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# Ly$\alpha$ emission from GRB host galaxies

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**Abstract.** Ly$\alpha$ emission is indicative of on-going star formation in a dust-poor environment. Ly$\alpha$ imaging is therefore a probe of the star formation rate and of the dust-content of Gamma-Ray Burst host galaxies. Both of these parameters are central to our understanding of GRB progenitors and of how the environments affect the propagation of afterglow emission out of host galaxies. We have started a program aimed at imaging high redshift ($z > 2$) host galaxies of GRBs at the Ly$\alpha$ resonance line from neutral hydrogen. Here were report the results from imaging of the fields of GRB 000301C and GRB 000926 and outline upcoming observations of further hosts.

## 1. Introduction

The ability since 1997 to determine precise positions of GRB afterglows have given us a new method by which to locate and study galaxies in the early universe – the host galaxies. An important aspect of Gamma Ray Burst selection

compared to other selection mechanisms is that it is not flux limited. This is obviously the case for most other selection methods; Lyman-Break selection (Steidel & Hamilton 1992, Steidel et al. 1996) is continuum flux limited and Ly$\alpha$ selection (e.g. Møller & Warren 1993; Cowie & Hu 1998; Fynbo et al. 2001a) is line flux limited. Once an afterglow position has been determined we just need to keep integrating on this position until the host galaxy emerges from the noise. So far this approach has led to the detection of a host galaxy for all well localised GRBs (see e.g. the review by Fruchter in these proceedings) with the possible exception of GRB 020124 (Berger et al. 2002). Therefore, GRB selection allows us to probe the part of the luminosity function currently inaccessible to other techniques. Of course GRB selection is subject to other selection mechanisms that are not yet completely known. The precise nature of these will tell us (something) about the nature of the GRB progenitors.

## 2. Ly$\alpha$ emission from GRB host galaxies

Ly$\alpha$ emission is indicative of on-going star formation in a dust-poor environment (Charlot & Fall 1993, Valls-Gabaud 1993). Ly$\alpha$ imaging is therefore a probe of the star formation rate as well as of the dust-content of GRB hosts. Both of these parameters are central to our understanding of GRB progenitors and of how the properties of the environment affect the propagation of afterglow emission out of host galaxies. In the currently favored scenario the progenitors are very massive stars (Woosley 1993 and the review in these proceedings). Due to their short life-times massive stars are only found in galaxies with on-going star formation. As for the dust it is currently debated whether the non-detection of optical afterglows for 50–70% of well-localised GRBs is due to dust in the hosts or due to intrinsic properties of the bursts (Fynbo et al. 2001; Lazzati et al. 2002; Reichart & Price 2002; Berger et al. 2002; De Pasquale et al. 2002). Such a bias would imply that the current sample of GRB hosts, most of which have been located via bright optical afterglows, would be biased against dusty hosts. From simulations there are furthermore indications that the ability for a super-massive star to produce a GRB is metallicity dependent such that low metallicities are favored (Woosley, these proceedings). If true, this could also imply a bias against very dusty GRB host galaxies. Finally, Ly$\alpha$ emission is an efficient way to probe the faint parts of the luminosity function relevant for the majority of GRB hosts (Fynbo et al. 2001a) as the equivalent width of the Ly$\alpha$ line can be very high, several hundred Ångstrøm in the rest frame.

### 2.1. Observations of the fields of GRB 000301C and GRB 000926

Our first study in this project consisted of deep Ly$\alpha$ narrow-band imaging of the fields of GRB 000301C at $z = 2.0404$ and GRB 000926 at $z = 2.0378$ at the 2.56-m Nordic Optical Telescope (NOT). Both GRBs had bright optical afterglows. This fortunate situation of two host galaxies with nearly identical absorption redshifts made it possible to use a single 45Å wide custom made interference filter and search for Ly$\alpha$ emission from the host galaxies and Ly$\alpha$ emitting galaxies in their environment. The observations were done at the NOT in May 2001 and the results are published in Fynbo et al. (2002) and summarized here. The host galaxy of GRB 000926 is an extended (more than 18 kpc), strong

