Long-term Radio Observations of GRB 080319B and GRB 110328A

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The radio afterglows of GRBs can be observed with rather modest telescope. Long-term observations are possible up to $z \sim 1$ (GRB080319B).

The data obtained by radio telescopes IPA RAS for GRB 112803A proved to be in good agreement with the results presented by VLBA and GARMA teams. The long-term radio emission from GRB 080319B and GRB 110528A is interpreted taking into account the orientation of the relativistic plasma jets to the line-of-sight.
Instruments:

Radiotelescope RTF 32 (32 m)  
Frequency 8.45 GHz (3.5 cm)  
Zelenchukskay, Noth Caucasus
Naked eye GRB 08 03 19B
m=5.6 mag (peak brightness)
Radio afterglow of GRB 080319B

- \( z = 0.937 \)
- 3 days after burst

VLA: \( 189 \pm 39 \) microJy (4.9 GHz),
WSRT: \( 163 \pm 39 \) microJy (4.9 GHz)
(Westerbork Synthesis Radio Telescope)

- Long term monitoring.

Institute of Applied Astronomy: Svetloye and Zelenchukskaya, RTF-32
Interaction of jet with single shell

Light echo

radio burst 2

radio burst 1

GRB

θ₀

Circumburst shell ejected prior to the explosion
Results and interpretation

- 8.45 GHz
- March 26: $F=44 \pm 12\text{mJy}$
- May 17: $F=34 \pm 12\text{mJy}$
- Blastwave interaction with circumburst medium inhomogenities at scales of $10^{16}$ cm
## GRB 110328A: radio flux (mJy)

<table>
<thead>
<tr>
<th>T-T&lt;sub&gt;0&lt;/sub&gt; (d)</th>
<th>Date</th>
<th>UT</th>
<th>ΔT (h)</th>
<th>Flux (mJy)</th>
<th>σ</th>
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<tbody>
<tr>
<td>39</td>
<td>2011-05-16</td>
<td>02:44</td>
<td>2</td>
<td>11±4</td>
<td>2.8</td>
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<tr>
<td>75</td>
<td>2011-06-20</td>
<td>21:36</td>
<td>3</td>
<td>20±7</td>
<td>2.9</td>
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<td>80</td>
<td>2011-06-25</td>
<td>22:45</td>
<td>4</td>
<td>14±4</td>
<td>3.5</td>
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<td>95</td>
<td>2011-07-10</td>
<td>22:00</td>
<td>3</td>
<td>12±5</td>
<td>2.4</td>
</tr>
<tr>
<td>102</td>
<td>2011-07-17</td>
<td>20:45</td>
<td>3</td>
<td>12±4</td>
<td>3.0</td>
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<td></td>
<td><strong>VLBA 45 GHz</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>22 GHz</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>115</td>
<td>2011-07-30</td>
<td>18:44</td>
<td>2</td>
<td>23±7</td>
<td>3.3</td>
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<td>155</td>
<td>2011-09-08</td>
<td>19:00</td>
<td>3</td>
<td>13±4</td>
<td>3.3</td>
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<td>158</td>
<td>2011-09-11</td>
<td>19:00</td>
<td>3</td>
<td>17±5</td>
<td>3.4</td>
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</table>

Below is a graph showing the radio flux over time, with markers for various dates and times, indicating the intensity of the flux at those times.
Interpretation of the radio bursts

**Stage 1:** interaction of jet with the inner shell
Dynamic of the radio bursts

Stage 2: interaction of the opposite jet with the inner shell
Dynamic of the radio bursts

Stage 3: interaction of jet with the outer shell
Dynamic of the radio bursts

Stage 4: interaction of the opposite jet with the outer shell
Interaction of jets with multiple shells: times and scales

For GRB 110328A:
\[ R_1 = 5 \times 10^{16} \text{ cm} \]
\[ R_2 = 2 \times 10^{17} \text{ cm} \]

1 – April: 1st radio burst
2 – May: 2nd radio burst
3 – June-July: 3rd radio burst
4 – September: 3rd radio burst
Times of the shocked plasma exhausting

Recombination time:
\[ \tau = [n_e^2 \alpha(T)]^{-1} \]

\[ \alpha = 10^{-14} \text{ cm}^3 \text{ s}^{-1} \]

\[ T_e = 10^6 - 10^7 \text{ K} \]

<table>
<thead>
<tr>
<th>( n_e \text{ [cm}^{-3} )</th>
<th>( \tau )</th>
</tr>
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<tbody>
<tr>
<td>( 10^4 )</td>
<td>12 days</td>
</tr>
<tr>
<td>( 2 \times 10^4 )</td>
<td>3 days</td>
</tr>
<tr>
<td>( 3 \times 10^4 )</td>
<td>1 day</td>
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</table>
Challenges

- Can we detect the opposite jet?
- Is the radio emission in GRBs similar to RSN?
- Can we see light echoes?
- Can multiple shells model explain the several maxima in the GRB radio afterglow?
Thank you!