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Rapid follow-up ROSAT observation of GRB 940301

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Abstract. The strong γ-ray burst of March 1, 1994 was imaged by COMPTEL and found to have an identical location within the errors as a burst which occurred on July 4, 1993. This location coincidence had prompted speculations on a possible single source origin for both bursts.

We have performed a ROSAT PSPC mosaic observation within four weeks of GRB 940301. The results of these observations and the comparison of the intensities of the detected sources with those detected during the ROSAT all-sky-survey in September 1990 are presented. We neither find a flaring X-ray source in the April 1994 observation nor any variability of the X-ray sources detected in the all-sky-survey.

We discuss the consequences of our negative result on both, the possibility of the location coincidence being due to a repeating burst source as well as due to two independent sources. In the former case the source could either be a Soft Gamma Repeater similar to SGR 1806–20 and SGR 0525–66, or a sofar unknown classical burst repeater. We conclude that a quiescent luminous X-ray source as is found for the above mentioned Soft Gamma Repeaters is very unlikely to be present in the case of GRB 930704 / GRB 940301.

Key words: gamma-ray: bursts – X-ray: stars

1. Introduction

During the first three years of operation the COMPTEL instrument on the *Compton* Gamma-Ray Observatory has localized 18 γ-ray bursts (GRBs). The location of two of these bursts, GRB 930704 and GRB 940301, is consistent with the same location within the statistical uncertainties (Kippen et al. 1995). With statistical 1σ errors in the COMPTEL location of these events of $1\overset{\circ}{.}5$ and $0\overset{\circ}{.}5$, respectively, the occurrence of two bursts with $1\overset{\circ}{.}7$ separation results in a 3% probability for a random coincidence (Kippen et al. 1995).

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Table 1. Sequence of events

Event	Date
ROSAT all-sky survey[a]	Sep. 13–29, 1990
GRB 930704	July 7, 1993
GRB 940301	March 1, 1994
ROSAT mosaic pointings	April 1, 1994

[a] The all-sky survey lasted 6 months; the date gives the time span when the location of the two GRBs was observed.

Both bursts have also been observed by other instruments allowing an interplanetary network (IPN) location. While the IPN triangulation arc can neither prove nor dismiss the possibility of a true burst recurrence, the combined COMPTEL and IPN location evaluation reduces the probability of random spatial coincidence to 1.5% (Kippen et al. 1995).

Besides a random coincidence there are two alternatives for the origin of these two bursts (Kippen et al. 1995): (1) These events may be time-delayed images of the same event which has been gravitationally lensed by an intervening massive object (Paczyński 1986). Using high time resolution OSSE data and spectral information from the BATSE and COMPTEL instruments it was convincingly shown that the gravitational lensing hypothesis can be ruled out due to the dissimilarities between the two GRBs (Hanlon et al. 1995). (2) These two events may have been produced by a single GRB source with a separation of eight months. If the burst source resides at cosmological distances then many GRB scenarios have to be excluded because they invoke singular catastrophic events such as mergers of compact objects (Paczyński 1991) or failed supernovae (Woosley 1993).

Here we report on mosaic observations with the ROSAT position-sensitive proportional counter (PSPC) of the location of this pair of bursts. The sequence of events is given in Table 1. All the ROSAT data analysis described in the following has been

