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*Research Note*

# A serendipitous observation of the gamma-ray burst GRB 921013b field with EUVE

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**Abstract.** We report a serendipitous extreme ultraviolet observation by *EUVE* of the field containing GRB 921013b, $\sim 11$ hours after its occurrence. This burst was detected on 1992 October 13 by the WATCH and PHEBUS on *Granat*, and by the GRB experiment on *Ulysses*. The lack of any transient (or quiescent) EUV source imposes a $2\sigma$ upper limit of 1.3 $\times 10^{-12}\,\mathrm{erg\,s^{-1}\,cm^{-2}}$ in the 58–174 Å bandpass. In the likely case that GRB 921013b was extragalactic, and assuming the existence of an X-ray afterglow similar to those observed for GRB 970228 and GRB 970828, the resulting EUV flux 11 hours after the burst is 1.8 $\times 10^{-16}\,\mathrm{erg\,s^{-1}\,cm^{-2}}$ after correction for absorption by the Galactic interstellar medium. Even if we exclude an intrinsic absorption, this is well below the detection limit of the *EUVE* measurement. Although it is widely accepted that gamma-ray bursts are at cosmological distances, if the source of GRB 921013b would be a galactic neutron star, the data presented here place a lower limit to its distance of $\sim 30$ pc.

**Key words:** gamma rays: bursts – ultraviolet: ISM

## 1. Introduction

On 1992 October 13, 23:00:42 UT, the all-sky X-ray monitor WATCH on board the *Granat* satellite (Lund 1986) was triggered by a 50 s long transient high-energy event in the 8-60 keV WATCH energy range (Sazonov et al. 1998), with a peak flux $F_{(8-60\ \mathrm{keV})}$ = (3.5 ± 1.3)$\times 10^{-6}\,\mathrm{erg\,s^{-1}\,cm^{-2}}$, and fluence $S_{(8-60\ \mathrm{keV})}$ = (3.1 ± 0.2) $\times 10^{-5}\,\mathrm{erg\,cm^{-2}}$. This is the largest fluence of any of the $\sim 70$ bursts detected by WATCH. GRB 921013b was also detected by PHEBUS on *Granat* and by the Gamma-ray Burst Detector on *Ulysses* (Hurley et al. 1992). PHEBUS recorded a fluence of $S_{(\geq 100\ \mathrm{keV})} = (6.9 \pm 2.6) \times 10^{-5}$ $\mathrm{erg\,cm^{-2}}$ for a 15 s long event (Terekhov et al. 1995). The position of the burst was determined by WATCH to be R.A.(2000) = 7h50m50.4s, Dec(2000) = +33° 24' 36" ($l^{II}$ = 187°, $b^{II}$ = 26°) with a $3\sigma$ error radius of 0°.32. The combination of the *Ulysses* and PHEBUS data (Barat 1998) provided an annulus that led to an improvement of the GRB error box.

Here we present the results of a search performed in the *EUVE* database in order to find observations close in time to the 55 events localized by the WATCH detectors on board *Granat* and *Eureca* (Sazonov et al. 1998; Brandt, Lund and Castro-Tirado 1995). A similar search for bursts detected by the Third Interplanetary Network was carried out by Hurley et al. (1995).

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**Table 1.** WATCH GRBs close-in-time to EUVE passages.

| GRB | EUVE passage (days) |
|---|---|
| 920918 | −22 |
| 930614 | −10 |
| 920718a | −6 |
| 921013b | +0.46 |
| 920714 | +21 |
| 920902 | +24 |
| 921013a | +25 |
| 920814 | +26 |
| 921118 | +45 |

## 2. Observation and data analysis

An overview of the *EUVE* instrumentation can be found in Bowyer & Malina (1991). Table 1 displays the bursts detected by WATCH which occurred close in time to the passages of *EUVE* during the all sky survey phase, carried out between 1992 July and 1993 January. No near-simultaneous observations were found, with the exception of GRB 921013b. *EUVE* serepinditously observed the location of GRB 921013b between 12 Oct 1992 (12:25:35 UT) and 17 Oct 1992 (23:45:38 UT). There were scans of the target area beginning on 14 Oct (10:02 UT, 11-hr after the burst), but no source was seen in the field of view for the entire interval of *EUVE* coverage, in the 100, 200, 400, or 600 Å *EUVE* bandpasses. We extracted from the *EUVE* all-sky survey archive the 100 Å-band photon images for each sweep of the *EUVE* telescopes past the position of GRB 921013b. From each image we determined the maximum point-spread function (PSF)–convolved count rate. From these rates and their statistical errors, we determined 2-$\sigma$ upper limits to the observed count rates.

