Revisiting the internal shocks as a mechanism for GRB prompt emission

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Gamma-ray bursts (GRBs) release a star's lifetime energy in seconds through an ultra relativistic jet, but the exact process behind the jet prompt emission remains unknown. In the internal shocks model, variations in the jet velocity causes the material to collide at a large distance from the source. These collisions accelerates electrons which emits this energy as gamma-rays by fast synchrotron cooling ('fast' in comparison to the dynamical time). However, observations have shown more photons at low energies than what synchrotron models can predict, pushing towards alternate explanations.

In this work, we revisit the internal shock model through a full analytical derivation and careful numerical modeling. Identifying the ratio of the shells Lorentz factors as the main physical parameter, we build a spectral model that produces the expected observed flux for any input shell parameters. For a typical collision of shells with equal energy and Lorentz factor ratio of 2, the model predicts a significant spectral component at $\sim$1/10th of the main spectral peak. This secondary component consistently explains the observed low-energies photon excess in GRB spectra over the range of expected jet parameters. We test the model over a few selected 'single pulse' GRBs and pave the way for the analysis of more complex bursts.