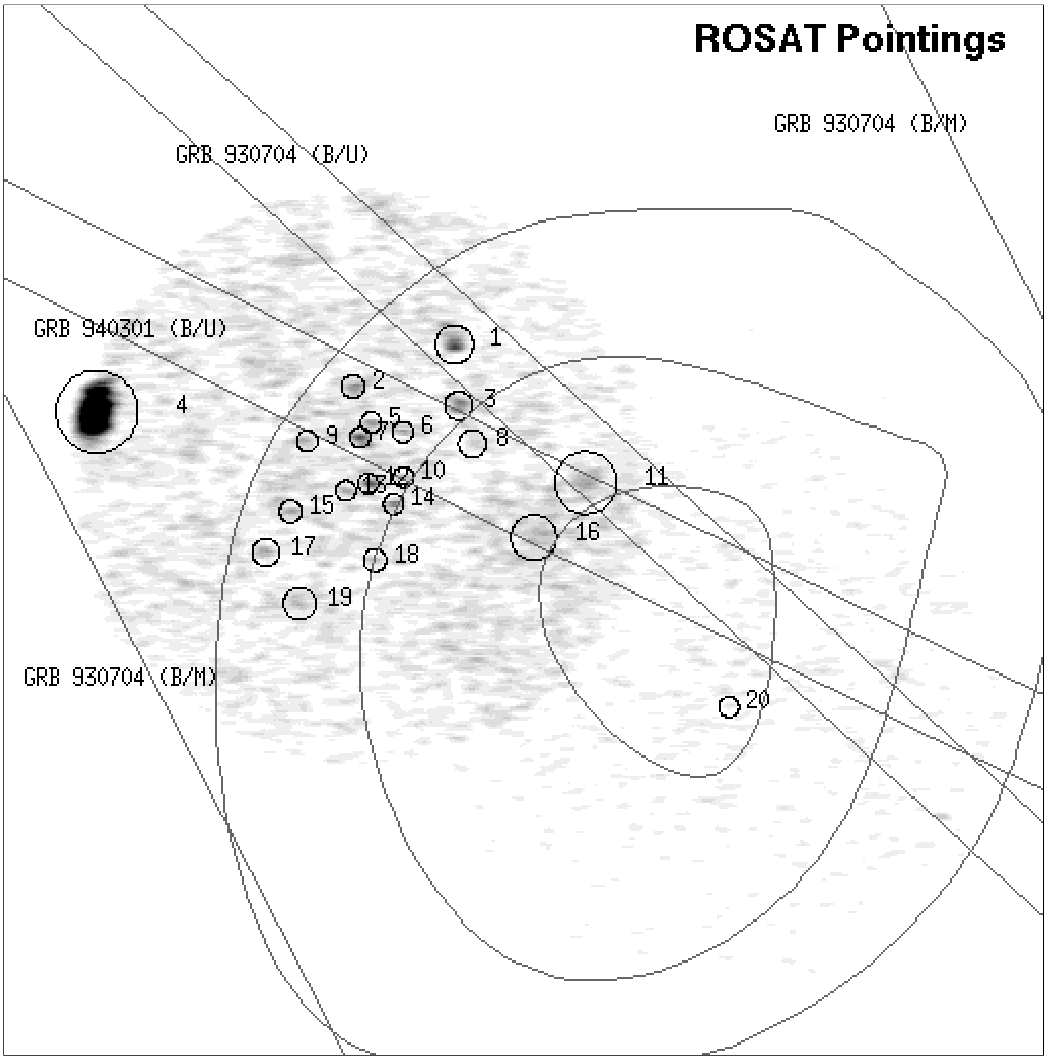

Fig. 1. Smoothed 3° by 3° ROSAT mosaic image of the location of the GRB 930704/940301 burst pair. Circles denote X-ray sources with a likelihood greater than 8 and the numbers reference these sources according to Table 2. The circle size is proportional to the full width half-maximum of the point spread function of the PSPC. The COMPTEL 1 to 3σ contours of GRB 940301 are given as closed polygons, and the IPN arcs are labelled with the burst and B/U (BATSE/Ulysses) or B/M (BATSE/Mars Observer) for the satellite combinations

performed using the dedicated EXSAS package (Zimmermann et al. 1994).

2. X-ray observations

2.1. ROSAT PSPC pointings

ROSAT pointed observations of the location of the burst pair were performed on April 1, 1994. One of the initially planned two mosaic pointings was unfortunately split into two short exposures with slightly different pointing directions due to scheduling problems. As a consequence, we obtained three pointings with 3150 sec, 1020 sec and 364 sec, respectively, which results in an uneven sensitivity over the GRB error boxes.

Using a maximum likelihood technique we detected 19 sources in the longest and 1 source in the 1 ksec observation with a likelihood exceeding 8 (95% confidence, i.e. 5 out of 100 detected sources are spurius). The merged image of all three pointings is shown in Fig. 1, with the detected sources marked by small circles and referenced with numbers detailed in Table 2. In addition to the ROSAT source name and the X-ray position error (column 3) we give the countrate in the ROSAT PSPC (column 4), the hardness ratio HR1 of the detected X-ray emission (column 5, see table for the definition), the likelihood for the existence of a point source (column 6) the optical counterpart candidates (column 7) and the brightness (B band) and optical position for unambiguous identifications.

