CATCHING GRB ORPHAN AFTERGLOWS FROM GAIA TRIGGERS

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Special thank to: J. Japelj & G. Ghirlanda
GAMMA-RAY BURSTS

Ultra-relativistic jets associated with black holes formation
merging of compact objects massive star explosion
LGRBs / CCSNe connection

LONG GRBS ASSOCIATED WITH SN TYPE IC-BL

LONG GRBS ASSOCIATED WITH MASSIVE STARS
AFTERGLOW SPECTROSCOPY

- Study the disk / star-forming region gas
AFTERGLOW SPECTROSCOPY

- Study the disk / star-forming region gas
AFTERGLOW SPECTROSCOPY

- at any $z!$ (record holder $z=8.2$)
AFTERGLOW SPECTROSCOPY

- at any z! (record holder z=8.2)
AFTERGLOW SPECTROSCOPY

- Study the disk / star-forming region gas
- Time variation of fine structure lines: gas cloud distances
- > 50pc (hard X-ray ionisation at smaller radii)
GAMMA-RAY BURST ORPHAN AFTERGLOWS

Norph \sim N_{\text{grb}}(2/\theta^2)

\sim 300 orphan afterglows for each on-axis GRB!
GAMMA-RAY BURST ORPHAN AFTERGLOWS

Expected Gaia light-curve
### ORPHAN AFTERGLOWS & SURVEYS

Gaia can see them!

<table>
<thead>
<tr>
<th>Survey</th>
<th>FOV $^{(\text{deg}^2)}$</th>
<th>Cadence</th>
<th>$F_{lim}$ (mJy)</th>
<th>Coverage (deg$^2$ night$^{-1}$)</th>
<th>Lifetime days</th>
<th>$\mathcal{P}_{OA}$ (deg$^2$ yr$^{-1}$)</th>
<th>$\langle T \rangle$ days</th>
<th># OA yr$^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTF</td>
<td>7.8</td>
<td>1m–5d</td>
<td>$1.17 \times 10^{-2}$</td>
<td>1000</td>
<td></td>
<td>$1.5 \times 10^{-3}$</td>
<td>1[0.2-3.8]</td>
<td>1.5</td>
</tr>
<tr>
<td>ROTSE–II</td>
<td>3.4</td>
<td>1d</td>
<td>$1.17 \times 10^{-1}$</td>
<td>450</td>
<td></td>
<td>$5.2 \times 10^{-4}$</td>
<td>0.4[0.1-1.7]</td>
<td>0.1</td>
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<tr>
<td>CIDA–QUEST</td>
<td>5.4</td>
<td>2d–1yr</td>
<td>$4.60 \times 10^{-2}$</td>
<td>276</td>
<td></td>
<td>$8.0 \times 10^{-4}$</td>
<td>0.5[0.1-2.3]</td>
<td>0.1</td>
</tr>
<tr>
<td>Palomar–Quest</td>
<td>9.4</td>
<td>0.5h–1d</td>
<td>$1.17 \times 10^{-2}$</td>
<td>500</td>
<td>2003–2008</td>
<td>$1.5 \times 10^{-3}$</td>
<td>1[0.2-3.8]</td>
<td>0.8</td>
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<tr>
<td>SDSS–II SS</td>
<td>1.5</td>
<td>2d</td>
<td>$2.68 \times 10^{-3}$</td>
<td>150</td>
<td>2005–2008</td>
<td>$3.2 \times 10^{-3}$</td>
<td>1.6[0.4-6.3]</td>
<td>0.8</td>
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<tr>
<td>Catilina</td>
<td>2.5</td>
<td>10m–1yr</td>
<td>$4.60 \times 10^{-2}$</td>
<td>1200</td>
<td></td>
<td>$8.0 \times 10^{-4}$</td>
<td>0.6[0.1-2.4]</td>
<td>0.6</td>
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<tr>
<td>SLS</td>
<td>1.0</td>
<td>3d–5yr</td>
<td>$5.60 \times 10^{-4}$</td>
<td>2</td>
<td>2003–2008</td>
<td>$5.2 \times 10^{-3}$</td>
<td>2.8[0.8-11]</td>
<td>0.03</td>
</tr>
<tr>
<td>SkyMapper</td>
<td>5.7</td>
<td>0.2d–1yr</td>
<td>$7.39 \times 10^{-2}$</td>
<td>1000</td>
<td>2009–...</td>
<td>$6.4 \times 10^{-4}$</td>
<td>0.5[0.2-2.0]</td>
<td>0.3</td>
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<tr>
<td>Pan–STARRS1</td>
<td>7.0</td>
<td>3d</td>
<td>$7.39 \times 10^{-3}$</td>
<td>6000</td>
<td>2009–...</td>
<td>$2.0 \times 10^{-3}$</td>
<td>1[0.3-4.4]</td>
<td>12</td>
</tr>
<tr>
<td>LSST</td>
<td>9.6</td>
<td>3d</td>
<td>$4.66 \times 10^{-4}$</td>
<td>3300</td>
<td>2022–...</td>
<td>$5.1 \times 10^{-3}$</td>
<td>3[0.8-11]</td>
<td>50</td>
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<tr>
<td><strong>Gaia</strong></td>
<td>0.5x2</td>
<td>20d</td>
<td>$3.00 \times 10^{-2}$</td>
<td>2000</td>
<td>2014–2019</td>
<td>$1.0^{-3}$</td>
<td>1[0.5-5]</td>
<td>2</td>
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<tr>
<td>ZTF</td>
<td>42.0</td>
<td>1d</td>
<td>$2.00 \times 10^{-2}$</td>
<td>22500</td>
<td>2017–...</td>
<td>$1.1 \times 10^{-3}$</td>
<td>0.8[0.4-4.8]</td>
<td>20</td>
</tr>
<tr>
<td>RASS</td>
<td>3.1</td>
<td>...</td>
<td>$4.00 \times 10^{-5}$</td>
<td>12000</td>
<td>6 months</td>
<td>$8.0 \times 10^{-4}$</td>
<td>1[0.3-4.4]</td>
<td>10</td>
</tr>
<tr>
<td>eROSITA</td>
<td>0.8</td>
<td>6 months</td>
<td>$2.00 \times 10^{-6}$</td>
<td>4320*</td>
<td>4 years</td>
<td>$3.0 \times 10^{-3}$</td>
<td>2[0.5-6.5]</td>
<td>26</td>
</tr>
</tbody>
</table>

Ghirlanda+15
THE IMPORTANCE OF ORPHAN AFTERGLOWS

- to confirm the GRB jet model
- to put constraints on the jet opening angle and structure
- Not (or less) affected by hard-X rays: unique access to the pristine gas surrounding massive stars at any z!
- GW
HOW CAN WE RECOGNIZE THEM?

- First hints with light-curve
- Optical spectroscopy: z, continuum, HI & metal absorption line, fine structures lines
- we had a VLT ToO program with X-Shooter, now DDT?
- we need to improve the Gaia Alert Pipeline and flags!
SUGGESTIONS FOR GAIA ALERTS

- As fast response as possible (automatised after downloading?)
- include the following info in the Alert (script readable): blue/red, hostless?, last non-detection
- access to light curves
CONCLUSIONS

- GRB orphan afterglow detection will bring unique info on GRB models
- GRB orphan afterglow detection will give unique access at any \( z \) to the pristine gas surrounding massive stars
- we can obtain VLT ToO observations: we need to improve the Gaia Alert Pipeline and flags!
THANKS!