

Research Note

Archival search for recurrent activity at the position of the gamma-ray burst GRB 970228 optical counterpart

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Abstract. We have examined 8004 plates at the Harvard College Observatory Plate Collection searching for optical transient emission from the gamma-ray burst GRB 970228. This is the first archival search carried out so far for a gamma-ray burst with known transient optical emission. The total exposure time amounts to ~ 1.1 yr. No convincing optical activity was found above 12.5 mag at the expected position of the GRB 970228 optical counterpart.

Key words: gamma rays: bursts

1. Introduction

GRB 970228 was detected as a 5.5-s brief, high energy event on 28 February 1997, by the satellite BeppoSAX (Costa et al. 1997a). A decaying X-ray emission (the X-ray afterglow) was found 8 hr after the onset of the event (Costa et al. 1997b). Optical observations started 15.4 hr after the burst (Pedichini et al. 1997), which allowed the search of variable objects in the intersection between the γ -ray error box, the X-ray error box and the Interplanetary Network (IPN) annulus (Hurley et al. 1997). They led to the discovery of the first optical counterpart of a GRB (van Paradijs et al. 1997).

The recent measurement of the redshift of the GRB 970508 optical counterpart has established that most GRBs - if not all - lie at cosmological distances (Metzger et al. 1997). While galactic GRB models allow multiple outbursts from each source (Li and Dermer 1992), the cosmological models are usually based on singular, cataclysmic highly energetic events. Thus, the detection of recurrent optical emission for a GRB would impose severe constraints on the cosmological models (Narayan, Paczyński and Piran 1992, Mészáros and Rees 1993). Archival searches can be crucial in order to clarify this problem.

Archival searches in GRB error boxes rely upon the assumption that GRBs do repeat and show optical transient emission. With perhaps the exception of OT 1928 (Schaefer 1981, Hudec et al. 1994), no firm candidates have yet been established (Hudec

et al. 1993, and references therein, also Gorosabel and Castro-Tirado 1998). The detection of the two first optical counterparts for GRB 970228 (van Paradijs et al. 1997, Guarnieri et al. 1997) and GRB 970508 (Bond 1997, Castro-Tirado et al. 1998) has been an important breakthrough. However, for some other GRBs no optical emission was detected although very fast and deep follow up observations were carried out (Castro-Tirado et al. 1997, Groot et al. 1998).

2. The archival search

In order to search for optical recurrent activity at the position of the GRB 970228 optical counterpart we have examined 8004 plates at the Harvard College Observatory Plate Collection (HCO). Table 1 displays the list of plates examined at HCO. The plates span 64 yr, from 1889 to 1952, and the total exposure time amounts to ~ 1.1 yr. The accurate position of the optical counterpart made the archival search very easy in comparison to other GRBs with larger error boxes.

Many spots were found on the plates, but none of them was consistent with the position of the true optical counterpart, except for a ~ 9 mag star-like spot found on the plate RH 4888 (see Fig. 1). This plate was taken on 18 March 1933 and represents three exposures of 6 min each. Two of the three exposures included the GRB 970228 field and are shifted $\sim 4'.8$ from each other. The third one includes the north equatorial pole. As expected for a real optical transient, we found two spots corresponding -within the astrometrical errors- to both the real and "shifted" positions of the true GRB 970228 optical counterpart. However, an accurate measurement of the two positions revealed that they are not trailed in a similar way to other stellar images. We then realized that the two spots correspond to a pair of stars near the north pole that were imaged during the third exposure.

In order to estimate the rate of plate faults, we investigated the number of spots found on the AC plates in a $15'$ radius region around the OT position (see Fig. 2). The rate of plate faults with 0.2–0.6 mag above the background is $\sim 8 \times 10^{-4}$ mm $^{-2}$ plate $^{-1}$, a value comparable to that reported by Greiner et al. (1987).

