GRB 000301C : a possible short/intermediate duration burst connected to a DLA system

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Abstract. We discuss two main aspects of the afterglow GRB 000301C [1,2]; its short duration and its possible connection with a Damped Lyα Absorber (DLA). GRB 000301C falls in the short class of bursts, though it is consistent with belonging to the proposed intermediate class or the extreme short end of the distribution of long-duration GRBs. Based on two VLT spectra we estimate the H I column density to be log(N(H I))= 21.2 ± 0.5. This is the first direct indication of a connection between GRB host galaxies and Damped Lyα Absorbers.

1 Introduction

GRB 000301C was localised by the Inter Planetary Network (IPN) and RXTE to an area of $\sim$50 arcmin^2. A fading optical counterpart was subsequently discovered with the Nordic Optical Telescope (NOT) about 42 h after the burst. The GRB was recorded by the Ulysses GRB experiment and by the NEAR X-Ray/Gamma-Ray Spectrometer. From the NEAR data we estimate the 150–1000 keV fluence to be approximately 2×10^{-6} erg cm^{-2}. The IPN/RXTE error-box of GRB 000301C [3] was observed with the 2.56-m Nordic Optical Telescope (NOT) on 2000 March 3.14–3.28 UT ($\sim$1.8 days after the burst) using ALFOSC. Comparing with red and blue Palomar Optical Sky Survey II exposures, a candidate Optical Transient (OT) was found at the position $(\alpha, \delta)_{2000}$=(16^h 20^m 18.56^s, $+29°$ $26'$ $36.1''$).

2 The first short GRB optical counterpart detection?

As measured by both Ulysses and NEAR, in the >25 keV energy range, the duration of this burst was approximately 2 s. GRB 000301C falls in the short class of bursts, though it is consistent with belonging to the proposed intermediate class or the extreme short end of the distribution of long-duration GRBs. We obtain a hardness ratio of 2.7$\pm$0.6(cutoff)$\pm$30%(statistical error, see [2] for

details on the calculation of the hardness ratio). Fig. 1 shows the location of GRB 000301C in a hardness vs. duration plot.

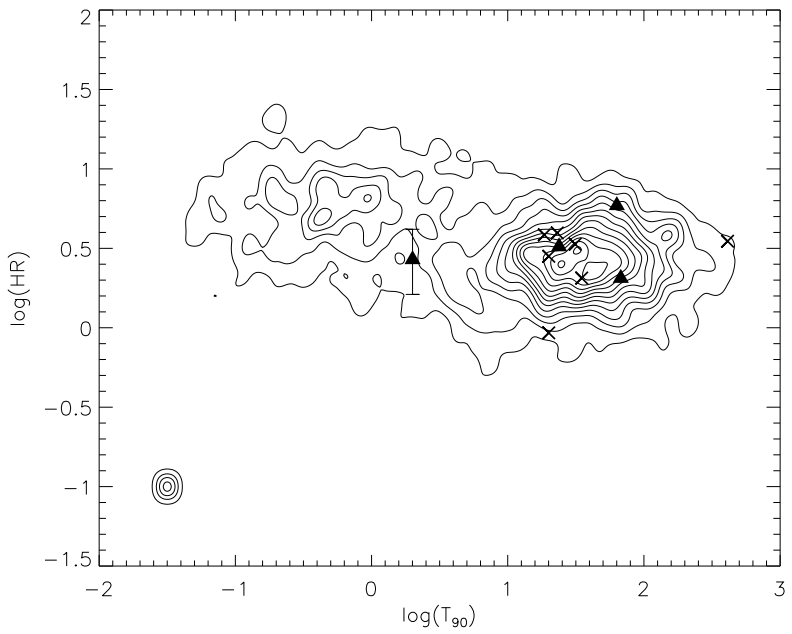

Fig. 1. A contour plot showing the duration–hardness ($\log(T_{90})$–$\log(HR_{32})$) distribution of 1959 BATSE bursts. The triangle with an error-bar near the center of the plot represents GRB 000301C. As seen, the burst was located in the short/intermediate duration part of the distribution. Other symbols represent 10 other BATSE bursts with identified optical counterparts for which data on fluence and duration are available. Triangles are bursts which have a break in their optical light curves. Errors in the BATSE data are smaller than the symbol size. Contour levels scale linearly. The point in the lower left corner illustrates the resolution of the contours.

