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Neutrino signal dependence on gamma-ray burst emission mechanism

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Long-duration gamma-ray bursts (GRBs) have been subject of investigation for a long time, being among the most mysterious and powerful transients occurring in our universe. In the attempt of explaining the observed electromagnetic GRB emission, various models have been proposed, even if an exhaustive theoretical explanation of the mechanism powering GRBs is still lacking. GRBs are also candidate sources of ultra-high energy cosmic rays and high energy neutrinos. In this work, we show that, although different jet models may be equally successful in fitting the observed electromagnetic spectral energy distributions, the neutrino production strongly depends on the adopted emission and dissipation model. To make a fair comparison of the neutrino production across models we compute the neutrino emission for a benchmark high-luminosity GRB in various jet emission and dissipation scenarios. In particular, we consider an internal shock model, a dissipative photosphere model in the presence of internal shocks, a three-component model with emission arising from the photosphere, the IS, and external shock, and the internal-collision-induced magnetic reconnection and turbulence model. We also compute, for the first time, the neutrino signal expected in two models where the jet is assumed to be magnetically dominated, namely a magnetized jet model with gradual dissipation, and the recently proposed proton synchrotron emission model. We find that the expected neutrino fluence can vary up to 1–1.5 orders of magnitude in amplitude and peak at energies ranging from 10^4 GeV to 10^8 GeV. For our benchmark input parameters, none of the explored GRB models is excluded by the targeted searches carried out by the IceCube and ANTARES Collaborations. This work highlights the great potential of neutrinos in pinpointing the GRB emission mechanism in the case of successful neutrino detection and the importance of relying on different jet models for unbiased stacking searches.

Collaboration name

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