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Neutrino and cosmic ray production in an evolving GRB fireball

Neutrino astronomy is currently presenting us a fascinating new addition to multi-messenger astrophysics and allows for ever better constraints on astrophysical source models such as those for gamma-ray bursts (GRBs). The non-detection of neutrinos from GRBs so far is challenging the concept of GRBs as sources of ultra-high energy cosmic rays (UHECR). We therefore reconsider the particle emission from internal shocks inside a GRB under the premise of an evolving fireball. By combining an approach for the calculation of synthetic light-curves from the collision of several shells with our treatment of photohadronic interactions, we are able to model neutrinos, UHECR, and the maximal energy of the escaping photons on basis of individual collisions. We show that the neutrino production, the maximal UHECR energies, and the maximal photon energies all peak at different collision radii. Moreover, we test how this affects neutrino flux predictions compared to the commonly used models using a fixed collision radius.

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