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Recent high-redshift GRB and LAE observations at the Subaru Telescope

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Abstract. Recent spectroscopic observation of $z = 6.3$ GRB 050904 is reported with an emphasis on the importance of making similar prompt spectroscopy for long burst GRB events yet to come. A preliminary result of a survey for $z \sim 7.0$ Lyman α emitters (LAEs) using a narrow band filter NBF973 is also presented.

Keywords. Cosmology: early universe; Galaxies: high-redshift; Gamma rays: bursts.

1. Introduction

I would like to flash two recent unpublished results from the Subaru Telescope that I believe would be relevant to this session where the cosmic reionization is one of the hot topics of interest.

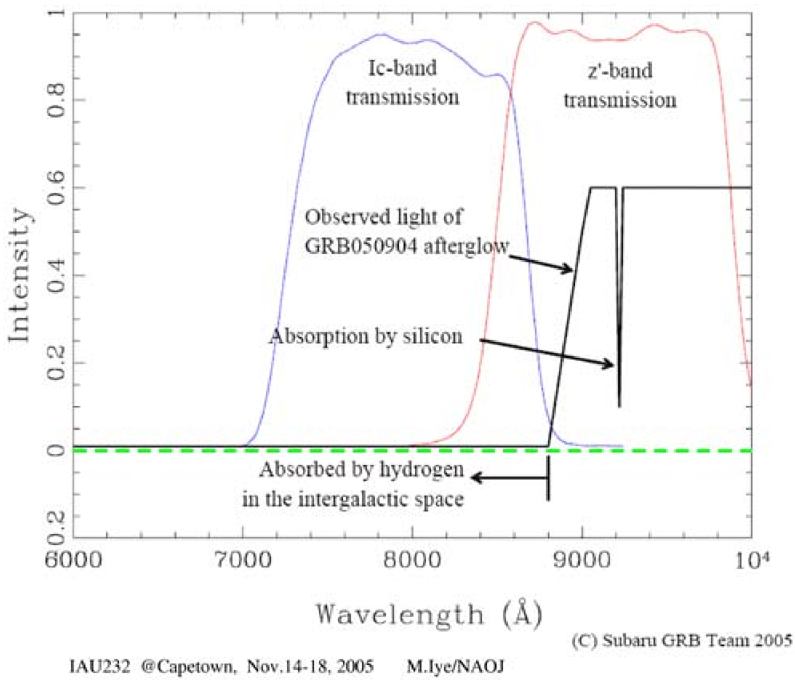

Figure 1. Schematic spectrum of GRB 050904.

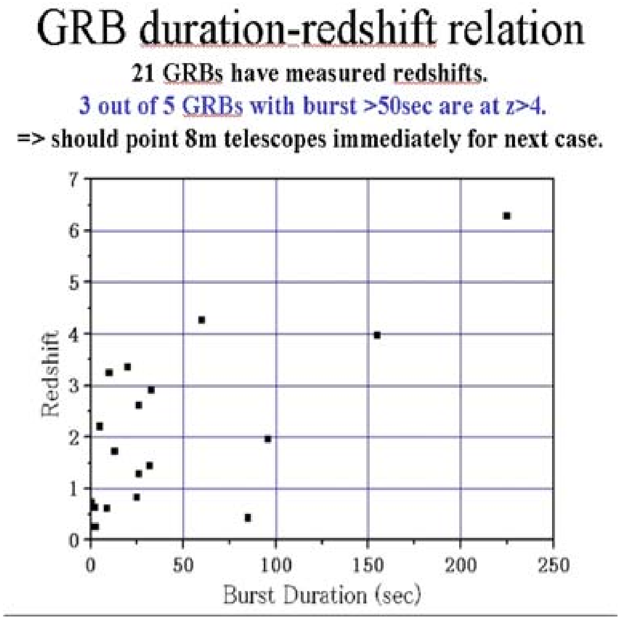

Figure 2. Redshift versus burst duration for 21 GRBs with known redshift.