3 The first GRB-DLA connection?

Spectroscopic observations were carried out on 2000 March 5 and 6 UT with VLT-Antu equipped with FORS1. Fig. 2 shows the normalized spectrum of the OT. Following the procedure explained in [2] we obtained a redshift of $z_{\rm abs} = 2.0404 \pm 0.0008$. The oscillator strength weighted mean observed equivalent width of the Fe II lines is 2.56 Å, which is strong enough that by comparison to known quasar absorbers one would expect this to likely have a column density of neutral Hydrogen in excess of $2 \times 10^{20} {\rm cm}^{-2}$. Such absorbers are known as Damped Lyα Absorbers (DLAs), and hold a special interest because of the large amounts of cold gas locked up in those objects [4]. On the other hand we found that the

spectrum drops steeply before the expected central position of the Lyα line, and well before the S/N drops below detection (see right side plot of Fig. 2). One likely explanation for this is the presence of a very broad Lyα absorption line. To quantify this we have modelled several Lyα absorption lines, all at redshift 2.0404. The formal χ^2 minimum is found at N(H I)= 1.5×10^{21}cm^{-2} (χ^2 per DOF = 0.86), but any value within a factor 3 of this is acceptable.

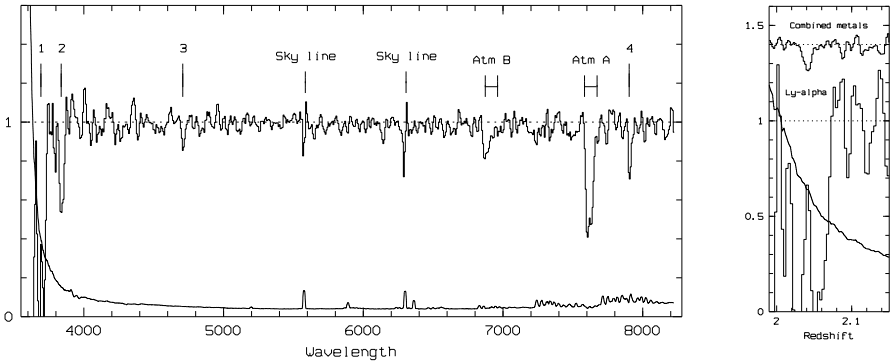

Fig. 2. Combined VLT+FORS1 spectrum of GRB 000301C from 2000 March 5+6 UT. The spectrum is normalized to 1 in the continuum. The atmospheric absorption bands and residuals from strong sky–lines are marked, as well as the 4 absorption lines. The spectrum is binned to 7 Å pixels, and the lower curve shows the noise (per pixel). The detected lines are: Lyα (1), SI II (2), C IV (3) and Fe II (4). On the right side we can see a blow up of the Lyα region in the redshift space. We have overplotted the oscillator strength weighted mean of metal lines lines (Fe II, Si II and C II). The lower curve shows the noise per bin. Note the very sharp onset of absorption well above the expected redshift. This is consistent with a very broad Lyα absorption line as detailed in the text.

4 Conclusions

GRB 000301C is so far the GRB of shortest duration, for which a counterpart has been detected. The high-energy properties of the burst are consistent with membership of the short-duration class of GRBs, though GRB 000301C could belong to the proposed intermediate class of GRBs or the extreme short end of the distribution of long-duration GRBs. We argue that there may be a connection between the host galaxy of GRB 000301C and DLAs.

References

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