The proto-black hole concept in GRB 101023* and its possible extension to GRB 110709B.

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A clear evidence of two components in GRB 101023 has been outlined[1]. The 1° episode has been fit by a black body plus power-law spectral model. The temperature changes with time following a broken power-law and the radius varies from 10^4 to 10^5 km. The 2° episode appears to be a canonical GRB. Using the Amati[2] and Atteia[3] relations we determined the cosmological redshift to be z =0.9 ± 0.08 (stat.) ± 0.2(sys.). This source appears to be a twin of GRB 090618[4]: the 1° episode has been defined as the proto-black hole and the 2° presents the characteristics of a canonical GRB. We are exploring the possibility to extend these considerations to GRB 110709B. GRB 110709B has been detected by Konus Wind and Swift[5] in the high energy band, and by Gemini and GROND telescopes in the visible bands[6]. It is a very particular GRB , since Swift has triggered twice[7]. Its light curve presents a two-episode structure, one that begins 40 s before the trigtime and lasts ~100 s, and another that starts 485 s after the trigtime and lasts ~380 s. This separation between the two episodes is the largest seen up to date.

GRB 101023

Observations: The 23rd October, 2010 the Fermi GBM[8] detector triggered on a source quite similar to GRB 090618, with a trigtime of 309567006.72 (in MET sec.). The burst was also detected by BAT[5] on board Swift satellite with a trigger time of 436981 (in MET sec.) and the following location coordinates: RA(J2000) = 21h11m49s, Dec (J2000) = −65◦23′37″ with an uncertainty of 3 arcmin. The Swift XRT detector[9,10] has also triggered on this source 88 s after the BAT trigger. GRB 101023 was also detected by the Wind instrument on board Konus satellite, in the energy range (10 − 770) keV[11]. The inferred location is in complete agreement with that determined by Swift and Fermi. Moreover, there have been detections in the optical band by the Gemini telescope[12].

Data reduction: To obtain the Fermi GBM light-curve and spectra in the band 8−440 KeV (see Fig 1) we made use of the standard headas procedure. We used the data from the 2° INa detector in the range 8-440 KeV. Then we proceeded with its time resolved spectral analysis with the program XSPEC. The GBM light curve shows two major pulses. The first one starts at the trigtime and lasts 25 s. The topology of this curve leads to think that this may not be the case of a canonical GRB, but its origin may lie on another kind of source, which is still unidentified. The second pulse starts 45s after the trigtime and lasts 44s. This second emission does have all the characteristics which describe a canonical GRB. We analysed this source within the fireshell model[13].

Pseudo-Redshift determination: The redshift of this source is unknown, due to the lack of data in the optical band. However, to constrain it, we employed different methods. First we made use of the Amati relation[2], under the hypothesis that only the second episode is a long GRB. We computed the values of $E_{p,i}$ and E_{iso} for different given values of z. We found that the Amati relation is fulfilled by episode 2 for 0.3 < z < 1.0.
Then we used an empirical method, following Atteia[3] and Pelangeon[14], which consists in determining a pseudo-redshift from the GRB spectral properties. Using the parameters from the Band model (the index of the low-energy power-law α and the break energy E_0) we can compute the value of the peak energy of the νF_ν spectrum, as $E_p = E_0(2 + \alpha)$. Then, we define the isotropic-equivalent number of photons in a GRB, Nγ, as the number of photons below the break, integrated from Ep /100 to Ep/2. If we also know the T_{90}, we define the redshift indicator $X= N\gamma/(E_p \sqrt{T_{90}})$. From a sample of 17 GRBs with known redshift reported in Atteia (2003) we compute the theoretical evolution of X with the redshift z, that is X = f (z). Then we invert the relation to derive a pseudo-redshift from the value of X. That way we get $\hat{z} = f^{-1}(X)$, for the GRB of interest. We applied this treatment to episode 2, introducing the spectral parameters from the Band model in the Cosmos website[15] and obtained a value for the redshift of z =0.9 ± 0.08 (stat.) ± 0.2(sys.).

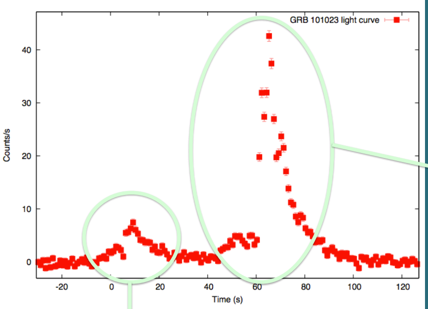


Fig. 1: GRB 101023 count light curve from Fermi GBM detector (bin time of 1 s). The time is given with respect to the GBM trigtime of 22:50:04.73 UT, 23 Oct, 2010.

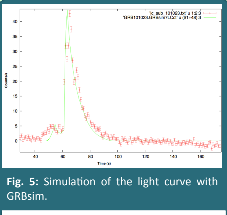


Fig. 5: Simulation of the light curve with GRBsim.