2. A gamma ray burster at redshift 6.3

The early phase afterglow emission from a long γ-ray burst (GRB) might well be detectable out to distances of $z \geqslant 10$ (Lamb & Reichart 2000), and would provide excellent chances to study the evolution of cosmic star formation, reionization of the intergalactic medium, and the enrichment history of the Universe. The highest measured redshift for a GRB has been $z \geqslant 4.50$ (Anderson *et al.* 2000). The recent GRB 050904 was a long burst (duration $T90 \geqslant 225$ s) detected by the Swift γ-ray burst satellite showing an early detection infrared counterpart (Haislip *et al.* 2005a, Haislip *et al.* 2005b). We made Subaru FOCAS (Kashikawa *et al.* 2002) observations of GRB 050904 3.4 days after the burst Kawai *et al.* 2006. Figure 1 shows a schematic spectrum, indicating a clear continuum longward of 9000 $\AA$. The sharp decline at 9000 $\AA$ is ascribed to Lyman α absorption at $z \leqslant 6.3$ (with a damping wing). A system of absorption lines of heavy elements at $z = 6.295 \pm 0.002$ was also detected, yielding the precise measurement of the redshift. The Si II fine-structure lines suggest a dense, metal-enriched environment around the progenitor of the GRB.
The GRB 050904 spectrum is similar to those of quasars at similar redshift, in the sense that they have a Gunn-Peterson trough, metal absorption systems, and weak residual emission around the Lyman-β feature. One striking difference is the fact that GRBs do not show Lyman-α emission as is seen for quasars. Although GRBs are energetic sources, they do not ionize the surrounding region as is clearly seen in the spectrum of quasars and the absence of “proximity effect” makes the spectroscopic interpretation much less complicated than in the case of quasars. In this sense, GRBs are cleaner light sources to study the interstellar and intergalactic space at high redshift.

Totani *et al.* (2006) made a detailed analysis of the spectrum to evaluate the Gunn-Peterson trough due to the intergalactic neutral hydrogen content. This is the first example to show that high-z GRBs are actually useful for such a study.

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Figure 2 shows the redshift versus burst duration diagram for 21 GRBs with known redshift. Three out of 5 GRBs with burst duration longer than 50s are at redshifts larger than 4. Time dilatation for high redshift GRBs tends to contribute to this correlation. This indicates that long burst GRBs (with burst durations longer than, say, 50s) are very promising sources for further studies. When such an event takes place, every possible telescope should point to the target at their earliest convenience.

3. Lyman alpha emitters at redshift 7.0

The second topic is a new survey for $z \sim 7$ Lyman-α emitters (LAEs) using a custom made narrow band filter NB973 for the SuprimeCam of the Subaru Telescope. A total exposure of 15 hours yielded a 5σ limiting magnitude NBF973=24.9 for a 2 arcsec aperture and we identified 5 photometric candidates with a NBF973 excess among some 40 000 objects. Follow-up spectroscopy of these candidates, although yet preliminary, allowed us to discover the first Lyman α emitter at a redshift of 6.96. The assessment of the number density of LAEs at $z = 7$ in comparison with that at $z = 6.6$ is under way and there is an indication that we see the last phase of cosmic reionization process in the Subaru Deep Field.

Acknowledgements

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Discussion

Bergeron: What was the GRB magnitude shortly after the explosion? If very bright, one could have probed intervening metal absorption with intermediate/high resolution spectroscopy at high S/N.

Iye: $J = 17.4$ and $Z = 22.1$, 3 hours and 11 hours after the burst, respectively. Expected to be as bright as $J = 12$, a few minutes after the burst (Haislip *et al.* 2005). Note also that as GRBs are point sources, ELTs with AO will be able to follow the evolution of the afterglow spectrum well after a month from the explosion.

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