Investigating GRB 171227A Prompt Phase under the Relativistically Expanding Fireball Scenario

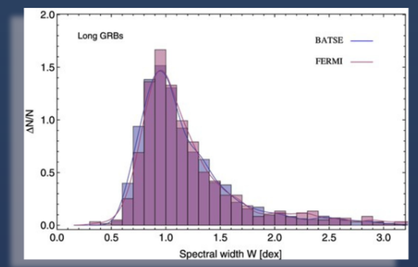
Soumya Gupta & Sunder Sahayanathan

Bhabha Atomic Research Center, Mumbai, India
Homi Bhabha National Institute, Mumbai, India

11TH INTERNATIONAL FERMI SYMPOSIUM

Motivation

- In the study by Axelsson et al (2015), it has been shown the FWHM for the distribution of ~1800 GRBs peaks at ~1 which is broader than a Planck Function while narrower than the typical synchrotron spectrum. In an attempt to explain the unusual FWHM of GRBs, we considered the thermal spectra under the relativistically expanding fireball model with its temperature evolving as a function of its radius.



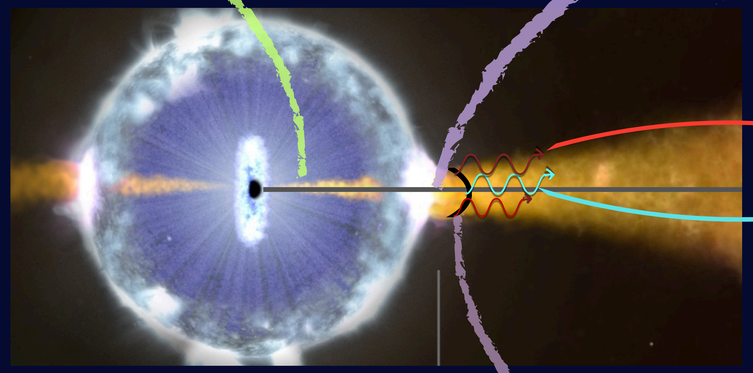
Axelsson et al 2015

- The emission process of the prompt phase of the GRB is still an open question. Observations from the GBM onboard the Fermi Gamma-Ray space telescope suggest the presence of a thermal component along with the non-thermal, whose origin is unintelligible. The thermal radiation from the GRB is modelled using the evolving fireball scenario to study the dynamics of the early phase of the burst.

A numerical code developed and coupled with XSpec, under this scenario is employed to reproduce the spectrum of one of the bright Fermi GRB detected GRB 171227A.

Optical Depth

$$\tau(r,\theta) = \frac{r_d}{\pi r}(\theta - \beta\sin\theta)$$



Picture Credits: NASA

Photospheric Radius

$$R_{ph}(\theta) = \frac{R_{ph0}}{(1-\beta)}\left(\frac{\theta}{\sin\theta} - \beta\right)$$

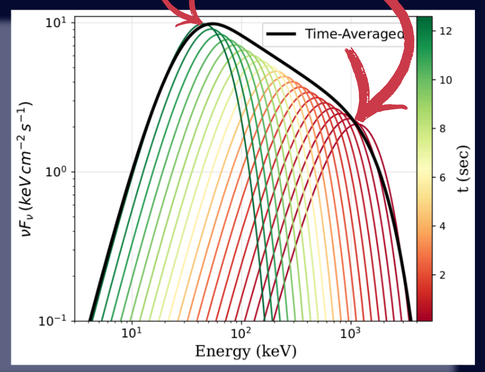
Temperature-Variation with expansion

$$\frac{T_\theta}{T_0} = \left[\frac{R(0)}{R(\theta)}\right]^\alpha = \left(\frac{1-\beta\cos\theta}{1-\beta}\right)^\alpha$$

Ranges from 0 to 2/3 depending on the dynamics of the fireball (Piran et al 1993)

Radially (Time)-Averaged Spectrum

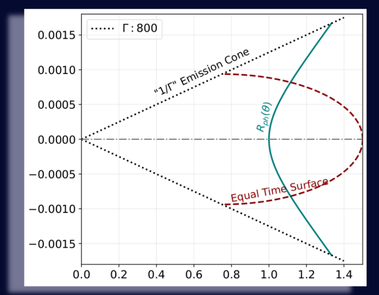
$$\mathcal{F}_\nu = \frac{\int_{R_1}^{R_2} F_\nu(x)\,dx}{R_2 - R_1}$$



Instantaneous Flux

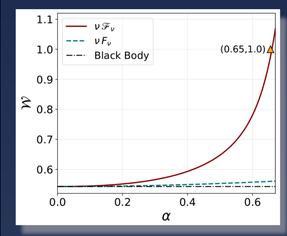
$$F_\nu = 4\pi h\nu^3\left[\frac{(1-\beta)R(0)}{cD_L}\right]^2 \times \int_{\cos\phi}^{1} \frac{\mu}{(1-\beta\mu)^2}\,\frac{\zeta(\theta)\,d\mu}{\left\{\exp\left[\frac{h\nu}{kT_{ph0}}\left(\frac{R(0)}{R_{ph0}}\frac{1-\beta}{1-\beta\mu}\right)^\alpha\right] - 1\right\}}$$

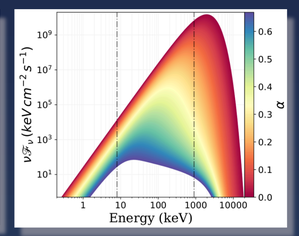
Initially the Opening angle will be smaller than 1/ Γ



Key Findings

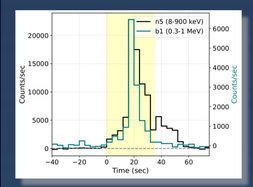
- The modified thermal spectra have a strong dependence on the α.
- Observed widths ranging from ~0.54 to 1.15 by varying α between 0 to 2/3.
- The FWHM ~1 was obtained for the α of 0.653.
- Most GRBs are in the Matter-dominated phase of fireball (Piran et al 1993)



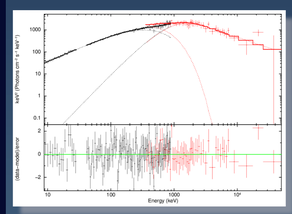


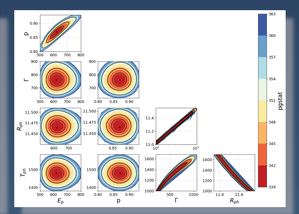
- These results are published in ApJL (Soumya et al 2024)

GRB 171227A (Preliminary Results)



- Single Pulse with T90 of 38 s.
- Fluence of (305.3 +/- 1.3) E-06 erg/cm^2 in 10-1000 keV energy range.
- Best Fit model: CPL + mBB.
- Degeneracy in parameters of mBB.





LETS DISCUSS MORE
(+91) 9999 635 779
soumya.gupta1512@gmail.com

SCAN & EXPLORE