ESO observing programme (GRB180728A_SN2018fip)

Abstract

This release concerns the spectroscopic observations of the afterglow of gamma-ray burst (GRB) 180728A, its associated supernova (SN) 2018fip, obtained with the X-shooter instrument for a total of 13 epochs. It also contains a special extraction of the spectra of the host galaxy in which this event occurred. We obtained the first three spectra under the ESO programme 0101.D-0648 (PI: N. Tanvir) during ESO observing periods P101, and the following spectra under the DDT ESO programme 2101.D-5044 (PI: A. Rossi) during ESO observing periods P101 and P102. The data and scope are further described in Rossi et al., arxiv.org/abs/2601.04179.

Overview of Observations

The observations started on 28 July 2018 approximately at 23:13:20 UT, 0.24 days after the GRB trigger. The coordinates of the GRB afterglow are: *RA, DEC (J2000) = +16h54m15s.48, -54°02′40″.3,* as measured in GROND images. We continued monitoring the event until 15 October 2018. Starting with the fourth epoch, we placed the slit at a position angle of 118.1 degrees, chosen to cover both the afterglow and the nearby star. Note that by chance the slit covered both objects also during the first observation. After the 4th observation, the source was also too faint for direct acquisition, thus, we acquired with blind offsets, using as reference a star at coordinates RA, DEC (J2000) = 16h54m16s.37, -54°02′55″.8. Observations were obtained by nodding along the slit with an offset of 5″ between exposures in a standard ABBA sequence. We used slit widths of 1″. 0, 0″. 9 and 0″. 9 for the UVB, VIS and NIR spectrograph arms, respectively, resulting in resolving powers of R = 4300, 7400 and 5400.

Release Content

GRB 180728A is well localized by its afterglow. This release contains a total of 13 observing epochs, with 3 spectra per epoch, one for each X-shooter arm, for a total of 39 files. The special extraction of the source from the last epoch is provided as an ancillary file. We provide an overview of all the observations in Table 1, which is reproduced from Rossi et al., arxiv.org/abs/2601.04179. We also provide a few figures to represent the difficulty of the analysis and the main results. In particular, Fig.1 is the finding chart used for the observations starting with epoch 4. In Fig.2 we show the afterglow and the nearby star. In Fig.3 we provide an overview of the 6 epochs dedicated to the study of the SN 2018fip.

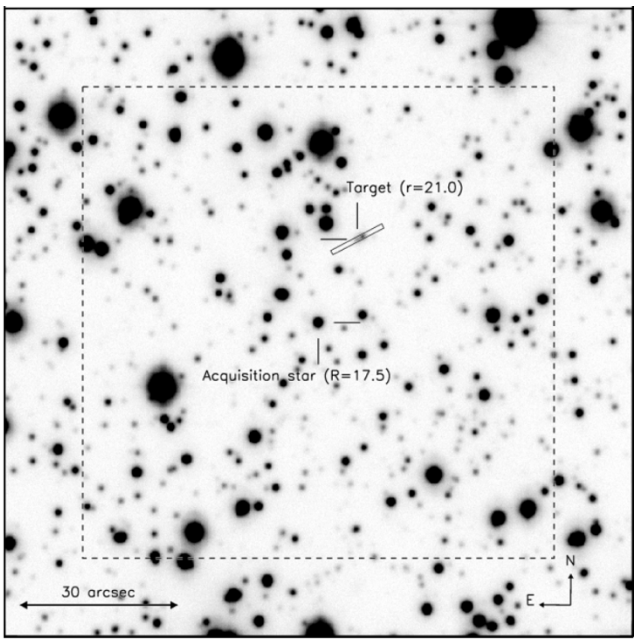

Fig.1. *Finding chart used for the X-shooter observations. The acquisition star and the afterglow (Target) are highlighted. We show the X-shooter slit with a position angle of 118.1 deg, which we selected to cover both the afterglow and the nearby star starting with the fourth observation. The rectangle (dashed line) indicates the field of view of the acquisition camera.*

