Magnetic Stars, 2011, pp. 440 – 443

The Precursor of GRB 080319B

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Abstract. The results of radio observations of GRB 080319B in the spectral range of 8.45 GHz are presented. The data corresponds to the phase of the afterglow. The observations were made at the telescopes of Zelenchuk and Svetloe observatories of the Institute of Applied Astronomy of RAS. Two episodes of radiobrightness increase of the afterglow of GRB 080319B were discovered. The radio flares are interpreted taking into account the orientation of the relativistic plasma jets to the line–of–sight.

Key words: Gamma–rays – bursts: observations – radio: individual: GRB 080319B

1 Introduction

Gamma–ray bursts (GRBs) are the most luminous explosions currently known in the Universe. Roughly 30 years have elapsed between the discoveries of GRBs in gamma–rays and their counterparts in the optical and X–ray wavelengths. These so–called afterglows were first found for GRB 970228, and a couple of months later the first radio afterglow was found in the case of GRB 970508. For the latter one the redshift of 0.835 was determined which showed that GRBs originate at cosmological distances. GRB afterglows are found to be located within the bright star forming regions of their host galaxies. In some cases GRBs are proved to coincide with the core collapse supernovae (SNe) (Sokolov et al., 2003; van der Horst, 2005 and references therein).

2 Observations

As the afterglows of GRBs are extremely weak at centimetre wavelengths, the observations of radio afterglows at these wavelengths usually requires sensitivity that only a few radiotelescopes have, i. e. the Very Large Array (VLA), the Australia Telescope Compact Array (ATCA) and the Westerbork Synthesis Radio Telescope (WSRT). Only unique events like GRB 030329 with $z = 0.1685$ make it also possible for other radiotelescopes to perform the follow–up. Three days after the burst GRB 080319B was detected at 4.9 GHz by the VLA (189 ± 39 microJy) and WSRT (163 ± 39 microJy) (GCN Circ. 7506, 7507) in spite of the fact that the redshift of 080319B did not look promising ($z = 0.937$) the long term monitoring of this object was carried out with the RTF–32 telescopes at Svetloe and Zelenchukskaya. The series of 148 observations were held at the wavelengths of 3.5 cm, 6.4 cm and 13 cm. Smooth angular scanning was used not only in GRB 080319B observations, but to specify the primary standard source radio flux density as well (Kharinov et al., 2010). The first radio flare was registered on March 28, seven days after the gamma burst event itself. The maximum radio flux at 8.45 GHz reached 44 ± 12 mJy. Almost two months later the second radio flux increase was registered. During six and a half hours the radio flux density was growing from 19 mJy to 34 mJy.

