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Critical tests of GRB prompt emission models

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Being discovered more than 40 years ago, gamma-ray bursts (GRBs) remain one of the mysterious astrophysical objects. In fact, the physics of relativistic jets formation, their composition, dissipation processes are still some of the biggest unknown in GRBs. The inability to establish the radiative processes shaping the observed prompt emission spectra does not allow us to make a big step towards understanding the fundamental properties of the GRB physics.
Most of the observed spectra in the 10 keV - 1 MeV energy range are too hard to be consistent with the straightforward synchrotron model in the fast cooling regime. Many alternative solutions have been proposed to solve this discrepancy. The possible explanations include modifications of the standard synchrotron model or invoke more complex scenarios with additional thermal components. I present recent investigations of the prompt emission that have
started with extension of the spectral energy range down to soft X-rays (to 0.5 keV). These studies have led to the discovery of the low-energy breaks at 2-20 keV below which the spectra harden. The inclusion of the breaks
into the empirical modelling has changed the distribution of the spectral shapes.
The averaged shapes of the spectra below and above the break energy are found
consistent with the synchrotron radiation. These findings are naturally interpreted in the synchrotron radiation scenario in the marginally fast cooling regime. The inclusion of the break energy in the modelling of one of the brightest GRB 160625B has resulted in similar findings with the break energy at ˜100 keV.
Motivated by the empirical results, the realistic synchrotron model has been tested for the number of GRBs with optical data which allowed us to probe this model in the broad-band energy range. While the synchrotron model is capable to account for the entire optical-to-gamma-rays spectrum, the alternative thermal plus non-thermal model fails to reproduce the optical emission in the presence or absence of the contaminating afterglow radiation. I discuss the
parameter space of the basic prompt emission model derived from the direct application of the synchrotron model to the spectral data. The overall results showed the importance of the soft X-ray/optical data for discriminating the prompt emission spectral models.

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