The error box of GRB 930704 as determined by the BATSE/Ulysses/Mars Observer network is not completely covered by the ROSAT pointings. We find two sources (P1 and P11) inside or at the border of the 3σ error box.

The 3σ error box of GRB 940301 determined by COMPTEL and the IPN is fully covered by the pointings and contains nine

Table 2. ROSAT X-ray sources from the mosaic pointings. The X-ray error depends on the off-axis angle of the source in the detector.

No.	Name	Position error (″)	Count-rate (cts/s)	Hardness ratio HR1[a]	ML	Identification[b]	m_B (mag)	Optical position (2000.0)
P1	RX J0656.1+6451	27	0.029	0.25±0.14	55.7	EBL-WK	19.5	$06^h56^m07\overset{s}{.}2$ +64°51′27″
P2	RX J0659.2+6442	23	0.004	0.35±0.33	18.4	2 candidates		
P3	RX J0655.9+6439	24	0.018	0.39±0.20	27.9	2 candidates		
P4	RX J0707.0+6435	42	0.632	0.27±0.04	1088.5	Zw VII 118 (Sy1)	14.6	$07^h07^m13\overset{s}{.}0$ +64°35′59″
P5	RX J0658.6+6435	21	0.006	–0.34±0.26	24.8	HD 50630 (G5)	8.9	$06^h58^m39\overset{s}{.}2$ +64°35′34″
P6	RX J0657.6+6433	21	0.004	0.50±0.36	13.7	2 candidates		
P7	RX J0659.0+6432	20	0.008	0.06±0.24	42.1	blue object[c]	18.8	$06^h59^m01\overset{s}{.}0$ +64°32′35″
P8	RX J0655.5+6431	25	0.004	1.00±0.00	13.0	LTS	11.5	$06^h55^m31\overset{s}{.}9$ +64°31′44″
P9	RX J0700.6+6431	22	0.003	0.73±0.41	10.8	red-WK[c]	18.7	$07^h00^m36\overset{s}{.}5$ +64°32′09″
P10	RX J0657.6+6425	21	0.004	–0.22±0.35	16.0	3 candidates		
P11	RX J0652.1+6424	35	0.020	0.15±0.39	9.8	K star	14.5	$06^h52^m07\overset{s}{.}9$ +64°24′37″
P12	RX J0658.7+6423	20	0.008	0.73±0.20	51.4	FG star	11.5	$06^h58^m43\overset{s}{.}2$ +64°23′39″
P13	RX J0659.4+6422	20	0.002	0.23±0.47	14.2	red-WK	17.9–19.6	$06^h59^m23\overset{s}{.}7$ +64°22′11″
P14	RX J0657.9+6419	21	0.004	0.49±0.29	38.4	blue object[b]	19.8	$06^h57^m57\overset{s}{.}5$ +64°19′55″
P15	RX J0701.0+6417	22	0.005	0.59±0.30	22.0	red-WK[c]	18.4	$07^h01^m06\overset{s}{.}6$ +64°18′21″
P16	RX J0653.7+6413	30	0.009	1.00±0.00	10.0	5 candidates		
P17	RX J0701.7+6409	24	0.006	1.00±0.00	10.1	4 candidates		
P18	RX J0658.4+6408	22	0.003	0.70±0.36	12.9	?[d]	21.3	$06^h58^m29\overset{s}{.}2$ +64°08′49″
P19	RX J0700.7+6400	26	0.007	0.78±0.46	11.2	5 candidates		
P20	RX J0647.9+6339	20	0.006	0.64±0.56	11.1	2 candidates		

[a] The hardness ratio HR1 is defined as the normalized count difference $(N_{52-201} - N_{11-41})/ N_{11-201}$, where N_{a-b} denotes the number of counts in the PSPC between channels a and b

[b] Based on the positional coincidence, the classification of the optical objects according to the objective prism plate spectra, the hardness ratio of the X-ray emission and the F_X/F_{opt} ratio. LTS denotes late-type star, and Sy1 means Seyfert 1 galaxy. Spectral types of the stars are given in parenthesis. Notations of "EBL-WK" (weak blue object with emission lines) or "Red-WK" (weak red object) are descriptions of the objective prism spectra and indicate extragalactic objects (see Bade et al. 1995 for details on the object classification)

[c] Identification uncertain. Another optical object inside error circle

[d] The optical brightness and position is given for the only object in the X-ray error circle down to $B=22^m$

X-ray sources including those at the border of the box (P2, P3, P5, P6, P7, P8, P10, P11, P16).