## 3. Discussion

The X-ray spectrum of GRB 921013b as seen by WATCH on *Granat* (8-60 keV) can be very roughly approximated by a power law, N(E) $\sim 1.1 \times (E/1\,keV)^{-1.5}$ $\mathrm{ph\,cm^{-2}\,s^{-1}\,keV^{-1}}$. If we extrapolate the spectrum to the *EUVE* 58-174 Å bandpass, we obtain $F_{(58-174\,\text{Å})} \sim 7 \times 10^{-10}\ \mathrm{erg\,cm^{-2}\,s^{-1}}$ which is the flux *simultaneous* with the GRB assuming no interstellar or intrinsic absorption. The *EUVE* observation took place 11.0-hours after the high energy event. Assuming the presence of an X-ray afterglow with a decaying flux following $t_{\mathrm{min}}^{-1.35\pm0.05}$ as seen in GRB 970228 (Costa et al. 1997), GRB 970828 (Murakami et al. 1997, Greiner et al. 1997) and GRB 980329 (in´t Zand et al. 1998), the unabsorbed flux that should have been detected by EUVE 11.0-hours later is $F_{(58-174\,\text{Å})} \sim 1.1 \times 10^{-13}\ \mathrm{erg\,cm^{-2}\,s^{-1}}$ or $\sim 0.015$ counts $\mathrm{s^{-1}}$. This is one order of magnitude *below* the 2-$\sigma$ upper limit for the flux after the first *EUVE* pass, $F_{(58-174\,\text{Å})} \sim 1.3 \times 10^{-12}\ \mathrm{erg\,cm^{-2}\,s^{-1}}$.

By summing the images over several passes scaled by the inverse of the assumed decay ($t^{-1.35}$), we can place a limit on the EUV flux *simultaneous* with the burst. We calculate this $2\sigma$ limit to be $\leq 680$ counts $\mathrm{s^{-1}}$ or $5.1 \times 10^{-9}$ erg $\mathrm{cm^{-2}\,s^{-1}}$. This is well above the expected value of $\sim 7 \times 10^{-10}$ erg $\mathrm{cm^{-2}\,s^{-1}}$.

For astronomical sources, absorption due to the interstellar medium will reduce the observed flux from the source. If the burster were a nearby neutron star, absorption from the local cloud surrounding the Sun would contribute an absorbing hydrogen column of $\sim 10^{18}$ $\mathrm{cm^{-2}}$. Using the effective cross sections of Rumph et al (1994), and assuming the local helium is 25% ionized (Dupuis et al. 1995), we find that this absorption has a negligible effect on our limits. If we assume that the source is more distant (either in the Galaxy or extragalactic), we must consider the absorption due to the galactic interstellar medium. The galactic HI column along this line of sight is $\sim 5.1 \times 10^{20}$ $\mathrm{cm^{-2}}$ (Stark et al. 1992). The resulting absorbed EUV flux 11.0-hours after the burst is then $F_{(58-174\text{Å})} \sim 1.8 \times 10^{-16}\ \mathrm{erg\,cm^{-2}\,s^{-1}}$ or $\sim 1.6 \times 10^{-5}$ counts $\mathrm{s^{-1}}$. This value is well below the detection limit of the EUV measurement. We have not included here the effect of intrinsic absorption which we know is present in GRB 970828 (Groot et al. 1998) and GRB 980329 (Palazzi et al. 1998). Therefore any fading source lying in the Galaxy or at cosmological distances would have been beyond the reach of *EUVE*.

Let us assume that the object responsible for the burst is a galactic neutron star. What constraints can we place on the basis of the *EUVE* observation? We have calculated the expected fluxes at Earth from a neutron star with 1 $M_{\odot}$ and 10 km radius, as a function of its absorption, distance and temperature, following Hurley et al. (1995) and Pizzichini et al. (1986). The results are shown in Fig. 1. It is obvious that if a neutron star is the counterpart, it would have had to be distant or heavily absorbed to escape detection. A lower limit of $\sim 30$ pc (for T $\sim 2 \times 10^5$ K and $N_{\mathrm{H}} \sim 10^{18}$) can be derived. This corresponds to a height above the plane of $\sim 15$ pc.

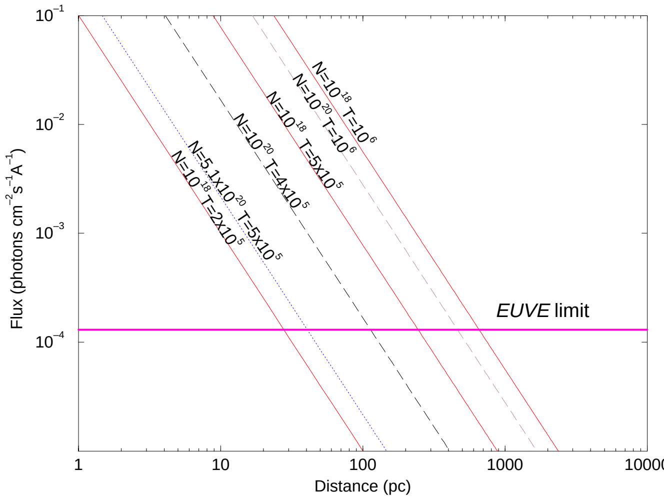


**Fig. 1.** The obtained *EUVE* sensitivity (*horizontal thick line*) compared with the fluxes (58-174 Å) for neutron stars as function of distance, temperature and hydrogen column.

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