Contribution ID: **54** Type: **not specified**

Self-Similarities and Power-laws in the Time-resolved Spectra of GRB 190114C, 130427A, 160509A, and 160625B

Thursday, 4 November 2021 15:30 (30 minutes)

Context. A new time-resolved spectral analysis performed on GRB 190114C has allowed to identify in its prompt emission observed by Fermi-GBM three specific Episodes predicted to occur in BdHNe I. Episode 1, which includes the "SN-rise" with a characteristic cutoff power-law and blackbody spectra; the Episode 2, initiated by the moment of formation of the BH, temporally coincident with the onset of the GeV emission and the onset of the ultra-relativistic prompt emission (UPE) phase a characterized by cutoff power- law and blackbody spectra; Episode 3, the "cavity", with its characteristic featureless spectrum recently described in a companion paper (Ruffini et al. 2019b). An extreme time-resolved analysis performed on an iterative process in a sequence of ever decreasing time interval, has allowed to find self-similar structures and power-laws in the UPE of GRB 190114C; see e.g., the companion paper (Ruffini et al. 2019a). This has led to the first evidence for the identification of a discrete quantized emission in the GeV and MeV emission presented in the companion papers (Ruffini et al. 2018b; Rueda & Ruffini 2019).
Aims. To identify and verify the BdHNe I properties in the additional sources GRB 160509A, GRB 160625B and GRB 1340427A, and compare and contrast the results with the ones of a BdHN II source GRB 180728A (Wang et al. 2019b). We have also identified in all four sources, following the analysis GRB 130427A in the companion paper (Ruffini et al. 2018b), the GeV radiation during and following the UPE phase. Also in all the four sources, we describe the spectral properties of their afterglow emission, including the mass estimate of the νNS, following the results presented in the companion paper (Rueda et al. 2019).

Methods. In GRB 160509A and GRB 160625B, we have first identified the aforementioned three BdHN I Episodes. In the UPE phase, we have performed the time-resolved spectral analysis following the iterative process in a sequence of ever decreasing time intervals. We have also examined both the GeV radiation and the afterglow phases. The same procedure has been repeated in the case of GRB 130427A with the exception of the UPE phase, in view of a pile-up problem. The case of GRB 180728A, a BdHN II, has been used as a counterexample.

Results. The results of the spectral analysis have validated the common properties in all BdHNe I: the three Episodes as well as the self-similar structures and the associated power-laws in the UPE phase. The profound similarities of the results have made a significant step forward in the taxonomy of GRBs and in evidencing a standard composition of the BdHN I. This opens the opportunity of a vaster inquire of the astrophysical nature of their components in the population synthesis approach: e.g., the BH formation in all BdHN I occurs due to accretion of the SN ejecta in a tight binary system with a neutron star companion which reaches its critical mass, leading to the formation of the BH. The SN-rise in all five BdHNe are compare and contrasted.

Conclusions. The most far reaching discovery of self-similarities and power-laws here extensively confirmed, thanks also to the conclusions presented in the companion papers (Ruffini et al. 2018b, 2019a), leads to the existence of a discrete quantized repetitive polarized emission, both in the GeV and MeV observed by Fermi-GBM and Fermi-LAT, on a timescale as short as 10−14 s. These results open new paths in the discovery of fundamental physical laws.

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