chain in Python: the photodisintegration optical depth through the giant dipole resonance, the neutron spectrum, the beta-decay kinematics (isotropic in the neutron rest frame, followed by a Lorentz transformation), flavor oscillation, and the synchrotron/inverse-Compton electromagnetic cascade. The model reproduces the structures of the original work, with a gamma-ray emission whose spectral energy distribution drops by more than four orders of magnitude between 1 GeV and 1 TeV, and it predicts a flavor ratio at Earth of $\nu_e : \nu_\mu : \nu_\tau \approx 0.55 : 0.17 : 0.28$ ($\sim 3 : 1 : 1$), distinguishable from the $1 : 1 : 1$ ratio expected from a pionic origin. Confronting the model with data through Bayesian inference (MCMC) on the helium luminosity $L_{\rm He}$, the spectral index p, and the maximum energy $E_{\rm high}$ shows that the $L_{\rm He}$ posterior is bounded by the energy budget of the jet and that the entire posterior region remains gamma-ray quiet (at most 20% of the most constraining Fermi-LAT data point); even so, the predicted flux lies a factor of ~ 13 below the lower edge of the IceCube 95% band at 15 TeV. We thus quantify the reach and limits of the mechanism, as well as its flavor signature as a discriminating observable for IceCube-Gen2 and KM3NeT.

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