MJD day	Time day	Exp time s	Seeing ''	Airmass	PA deg	Pipeline
58327.97	0.24	1x600	0.84	1.24	52.83	2.9.3
58328.22	0.50	2x600	0.93	1.7	-79.76	2.9.3
58329.21	1.48	2x600	0.99	1.67	-75.59	2.9.3
58333.99	6.26	2x600	0.75	1.16	-118.1	2.9.3
58337.05	9.32	4x600	0.85	1.16	-118.1	2.9.3
58340.02	12.29	4x600	0.78	1.15	-118.1	2.9.3
58346.10	18.37	4x600	0.96	1.23	-118.1	2.9.3
58351.09	23.36	4x600	0.89	1.24	-118.1	2.9.3
58369.05	41.32	4x600	0.77	1.3	-118.1	3.2.0
58399.00	71.27	4x600	1.02	1.58	-118.1	3.2.0
58403.02	75.29	4x600	1.18	1.64	-118.1	3.2.0
58405.02	77.29	4x600	0.59	1.97	-118.1	3.2.0
58406.01	78.28	4x1200	0.84	1.77	-118.1	3.2.0

Table. 1 *Spectroscopic observations obtained with X-shooter. Times in column 2 are the mid-times after the burst trigger. PA in column 6 indicates the position angle from N to E. Last column indicates the version of the ESO X-shooter pipeline used for the reduction during the observing campaign.*

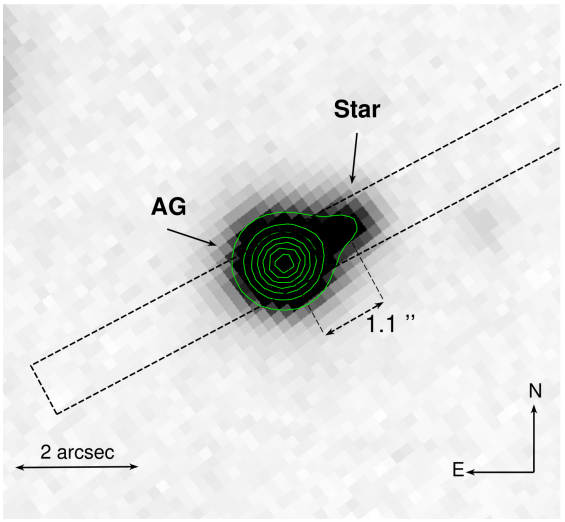

Fig.2. *Image of the optical afterglow of GRB 180728A obtained in the r-band with the X-shooter acquisition camera on 28 July 2018, 0.23 days after the burst trigger. We highlight the position of the afterglow (indicated as "AG") and the nearby star, together with their projected distance. The rectangle shows the X-shooter slit with a position angle of 118.1 deg, which we selected to cover both the afterglow and the nearby star starting with the fourth observation at 6.26 days. The green contours indicate equal count levels.*

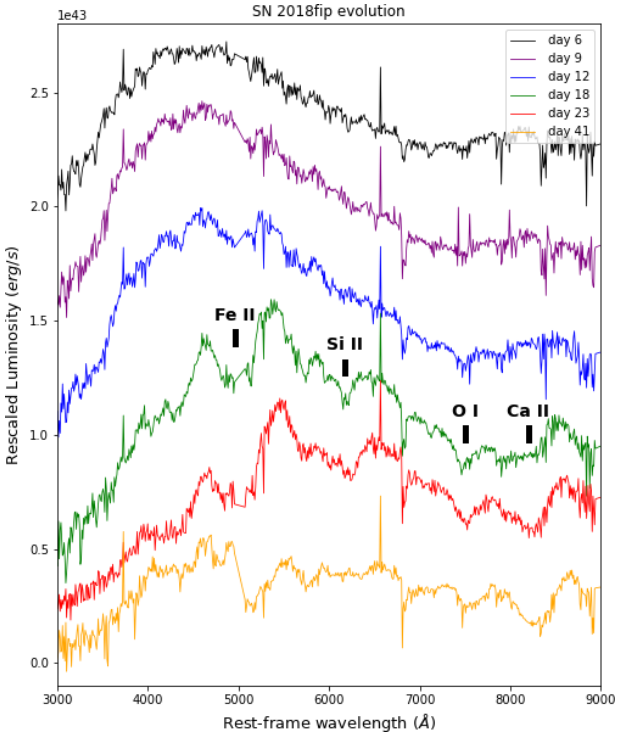

Fig.3. *Evolution of the spectra of SN 2018fip in the rest-frame. These correspond to the X-shooter observing epochs from 4 to 9, and between 6 and 41 days (observer frame) after the GRB trigger. The absorption features marked in the image refer to the spectrum obtained about 5 days after the peak (day 18).*