2.2. ROSAT all-sky-survey observation

In addition to the dedicated pointed observations, ROSAT data are also available which were taken about three years before GRB 930704. The location of the burst pair was scanned during the ROSAT all-sky-survey between September 9 and 28, 1990 with a mean exposure time between 350–420 sec over the 6°, by 6° field. Using a maximum likelihood method we detected 29 X-ray sources in this field with a likelihood larger than 8 corresponding to a minimum detectable countrate of ≈0.01 cts/s. These sources are shown in Fig. 2 together with the COMPTEL and IPN location contours, and details of these sources are given in Table 3.

There is one X-ray source located in (or near) each error box, namely S8 (GRB 940301) and S12 (GRB 930704). Also, there are some additional sources within a few arcmin distance of the GRB error box (S9, S13, S15, S16).

2.3. X-ray variability

The only source detected in both, the all-sky-survey scanning and the pointed observation in April 1994, is the Seyfert 1 galaxy Zw VII 118 (= S13 = P4). Within the errors, this source is found to be constant between the two ROSAT observations.

All other X-ray sources detected in the ROSAT mosaic pointings (in particular all nine objects inside the GRB 940301 error box as well as the two sources inside the GRB 930704 error box) have intensities which are below the sensitivity threshold of the all-sky survey observation. This explains their non-detection in the all-sky survey data. As a consequence we can therefore only state that the pointed ROSAT observations performed four weeks after GRB 940301 did neither reveal any flaring nor any fading X-ray source as compared to the all-sky survey observation in 1990.

3. Optical data

The error regions of the X-ray sources were investigated at optical wavelengths using two existing data sets: (1) Photographic plates with objective prism spectra taken with the Hamburg Schmidt telescope on Calar Alto. In the Hamburg objective