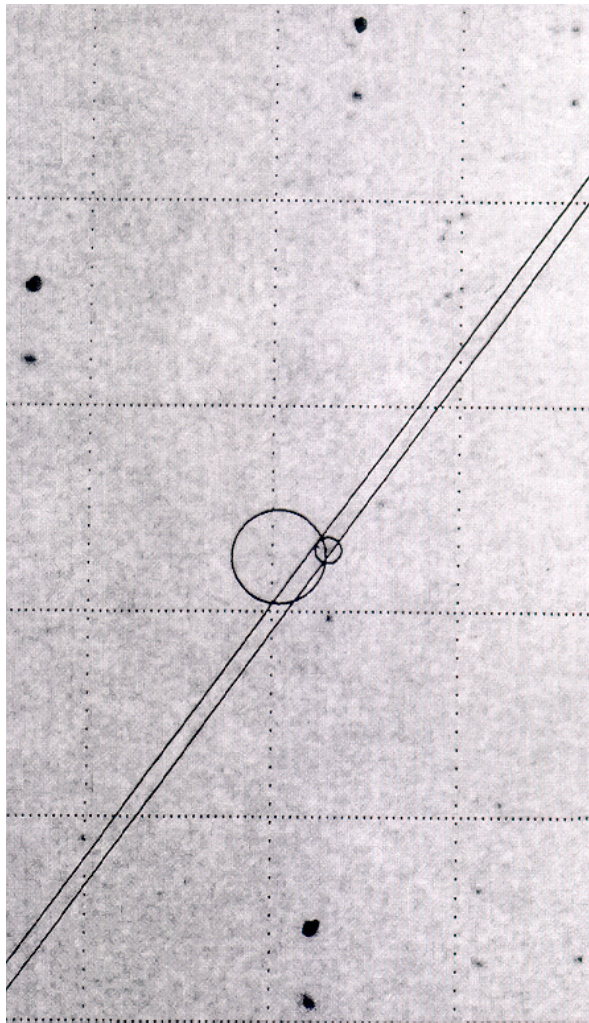


Fig. 1. The region of the HCO plate RH 4888 that includes the position of the GRB 970228 optical counterpart (at the center of the image). Both stars seen in the third exposure (see detailed explanation in the main text) coincide with the position of the true counterpart, but only one of them is shown here within the intersection of the IPN and WFC error boxes. North is at the top and east to the left. The field of view is $\sim 38' \times 66'$.

Table 1. Plates examined at HCO for GRB 970228

Plate series	Limiting mag.	Dates	Number of plates	Total exposure time (hr)	Limiting mag. (1-s burst)
A	16.5	1893-1950	3	0.5	8.2
AC	14.1	1898-1957	2906	3834	5.8
AI,BI,FA	12.5	1900-1953	4602	5287	4.2
MA	16.5	1905-1952	5	5.2	9.0
MC	16.5	1909-1952	7	5.4	9.0
MF	16.4	1915-1952	35	14.2	8.9
RH	14.8	1928-1952	446	472	6.5

3. Discussion and conclusions

The ~ 8000 plates span ~ 1.1 yr. Many star-like spots were found. With the exception of the above-mentioned case, none of them was consistent with the position of the true GRB

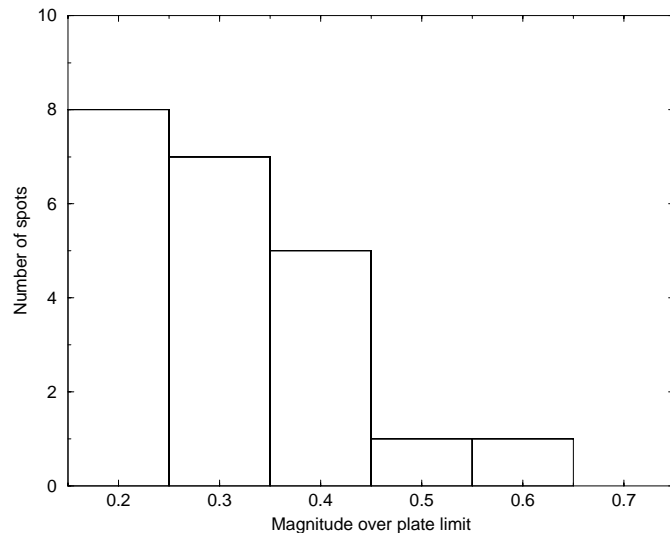


Fig. 2. Histogram of the 22 plate faults found in a $\sim 15'$ radius region around the OT position on the AC plate series.

970228 optical counterpart. Therefore we can settle a lower limit of ~ 1.1 yr for any recurrent optical transient emission activity brighter than 12.5 mag (or 4.2 mag if a 1-s flash is assumed). According to extrapolation of the gamma-ray spectra into longer wavelengths for the strongest bursts observed by BATSE, the magnitude of the optical flash that -eventually - would arise simultaneously to the gamma-ray event, could reach a magnitude of 2.5 in 1-s (for the spectral index $\alpha \geq -1$, Ford and Band, 1996). If this would have been the case for a previous bursting activity at the GRB 970228 location, such an optical flash would have been easily detected in any of the HCO plates.

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