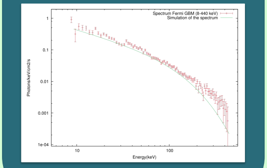


Fig. 6: Simulation. of the spectrum of Episode 2 with GRBsim

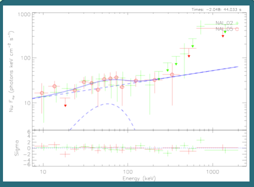


Fig. 2: Fit of the spectrum of Ep. 1 wit a Black body plus a power-law component. The fit gives a Chi squared of 0.98

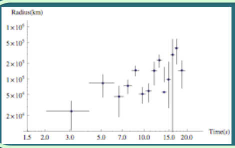


Fig. 3: Evolution of the radius of the frist episode progenitor. We see it varies from 2 x 10^4 to 5 x 10^5 km.

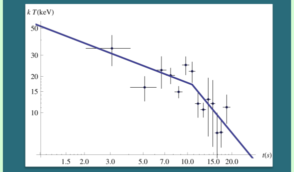


Fig. 3: Fit of the observed temperature kT of the BB component with a broken power-law model. The indices of the first and second power-law are α = −0.47±0.34 and β=−1.48±1.13, respectively. The break occurs at 11 s after the trgtime.

To identify the nature of Episode 1, we plotted the temperature of the BB component as a function of time, for the first 20 s of emission (see Fig. 3). We note a strong evolution in the first 20 s of emission which, according to Ryde[16] can be reproduced by a broken power-law behavior.

In order to simulate the light curve we made use of a numerical code called GRBsim[17]. This numerical code simulates a GRB emission by solving the fireshell equations of motion, taking into account the effect of the EQuiTemporal Surfaces (EQTS). We made the simulation for episode 2. We found, at the transparency point, a value of the laboratory radius of 1.34×10^{14}cm, a theoretically predicted temperature that after cosmological correction gives kTth = 13.26 keV,a Lorentz Gamma factor of Γ = 260.48, a P-GRB laboratory energy of 2.51×10^{51} erg and a P-GRB observed temperature of 28.43 keV. We adopted a value for the dyadosphere energy of $E_{dya} =1.8\times10^{53}$ erg and a baryon load of $B=3.8\times10^{-3}$. The simulated light curve and spectrum of episode 2 are shown in Figures 5 and 6, respectively.

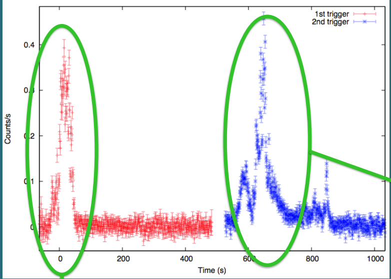


Fig. 7: GRB 110709B light curve obtained from the Swift BAT detector in the band 15-150 keV.. The red (blue) points correspond to the first (second) trigger.

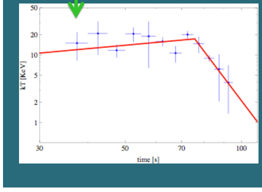
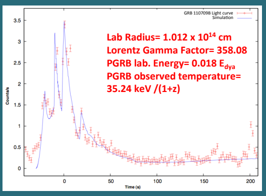


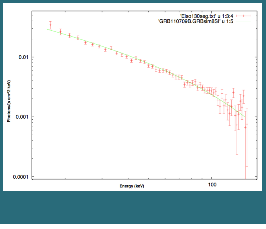
Fig. 8: Evolution of the kT of the BB plus power- law model of Episode 1. The solid line is the broken power-law fit.

Fig. 9 : Simulation of the light curve of the Episode 2 with GRBsim.



Lab Radius= 1.012 x 10^{14} cm
Lorentz Gamma Factor= 358.08
PGRB lab. Energy= 0.018 E_{dya}
PGRB observed temperature= 35.24 keV /(1+z)

Fig 10: Simulation of the spectrum with GRBsim.



GRB 110709B

GRB 110709B has been detected by Suzaku[18] and Swift[19] satellites, and by on-ground telescopes like GROND and Gemini. Unfortunately, as is the case also for GRB 101023, we do not know its redshift, so we inferred it by using the empirical methods mentioned above. We obtained a range for z of 0.6<z<1.35, so we decided to take the mean value, z=0.975.

Conclusions:

We conclude that GRB 101023 and GRB 090618 have striking analogies and are members of a specific new family of GRBs originating from a single core collapse. They both present what we defined as the "proto back hole" emission. It is also appropriate to remark that this new kind of sources does not present any GeV emission. We are proceeding to the identification of additional sources belonging to this family, as it can happen with GRB 110709B, which we are still analyzing. We have already found the thermal component in the first seconds of emission, which again follows a broken power-law behavior.

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