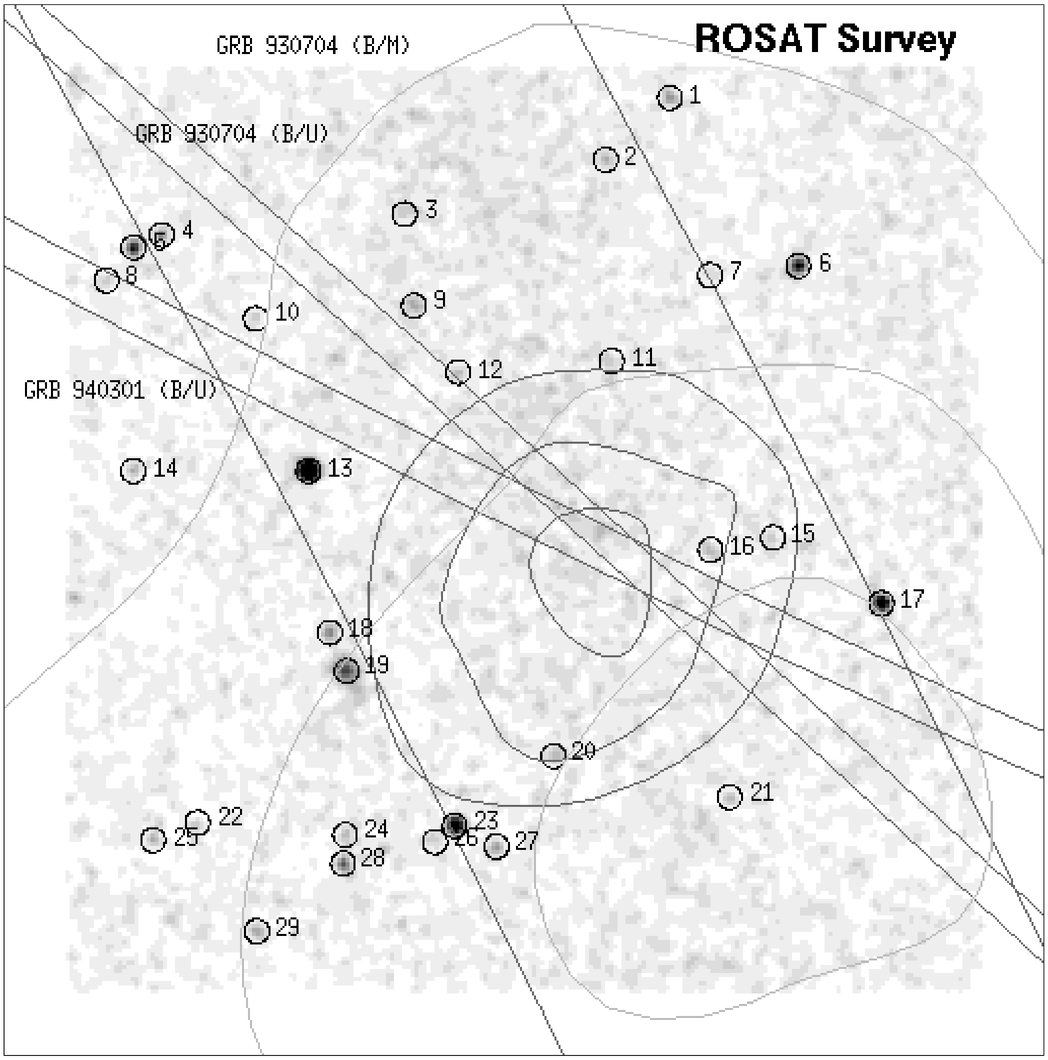

Fig. 2. Smoothed 6° by 6° ROSAT all-sky-survey image of the location of the GRB 930704/940301 burst pair. Circles denote X-ray sources with a likelihood greater than 8 and the numbers reference these sources according to Table 3. The COMPTEL 1 to 3σ contours are given as bold polygons near the center of the image for GRB 940301, and grey polygons for the less well localized GRB 930704, and the IPN arcs are labelled with the burst and B/U (BATSE/Ulysses) or B/M (BATSE/Mars Observer)

prism survey (Hagen et al. 1995) spectra are taken in the 3400–5400 Å range with a dispersion of 1390 Å/mm down to B $\approx$18.5. This survey covers the whole northern hemisphere for galactic latitudes (|bII| $>$20°). (2) The digital version of the Palomar Observatory Sky Survey (POSS) was used to check for the existence of objects fainter than B $\approx$18.5 as well as the colours of these objects.

The identification of the X-ray sources was done according to the positional correlation of the optical object with the X-ray position (which is accurate to typically less than 30″), the spectral information from the objective prism plates and using the knowledge of specific X-ray to optical intensity ratios for different classes of objects.

Among the X-ray sources detected during the pointed observation and located near the GRB error boxes, two have rather secure identifications: P11 is very probably a late-type star of spectral class K, and P1 has a 19th mag blue object inside the X-ray error circle with clearly detected emission lines which suggests a quasar identification. P1 is the second brightest source in the pointings and is just at the detection threshold for the 350 sec survey exposure time at this location. Though the optical (spectroscopic) identification is not complete, all of these X-ray sources inside or at the border of the GRB error boxes have at least one object with reasonable optical brightness inside the X-ray error box to expect no unusual nature for the X-ray source such as a fading GRB counterpart.

Among the securely identified X-ray sources detected in the all-sky survey observation is object S8 which is a V=15 mag M star, and S12 being correlated with the F5 star HD 50452. S13 is the above mentioned Seyfert 1 galaxy Zw VII 118 while the remaining other X-ray sources are correlated with coronal

Table 3. ROSAT X-ray sources from the all-sky survey observations. The error of the X-ray positions is identical for all sources due to the scanning mode (30″). Source S13 is identical to source P4 in Table 2. All other sources are different from those in Table 5