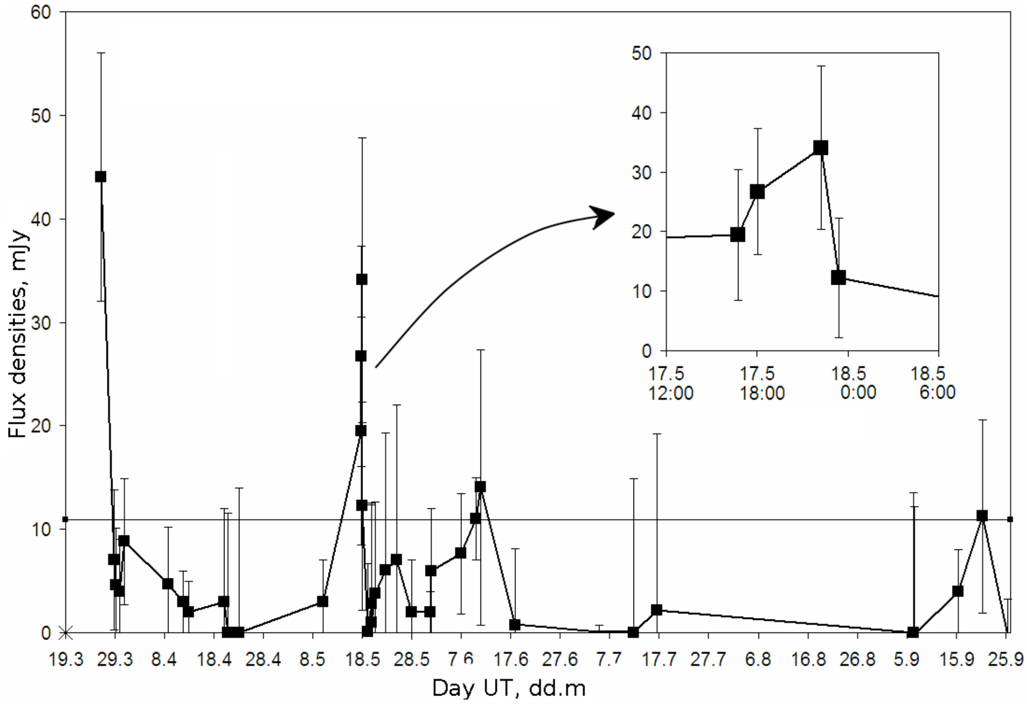

Figure 1:

Later on the source revealed a variability within 3σ with a characteristic period of 9 – 10 days. The data obtained at 3.5 cm are presented at Fig. 1.

3 Discussion

The discovered radio flares can be interpreted in terms of the interaction of accelerated plasma jets with inhomogeneous circumburst matter. If this inhomogeneity was originated by the mass loss of the GRB progenitor prior to the explosion, it is quite reasonable to suggest the shell structure of the surrounding matter. Such shells in the stellar wind, ejected by SNe precursors are not uncommon and are observed in planetary nebulae. It is possible that the second radio flare is due to the interaction of the relativistic jet, directed from the observer with the circumburst shell, while the first detected radio flux was originated by the interaction of the jet directed exactly towards the Earth. The supposition of the exclusive GRB 090319B space orientation can be supported by its outstanding optical observations. The optical brightness of such a distant cosmological object was quite impressive (Fig. 2). GRB 080319B could be observed even with the naked eye! At every definite moment after the burst the light echo surface is a paraboloid with the focus in the centre of the explosion and its axis directed towards the observer. The case when the relativistic jet coincides with the paraboloid axis is presented in Fig. 3. The light echo surfaces are presented for both observed radio flares. If we accept that the GRB is surrounded with the quasispherical shell denser then the mean interstellar medium, it is possible to explain the discovered radio fluxes to be generated in the regions of the shell subjected to the interaction with the relativistic plasma jets. In case if the second radioflare is caused by the jet directed from the observer, the radius of the circumburst shell can be estimated as $7.5 \cdot 10^{16}$ cm. As after the first observed radio flare a rather regular monitoring did not reveal any significant increases in the radio flux of the object up to May 17, the jet opening half–angle can be also estimated in the framework of this geometrical model. The maximum possible opening half–angle for the jet directed towards the observer is 40°.

