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Constraining GRB Prompt Emission Parametres Using IceCube Neutrino Upper Limits and pγ Simulation

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High-energy neutrino detectors such as IceCube and ANTARES have followed up several bright gamma-ray bursts but have not found any associated neutrino signals, instead placing upper limits on the neutrino flux. In this work, we study the photo-hadronic interaction model during the prompt phase of GRBs and estimate the resulting neutrino flux both analytically and numerically using the publicly available SOPHIA Monte Carlo code.

We use various models of the dissipation radius and its connection to the Lorentz factor to constrain the baryon loading parameter. Three emission scenarios, Baryonic Photosphere (BPH), Magnetically Dominated Photosphere (MPH), and Internal Shocks (IS), are analyzed to explore the dissipation radius, Lorentz factor, and baryon loading for several GRBs with existing upper limits from the IceCube detector. For some of these GRBs, including GRB 221009A, we scan the parameter space to identify allowed regions consistent with the neutrino non-detections. The current upper limits provide insights on the baryon loading parameter and provide the model parameter space that identifies the potential GRB detection by future generation neutrino telescopes.

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