No.	Name	Countrate (cts/s)	Hardness ratio HR1[a]	ML	Identification[b]	m_B (mag)	Optical position (2000.0)
S1	RX J0644.1+6702	0.058	0.91±0.20	54.0	7 candidates		
S2	RX J0648.5+6639	0.041	0.60±0.34	25.1	LTS	10.5	$06^h48^m35\overset{s}{.}9$ +66° 39′12″
S3	RX J0701.7+6617	0.026	0.38±0.40	9.4	4 candidates		
S4	RX J0717.4+6603	0.073	–0.04±0.20	54.0	K star	13.0	$07^h17^m29\overset{s}{.}1$ +66° 03′39″
S5	RX J0719.2+6557	0.165	0.48±0.12	126.1	CV		
S6	RX J0636.3+6554	0.196	–0.96±0.05	162.9	blue object [c]	19.5	$06^h36^m22\overset{s}{.}7$ +65° 54′15″
S7	RX J0642.0+6552	0.015	1.00±0.00	9.7	4 candidates		
S8	RX J0720.7+6543	0.023	1.00±0.00	15.0	M star	16.7	$07^h20^m41\overset{s}{.}5$ +65° 43′19″
S9	RX J0701.0+6541	0.046	0.29±0.27	24.5	K star	13.5	$07^h01^m02\overset{s}{.}2$ +65° 41′50″
S10	RX J0711.0+6533	0.015	1.00±0.00	8.8	K star	16.5	$07^h11^m03\overset{s}{.}9$ +65° 34′10″
S11	RX J0648.4+6520	0.018	1.00±0.00	12.8	LTS	11.7	$06^h48^m27\overset{s}{.}6$ +65° 20′57″
S12	RX J0658.1+6516	0.031	–0.30±0.39	9.5	HD 50452 (F5)	9.1	$06^h58^m09\overset{s}{.}3$ +65° 16′20″
S13	RX J0707.2+6435	0.858	0.28±0.06	998.2	Zw VII 118 (Sy1)	14.6	$07^h07^m13\overset{s}{.}0$ +64° 35′59″
S14	RX J0717.8+6430	0.036	0.70±0.23	23.6	QSO	17.7	$07^h17^m53\overset{s}{.}9$ +64° 30′48″
S15	RX J0638.9+6408	0.027	0.36±0.35	13.3	HD 46606 (K2)	8.9	$06^h38^m57\overset{s}{.}1$ +64° 09′23″
S16	RX J0642.7+6405	0.040	0.17±0.30	18.6	HD 47373 (K0)	8.9	$06^h42^m46\overset{s}{.}2$ +64° 05′46″
S17	RX J0632.7+6340	0.304	0.92±0.04	370.6	MCG+11-08-054	13.3	$06^h32^m47\overset{s}{.}9$ +63° 40′25″
S18	RX J0705.4+6333	0.079	0.15±0.22	43.9	2E 0700.7+6338 (Sy1)	15.4	$07^h05^m29\overset{s}{.}3$ +63° 33′32″
S19	RX J0704.3+6318	0.191	0.98±0.08	71.2	Galaxy [d]	17.2	$07^h04^m23\overset{s}{.}6$ +63° 18′30″
S20	RX J0652.2+6246	0.030	–0.68±0.38	8.1	M star[e]	15.3	$06^h52^m16\overset{s}{.}8$ +62° 47′10″
S21	RX J0642.3+6228	0.021	1.00±0.00	10.5	K star	13.3	$06^h42^m16\overset{s}{.}9$ +62° 28′49″
S22	RX J0712.4+6216	0.021	1.00±0.00	17.4	HD 54318 (B9)[f]	8.0	$07^h12^m28\overset{s}{.}0$ +62° 15′46″
S23	RX J0657.9+6219	0.304	0.05±0.10	192.7	LHS 1885 (M)	15.6	$06^h57^m55\overset{s}{.}0$ +62° 19′42″
S24	RX J0704.0+6214	0.040	0.43±0.43	15.6	K or M star		
S25	RX J0714.8+6208	0.046	0.02±0.29	25.7	HD 54943 (G0)	8.5	$07^h14^m54\overset{s}{.}0$ +62° 08′14″
S26	RX J0659.0+6212	0.019	1.00±0.00	10.5	FG star[e]	14.4	$06^h58^m59\overset{s}{.}7$ +62° 13′17″
S27	RX J0655.5+6211	0.053	0.24±0.30	16.6	HD 50054 (G5)	9.2	$06^h55^m38\overset{s}{.}1$ +62° 11′32″
S28	RX J0704.1+6203	0.104	0.08±0.19	64.0	red object[g]	20.2	$07^h04^m09\overset{s}{.}9$ +62° 03′27″
S29	RX J0708.7+6135	0.057	–0.35±0.25	28.4	M star	16.5	$07^h08^m45\overset{s}{.}0$ +61° 35′19″

