Contribution ID: **57** Type: **Talk in a parallel session**

Unveiling GRB prompt emission physics through empirical correlations

Monday 8 July 2024 17:00 (15 minutes)

Gamma-ray bursts (GRBs) are the brightest sources in the Universe.
They appear as gamma-ray flashes, with a spectrum that peaks around a few hundred keV . The prompt spectra of GRBs were historically characterised through the phenomenological Band function, composed of two power laws smoothly connected around the peak. Because of the broad spectral shape, GRB spectra seem consistent with non-thermal radiative processes, and the leading interpretation invokes synchrotron emission from relativistic electrons. In this framework, the Band function fails to describe an intrinsically complex synchrotron spectrum featuring spectral breaks in the X-ray/gamma-ray energy range. In this work, for the first time, we test the impact of physical models in understanding the physics of prompt emission through the well-known GRB prompt empirical correlations. We analyse a sample of GRBs with measured redshift observed by Fermi. We fit this dataset with two functions: a phenomenological Band function, and a physical synchrotron model. We compare our results with the established Epeak-Liso empirical correlation, the Yonetoku relation. We find that in our sample the Epeak-Liso relation is less tight when the synchrotron model is used. Interestingly, the spectral cooling strength appears to drive the specific GRB position in the Yonetoku relation plane. GRBs in an intermediate cooling state show a tighter correlation even concerning the results obtained from the fit with a Band function. Finally, we present the correlations between the characteristic synchrotron frequencies and the energetics/luminosity of GRBs in our sample.
These new findings suggest a possible connection between the prompt empirical correlations and the physical mechanisms inside the jet which drive the main gamma-ray emission.

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Session Classification: Emission mechanisms in gamma-ray bursts

Track Classification: Gamma-Ray Bursts (GB): Emission mechanisms in gamma-ray bursts