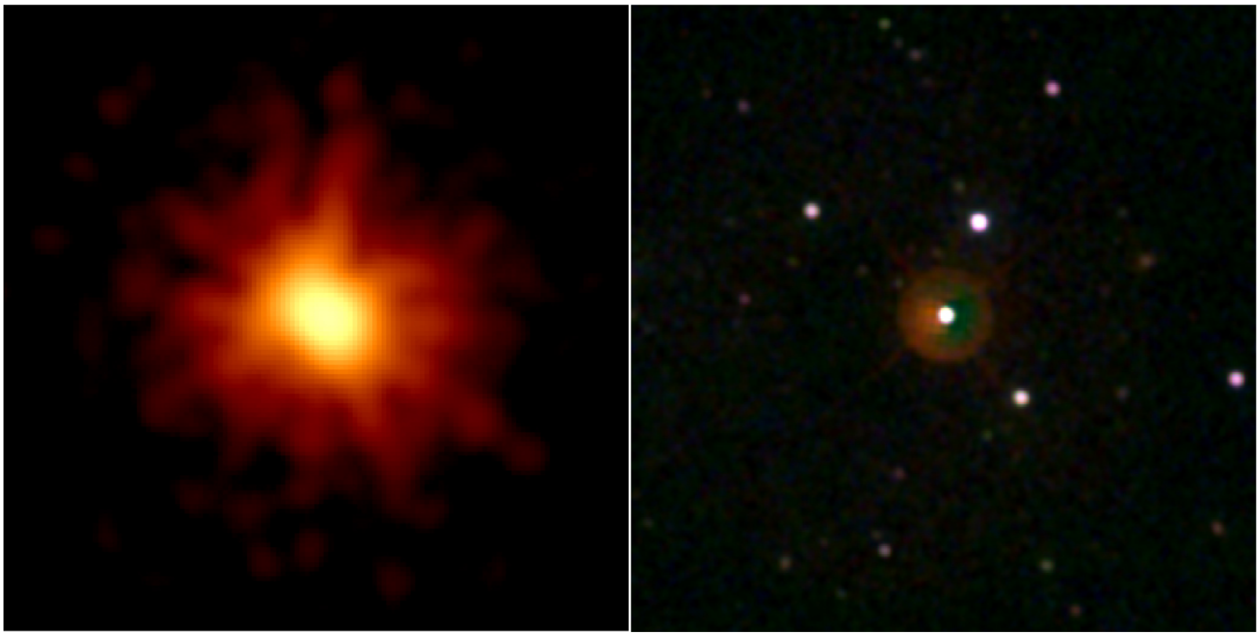

Figure 2:

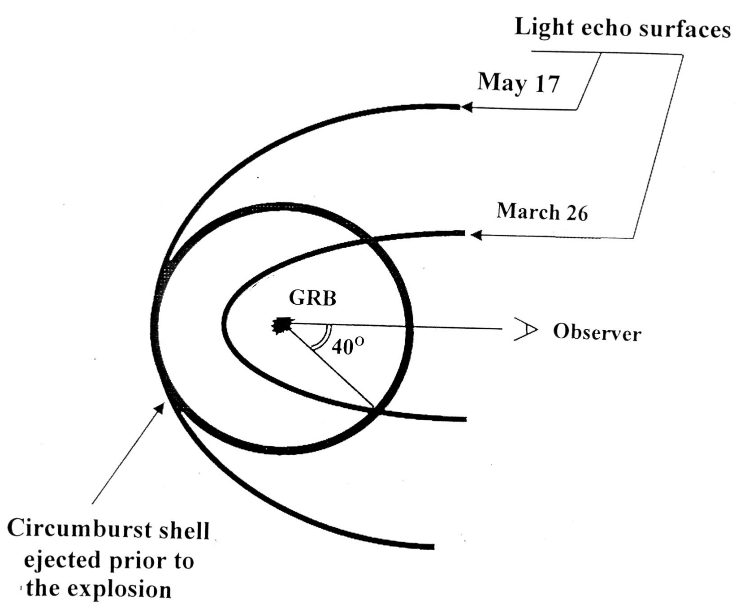

Figure 3:

References

Kharinov M. A., Finkelstein A. M., Ipatov A. V., Tsiopa O. A., Gnedin Yu. N., Piotrovich M. Yu., 2010, Astron. Rep., 54, 853

Sokolov V. V., Fatkhullin T. A., Komarova V. N., Kurt V. G., Lebedev V. S., Castro–Tirado A. J., Guziy S., Gorosabel J., de Ugarte Postigo A., Cherepaschuk A. M., Postnov K. A., 2003, Bull. Spec. Astrophys. Obs., 56, 5

Van der Horst A. J., 2005, Memorie della Società Astronomica Italiana, 76, 635