[a] and [b] See corresponding notes below Table 2

[c] This blue object (B–V<–0.5) is the only one in the X-ray error circle. The extreme softness in X-rays together with the F_X/F_{opt} ratio suggests a magnetic cataclysmic variable (AM Her type) classification

[d] The X-ray emission is extended, suggesting one of the three galaxies within the X-ray error box to be the counterpart. The most probable object (due to brightness and orientation) is given in the fifth and sixth column

[e] Identification uncertain. Other object(s) in the X-ray error circle

[f] This is the only object in the X-ray error box, though late B stars usually are thought to be X-ray quiet (Berghöfer & Schmitt 1994). Either the X-rays are produced by an optically invisible companion or the interaction with it, or the optical counterpart would by very faint (below B=22 mag) implying a ratio of L_X/L_{opt} larger than 20

[g] Most of the X-ray photons came in a flare, thus this red object (B–V=2.3) is probably a M star

emission from late-type (mostly K type) stars. Thus, none of these objects is thought to be a quiescent GRB counterpart.

4. Discussion

4.1. GRB 930704 and GRB 940301 as two independent classical GRBs

In the case of GRB 930704 and GRB 940301 being two separate bursts, the much wider error boxes of the individual bursts (about 6° and 2° along the triangulation arcs of GRB 930704 and GRB 940301, respectively) contain several X-ray sources. A correlation of one of these X-ray sources to the respective burst remains unresolved at this state. Though firm conclusions have to awit the complete optical identification of all the X-ray sources found in the error boxes, earlier identification work in small interplanetary network locations support the suspicion that none of the X-ray sources might be related to either GRB.

4.2. GRB 930704 and GRB 940301 from one repeating burst source

In the case of the interpretation of the GRB 930704 / GRB 940301 burst pair being due to a single repeating source (and thus the location being determined by the two crossing BATSE/Ulysses triangulation arcs of the individual burst events), the source P11 is the only X-ray source which is compatible with the burst location (just inside the 3σ location). This source has also been detected in a 10 ksec ASCA observation (Murakami et al. 1996). Using the ROSAT values of the countrate and hardness ratios, and assuming a Raymond-Smith spectrum of about 1–2 keV appropriate for a late-type star we estimate an expected ASCA GIS countrate of 0.002 cts/s. This is somewhat lower than the observed rate of 0.008 cts/s (Murakami et al. 1996), but due to the unknown spectral shape not inconsistent. The ASCA data have the potential of checking the thermal nature of the X-ray spectrum which is expected from a K star.

Since the ROSAT source P11 is presumably a K star and thus not thought to be a GRB counterpart, we determine an upper limit for the quiescent X-ray emission of the hypothetical burst repeater at the position of the shortest exposure time of 0.005 cts/s. At a galactic latitude of bII = 22–26° the interstellar absorption in the direction of the burst pair is already reasonable small ($N_H = 4–7\times10^{20}$ cm^{-2}, Dickey & Lockman 1990). Using this absorption and a –2.2 powerlaw photon index results in a corresponding upper flux limit of 1×10^{-13} erg/cm^2/s.

There are two alternatives about the possible nature of a bursting repeater: (1) A Soft Gamma Repeater or (2) a classical burst which emits more than one burst. Though a Soft Gamma Repeater nature is already unlikely on grounds of the observed γ-ray spectrum and temporal profile, we elaborate case (1) in more detail. The quiescent luminosity of the X-ray source associated with the soft gamma repeater SGR 1806–20 was measured with ASCA to be of the order of 10^{35} erg/s in the 0.5–10 keV range (Sonobe 1994). A similar hypothetical, quiescent 10^{35} erg/s source at the location of the burst pair would have to be at a distance larger than 50 kpc, incompatible with the association with a galactic supernova remnant as is generally believed to be the case for SGRs. Thus, the quiescent hypothetical repeater at the location of the GRB pair is rather certainly different from the repeater source in SGR 1806–20 (and similarly SGR 0525–66). While one can argue that the two burst events were distinctly different from soft repeater events in their temporal and spectral characteristics, our data only constrain the quiescent source nature. Even if one allows this hypothetical quiescent repeater source to be different from the SGRs, then still the flaring to quiescent flux ratio of at least $\approx10^7$ (determined by extrapolating the GRB 940301 gamma-ray spectrum to the ROSAT energy range with the flattest slope allowed by the COMPTEL data, Hanlon et al. 1995) is a stringent constraint on its nature.

