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Exploring Short Gamma-Ray Bursts: afterglow insights from the S-BAT4 extended sample

In the context of Gamma-Ray Bursts (GRBs) astrophysics, the class of short GRBs is particularly fascinating since they are expected to be produced in compact binary mergers, and to be associated with gravitational wave (GW) events. Double neutron star or neutron star-black hole binaries likely generate another electromagnetic transient, known as Kilonova (KN). As such, with the present and future planned GW observing runs we expect to observe more events with coincident detections in addition to GW170817/GRB170817A/AT2017gfo, the only observation of a short GRB, a GW, and a KN obtained so far. The knowledge of the population of short GRBs is thus essential for proper analysis and characterization of these events and a deeper understanding of the underlying physics.

In the talk, I will present a carefully selected sample of short gamma-ray bursts (SGRBs) observed with the Neil Gehrels Swift Observatory from Nov. 2004 to Dec. 2022, namely the S-BAT4 extended sample. GRBs selection criteria include bright events, prompt satellite repointing, and favorable observing conditions for the redshift determination from the ground. The sample consists of 51 events, 62% of which have a spectroscopic redshift measure, and for other 17% a photometric \textit{z} has been determined. Such flux-limited sample minimizes any redshift-related selection effects and can provide a robust base for the study of the energetics, redshift distribution, and environment of the Swift bright population of SGRBs. The prompt and afterglow emissions have been analyzed by computing the rest frame properties of the bursts in terms of energetics and luminosity. In particular, the analysis of the afterglow properties of the sample allowed us to derive and classify 35 and 12 rest-frame light curves in the X-rays and in the optical-near infrared bands, respectively. The majority of the light curves reveal a different evolution in the X-rays and in the optical band, at least at early times. In addition, the comparison of afterglow luminosity at different rest-frame times with prompt emission features suggests a different origin for the X-ray and optical emission, at least during the early phases, with the presence of additional components (e.g. late time activity of the central engine) on top of the pure afterglow emission, which dominates at later times. The large statistics of the sample also gives the opportunity to study the intrinsic absorption properties of short GRBs. Their distribution has been found to be consistent with 0, with no events displaying significant local absorption.

The comparison with a sample of long GRBs (the BAT6 sample) built with similar criteria and of comparable size revealed the different nature of the events belonging to the two samples, and this will be a useful benchmark for a more detailed classification of GRBs that will be observed in the future.

Primary author: BRIVIO, Riccardo (INAF-OAB)

Presenter: BRIVIO, Riccardo (INAF-OAB)

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