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Optical/IR follow-up observations of Gamma-Ray Bursts detected by RXTE

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ABSTRACT Optical/IR follow-up observations have been performed for GRB 970616, GRB 970815, GRB 970828 and GRB 980703. With the exception on GRB 980703, no optical/IR counterparts have been found. In the case of GRB 970828, the absence of the optical/IR afterglow, together with the rather high hydrogen column density towards the source, at a high galactic latitude, indicates an intrinsic absorption. For GRB 980703, a fading optical/IR object was detected, and further imagery revealed the GRB host galaxy, the brightest so far detected. These results would support the existence of a dense and rich-gas medium in which the GRBs occurred, thus linking these events to star forming regions, favouring the hypernova model scenarios.

KEYWORDS: gamma-ray-bursts.

1. INTRODUCTION

Gamma–ray bursts (GRBs hereafter) are one of the main objectives of INTEGRAL. With the advent of the BeppoSAX and RXTE satellites, it has been possible for the first time to detect in a few cases transient emission associated with the bursts, and proving that they are of extragalactic origin.

Here we present the results of a search for optical/IR counterparts to GRBs detected by RXTE in 1997-98. A similar search for counteparts to GRBs detected by BeppoSAX has been published elsewhere (Castro-Tirado et al. 1998a).

2. OBSERVATIONS AND RESULTS

Here we present the results for GRB 970616, 970815, 970828 and 980703.

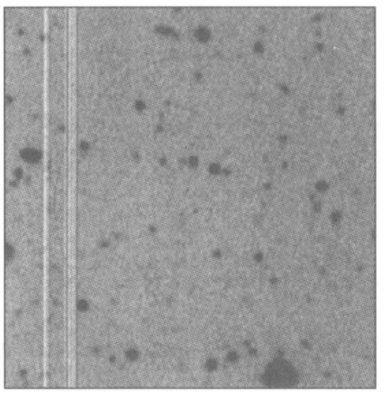

FIGURE 1. The content of the GRB 9706716 error box. North is up and east to the left. The ASCA (1′ radius) and ROSAT (10″ radius) error boxes are shown. Adapted from Gorosabel et al. (1998).

2.1 GRB 970616

Optical and IR images of the RXTE error box (Connaughton et al. 1997, Marshall et al. 1997) were obtained beginning 106-hr after the event. The K'-band frames were obtained at the 3.5-m telescope on the Calar Alto Observatory (CAHA) on 21, 25 and 26 June. V, R & I-band frames were taken at the 1.5-m Danish telescope at the ESO La Silla Observatory on June 26-30 and July 1-2.

The main result is that no variable IR/optical counterpart was found within the ASCA X-ray source error circle (Murakami et al. 1997), or within the rest of the RXTE/IPN annulus (Hurley et al. 1997) in a 5' x 4' region southeast from this source. Any fading or increase was ≤ 0.5 mag for K' ≤ 17.0 (Castro-Tirado et al. 1997a). The optical variable object reported by Galama et al. (1997), was observed at K' $= 17.4 \pm 0.3$ and did not show any obvious IR/optical variation. No objects brighter than R = 24 are seen within the error box of the ROSAT source detected at the ASCA position given by Greiner et al. (1997a). See Fig. 1.

2.2 GRB 970815

Optical and IR images of the RXTE error box (Smith et al. 1997) were obtained beginning 56-hr after the event. The K'-band frames were obtained at the 3.5-m CAHA telescope on 17 Aug. B & R-band frames were taken at the Observatorio de Sierra Nevada (1.5-m telescope), CAHA (2.2-m) on Aug 20-21, and La Palma (4.2-m WHT) on Aug 22.

The main result is that no variable IR/optical counterpart was found within the entire RXTE error box nor within the ROSAT X-ray source error circle (Greiner 1997) on the border of the RXTE region. See Fig. 2. Upper limits are K' ≥ 18 (Aug 17), B ≥ 21.5, R ≥ 22 Aaug 20), B ≥ 22.5, R ≥ 23 (Aug 23) (Castro-Tirado et al. 1997b).

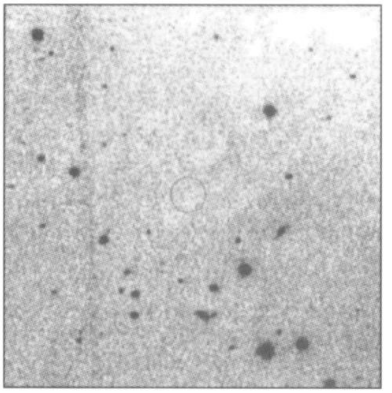

FIGURE 2. The content of the GRB 970815 error box. North is up and east to the left. The ROSAT error box ($10''$ radius) is shown. From Castro-Tirado et al. (1998b).

2.3 GRB 970828

Optical and IR images of the RXTE error box (Remillard et al. 1997) were obtained beginning 6.5-hr after the GRB. The R-band frames were obtained at the 0.8-m IAC telescope. Unfiltered, B & R-band frames were taken at the 2.2-m CAHA telescope on Aug 29-31. Additional B & R-band images were acquired at La Palma on Sep 3-5, 10 (4.2-m WHT) and Oct 23 (2.5-m NOT). The K-band frames were obtained at the 3.8-m UKIRT telescope at Mauna Kea on Sep 13, Oct 13 and 16.

The result (Castro-Tirado et al. 1997c) is that no variable IR/optical counterpart is found within the X-ray source error boxes provided by ASCA (Yoshida et al. 1998) and ROSAT (Greiner et al. 1997b), down to R = 24.5, K = 20. The IR source found by Klose and Eisloeffel (1997) has not changed significantly. A more extended discussion is published elsewhere (Groot et al. 1998, Castro-Tirado et al. 1998c).

2.4 GRB 980703

We imaged the gamma-ray error box of GRB 980703, beginning 22.5 hours after the γ–ray event, in both the optical R and near-infrared H bands with the IAC80, 2.5-m NOT and 3.5-m CAHA. A fading optical/IR object was detected within the X-ray error box (Zapatero-Osorio et al. 1998), coincident with the variable radio source reported by the Caltech group (Bloom et al. 1998), who also detected the optical transient independently of us.

Further imagery revealed the GRB host galaxy, with R = 22.50 ± 0.04, the brightest so far detected. When excluding its contribution to the total flux, both the R and H-band light curves are well fitted by a power-law decay with index $\alpha \simeq$ 1.3-1.4, as observed in X-rays. See Castro-Tirado et al. (1998d) for a more extended discussion.

3. CONCLUSIONS

It is clear now that not all GRBs displaying X-ray afterglows have optical counterparts similar to GRB 980703. The absence of an optical afterglow for GRB 970828 is probably due to high extinction by dust, as inferred from the ASCA data. The upper limits derived here (together with those of other authors already quoted in IAUCs) together with the derived intrinsic columns, indicate that a significant fraction of counterparts will be beyond the reach of optical telescopes. These results would support the theoretical models in which GRBs occur in high, dense populated region, perhaps related to star forming regions, and thus favouring the hypernoval model scenarios.

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