4.3. The variability limit

The fact that there is also no fading X-ray source, i.e. bright before the γ-ray burst and faint afterwards, has consequences for the γ-ray burst model involving slowly accreting neutron stars in which a shock accompanied with the γ-ray burst would prevent accretion onto the neutron star for a time span of several years following the burst (Lasota 1992). As detailed in Greiner et al. (1995) for the case of GRB 920622 this allows to constrain the pre-burst accretion rate of the neutron star to (assuming a 10^6 K blackbody and the total galactic absorbing column in the direction of the GRB locations)

$$\dot{M} \leq 1.5\times10^{-17} \left[\frac{R}{(10\,\mathrm{km})}\right] \left[\frac{M_{\rm NS}}{M_\odot}\right]^{-1} \left[\frac{D}{(100\,\mathrm{pc})}\right]^{2} \mathrm{M}_\odot\,\mathrm{yr}^{-1}.$$

Thus only for distances larger than $\approx$300 pc would the accretion rate be high enough to trigger a hydrogen flash (Hameury et al. 1983).

5. Summary

Independent of the relation of GRB 930704 to GRB 940301, the pointed ROSAT observation of the error box of the latter GRB exactly 4 weeks after the γ-ray event reveals no flaring/fading X-ray counterpart (upper limit of 0.005 PSPC cts/s).

While a gravitational lensing origin of the GRB 930704 / GRB 940301 pair has been excluded already earlier (Hanlon et al. 1995), the detection of a single repeater source is an a priori not excluded alternative to a random spatial coincidence of two bursts. However, this hypothetical repeater would cause problems at different distance scales. For cosmological distances most of the scenarios involving catastrophic events would be ruled out, whereas for galactic distances a similar nature as the SGR sources can be excluded by our ROSAT data. We mention that a SGR nature is also unlikely due to γ-ray properties of both bursts.

In both cases, a lower limit on the flaring to quiescent flux ratio of $\approx10^7$ has to be accomplished by a repeater source.

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References

Bade N., Fink H.H., Engels D., et al., 1995, A&AS 110, 469
Berghöfer T.W., Schmitt J.H.M.M., 1994, A&A 292, L5
Dickey J.M., Lockman F.J., 1990, ARA&A 28, 215
Greiner J., Sommer M., Bade N., et al., 1995, A&A 302, 121

Hagen H.J., Groote D., Engels D., Reimers D., 1995, A&AS 111, 195
Hameury J.M., Bonazzola S., Heyvaerts J., 1983, A&A 121, 259
Hanlon L.O., Hermsen W., Kippen R.M., et al., 1995, A&A 296, L41
Kippen R.M., Bennett K., Connors A., et al., 1995, A&A 293, L5
Lasota J.-P., 1992, in: "Gamma-ray bursts", Ho C. et al. (ed.). Cambridge Univ. Press, p. 17
Murakami T., et al., 1996, Proc. 3rd Huntsville Gamma-Ray Burst Workshop, AIP (in press)
Paczyński B., 1986, ApJ 308, L43
Paczyński B., 1991, Acta Astronomica 41, 257
Sonobe T., Murakami T., Kulkarni S.R., Aoki T., Yoshida A., 1994, ApJ 436, L23
Woosley S., 1993, ApJ 405, 273
Zimmermann H.U., Becker W., Belloni T., et al., 1994, MPE report 257

Note added in proof: A recent improvement in the localisation of GRB 930704 has been reached by including data from the Mars Observer (MO). The new error box as determined from the crossing of the Ulysses/BATSE and MO/BATSE triangulation rings is only marginally consistent with the COMPTEL location of GRB 940301, thus suggesting that these two bursts are possible not related to one single source (Laros et al. 1996, subm. to ApJ).

The source S5 = RX J0719.2+6557 (see Table 3) has been spectroscopically identified as magnetic cataclysmic variable (polar type), and the position of the optical counterpart is (equinox 2000.0) RA = $0.7^h19^m14\overset{''}{.}0$, Decl. = $65°57'48''$(Tovmassian, Greiner, Zickgraf et al. 1996, in Accretion Phenomena and Associated Outflows, Proc. of IAU Coll. 163, in press).