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High energy photon and neutrino emission from GRBs in the Hadronic Supercriticality expanding model

Hadronic Supercriticality (HSC) is a property of hadronic systems according to which relativistic protons lose the energy stored in them abruptly and very efficiently through the emission of violent photon outbursts. We investigate for the first time HSC in the context of an expanding system and show its direct analogy to GRB phenomenology. We simulate a variable GRB engine that injects a series of blobs, each of them having initial parameters leading to the onset of HSC. For low expansion velocities ($u_{\rm exp}$<0.01c), one blob can produce a quasi-periodic light curve. The superposition of all the light curves results in the production of a multi-pulse long duration light curve with a power spectrum similar to that of red-noise processes. For a benchmark jet Lorentz factor of 100 we find γ-ray luminosities reaching the values of $10^{49} - 10^{52}$ erg/sec and broadband photon spectra peaking at photon energies ~1 MeV for maximum proton energies ~10 PeV. The estimated total neutrino fluence is ~10% of the γ-ray fluence, while the neutrino spectra peak at lower energies (~10 TeV) compared to other standard neutrino models. The predicted quasi-diffuse flux is close to the projected IceCube-Gen2 limits in the energy range of 10-100 TeV. Therefore, the HSC model for GRBs could be tested by next-generation neutrino telescopes.

Primary authors: Dr FLOROU, Ioulia (National & Kapodistrian University of Athens); Prof. MASTICHIADIS, Apostolos (National and Kapodistrian University of Athens); Prof. PETROPOULOU, Maria (National & Kapodistrian University of Athens)

Presenter: Dr FLOROU, Ioulia (National & Kapodistrian University of Athens)

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