Release Notes

Data Reduction and Calibration

We reduced the spectra following the procedure described in Selsing et al. (2019), which includes a cosmic-ray removal algorithm (van Dokkum 2001) applied to the raw spectra, after which each individual exposure was reduced using the ESO X-shooter pipeline (Modigliani et al. 2010; the versions used are listed in Table 1). The observations were reduced in STARE mode and then combined in post processing steps. The pipeline is managed with the Reflex interface and used for subtraction of bias level, flat-fielding, tracing of the echelle orders, wavelength calibrations with the use of arc-line lamps, flux calibration using spectrophotometric standards, mirror flexure compensation, sky-subtraction and lastly the rectification and merging of the orders. For the initial sky-subtraction, the background has been estimated by a running median in regions adjacent to the object trace clear of contaminating sources. Finally, the pipeline produces a flat-fielded, rectified, and wavelength-calibrated 2D spectrum for every frame in the UVB, VIS, and NIR arms. We then combined the different frames using custom-made post-processing scripts. We limited the background light from a nearby bright foreground star (~1.1”), which also complicated the extraction of the 1D spectrum by using an extraction region from −3 to +3 pixels (equivalent to 0.96”). Errors and bad pixel maps are propagated throughout the extraction. The final extracted 1D spectra were then corrected for slit loss and Galactic extinction along the line-of-sight of the burst using the dust maps of Schlafly & Finkbeiner (2011). Wavelengths are transformed to vacuum and to the barycentric frame of the Solar System.

For the host galaxy spectra, we accounted for the small SN contribution at this late epoch and fine-tuned the absolute flux calibration using late-time g′, r′, i′, and z′ photometry obtained at 254 days, and available in Rossi et al., arxiv.org/abs/2601.04179.

Data Quality

The data quality ranges from excellent, high S/N spectra to observations that are essentially dominated by noise. Because these observations are time-critical, acquiring them has been a top priority, particularly during the first night. The initial attempt, corresponding to epoch 1, was only partially completed and took place during twilight, prior to scheduled VLTI visitor observations. The observations were later resumed on the same night and successfully completed in full (epoch 2). We also note that, for the supernova (SN) follow-up, only data obtained up to 41 days after the explosion (inclusive) were used in the analysis (see Fig. 3). Finally, we note that while the error is computed, the value of the SNR keyword is not computed correctly and is left to the user to decide if the data need further steps (for example, the subtraction of the afterglow or host component) before being used. It is only given for the last 4 epochs, where the spectra are dominated by the host galaxy.

Known issues

Epoch 13, the last one, is dedicated to the host galaxy. Since there was no detectable continuum in the NIR arm, we limited the analysis to the UVB and VIS arms. We recommend using the special 1d extraction, where we verified that the SN contribution is small at this late epoch and fine-

tuned the absolute flux calibration using late-time g′, r′, i′, and z′ GROND photometry at 254 days (see Rossi et al., arxiv.org/abs/2601.04179), which is free from SN and afterglow emission.

Data Format

Files Types

All spectra are released in the ESO Science Data Product (SDP) format and formatted as binary FITS files. The naming convention is based on the observation number and follows the scheme armOBx.fits. For example, the visual arm of the third observation is named VISOB3.fits.

Acknowledgements

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According to the Data Access Policy for ESO data held in the ESO Science Archive Facility, all users are required to acknowledge the source of the data with appropriate citation in their publications.

Since processed data downloaded from the ESO Archive are assigned Digital Object Identifiers (DOIs), the following statement must be included in all publications making use of them:

- *Based on data obtained from the ESO Science Archive Facility with DOI: https://doi.org/10.18727/archive/105*

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- *Based on data obtained from the ESO Science Archive Facility under request number <request_number>.*