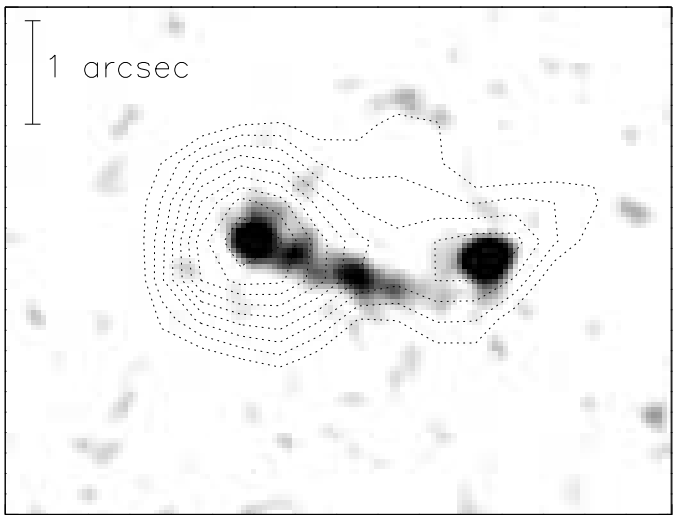


Figure 1. The HST/WFPC2/F606W image of the $z = 2.0378$ GRB 000926 host galaxy (Castro et al. 2001) with the Ly$\alpha$ contours over-plotted as dotted lines (from Fynbo et al. 2002). Most (65%) of the Ly$\alpha$ emission is emitted from the leftmost compact knot. The Gamma-Ray Burst occurred in the rightmost compact knot.

Ly$\alpha$ emitter with a rest-frame equivalent width of $71^{+20}_{-15}$ Å (see Fig. 1). The galaxy consists of two main components and several fainter knots. GRB 000926 occurred in the western component, whereas most of the Ly$\alpha$ luminosity (about 65%) is emitted from the eastern component. From HST F606W and F814W images of the host galaxy we measure the spectral slopes ($f_\lambda \propto \lambda^\beta$) of the two components to $\beta = -2.4\pm0.3$ (east) and $\beta = -1.4\pm0.2$ (west). This implies that both components contain at most modest amounts of dust (Meurer et al. 1999), consistent with both the observed strong Ly$\alpha$ emission and the spectral energy distribution of the afterglow (Fynbo et al. 2001c). We did not detect the host galaxy of GRB 000301C in Ly$\alpha$ emission nor in our U and I broad-band images. This is consistent with deep STIS/HST imaging from which the host was found to be extremely faint (R$\gtrsim$28, Fruchter in these proceedings; Bloom et al. 2002). The upper limit on the Ly$\alpha$ equivalent width is $\sim 150$ Å. Therefore, the GRB000301C host galaxy may also be a large equivalent width Ly$\alpha$ emitter, but a 8-m class telescope is required to test this. We detect 19 other galaxies with excess emission in the narrow filter in the two fields. These galaxies are most likely Ly$\alpha$ emitting galaxies in the environment of the host galaxies. Based on these detections we conclude that GRB 000926 occurred in one of the strongest centres of star formation within several Mpc, whereas GRB 000301C occurred in an intrinsically very faint galaxy far from being the strongest centre of star formation in its galactic environment.

## 3. Perspectives

In addition to GRB 000926 Ly$\alpha$ emission has been detected from the host galaxies of GRB 971214 and GRB 021004 (Kulkarni et al. 1998; Ahn 2000; Møller et al. 2002; Castro-Tirado et al. 2003). In fact, all current evidence is consistent with the conjecture that high-z GRB host galaxies are Ly$\alpha$ emitters. This is intriguing as only $\sim$25% of the Lyman-Break selected galaxies at the bright end of the high-z galaxy luminosity function are Ly$\alpha$ emitters (Steidel et al. 2000). This may be due to a bias against dust in GRB hosts, either observational or intrinsic as discussed in Sect. 2. To study this further we will continue the program with observations of more high-z GRB hosts in order to expand the sample. For now we have time to observe the host galaxies of GRB 011211 ($z = 2.140$) and GRB 020124 ($z = 3.20$) with Ly$\alpha$ narrow band imaging, and in the near future the Swift satellite mission should make it possible to build up a larger sample.

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