Modest Obscured Star-Formation Rates Inferred from EVLA Observations of Dark GRB Host Galaxies

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We present host observations with the full-bandwidth EVLA of a sample of highly dust-obscured ("dark") GRBs previously found to have occurred within significantly dust-obscured galaxies. All systems are quite faint at radio wavelengths, and most are undetected even at the level of the EVLA's sensitivity (RMS ~5 μJy). The implied radio-derived star-formation rates are modest, usually comparable to what is inferred from the dust-corrected optical observations. These results suggest that most dark GRBs occur within dusty regions of relatively ordinary galaxies, and indicate that the most extreme systems rarely produce GRBs.

GRBs and cosmic SFR

Long gamma-ray bursts (GRBs) are produced by the explosions of massive stars at cosmological distances. A large fraction of cosmic star formation at z=1-2 is believed to occur in submillimeter- and radio-luminous galaxies, so one might expect many GRBs should be hosted within these systems. However, few radio or submillimeter host detections have been reported to date.

Dark GRBs and dark GRB host galaxies

Locating the host galaxy of a GRB requires a precise position, which historically resulted in a host-galaxy sample strongly biased away from GRBs occurring along dusty sightlines ("dark" GRBs). Recently, IR photometry of the hosts of dark GRBs has shown them to be much more massive and dusty than the hosts of unobscured GRBs, confirming that the host population studied by earlier radio surveys was not fully representative of all GRB hosts.

Observations

We selected ten GRBs with unambiguously large afterglow dust columns (dark), and bright host detections in Spitzer-IRAC observations (massive), properties we expected would most clearly separate this group from previous host samples. Seven of these galaxies have known spectroscopic or photometric redshifts. All sources were observed using the full-bandwidth EVLA in C-band (4.19-6.24 GHz) for 1.0-1.5 hours integration per object during the summer of 2011 with the array in the A configuration (0.3" resolution). Point-source RMS sensitivity varies from 3.5-5.4 μJy.

This space is reserved for the references footnotes.

Results

Of the ten sources, only one (GRB 080207, right) is clearly detected. A few others show weaker (~2σ) evidence of extended radio flux, which will need to be confirmed by observations in more compact configurations. In all cases except GRB 080207 we can conclusively rule out a point-like nuclear starburst to a 3σ limit of <15 μJy or less, and limit the total host radio flux to 40 μJy or less.

Implications

The lack of radio emission from most GRB host galaxies indicates that their star-formation rates are not extreme (<200 Mo/yr depending on redshift). This seems to confirm the trend among pre-Swift, non-dark bursts that GRBs tend to avoid the most extreme systems in the universe, and (in the prevailing collapsar paradigm) may indicate that these systems are too metal-rich to produce GRBs. Alternatively, variations in the IMF in dense starbursts (a "top-light" IMF at very high masses) could also produce this result.

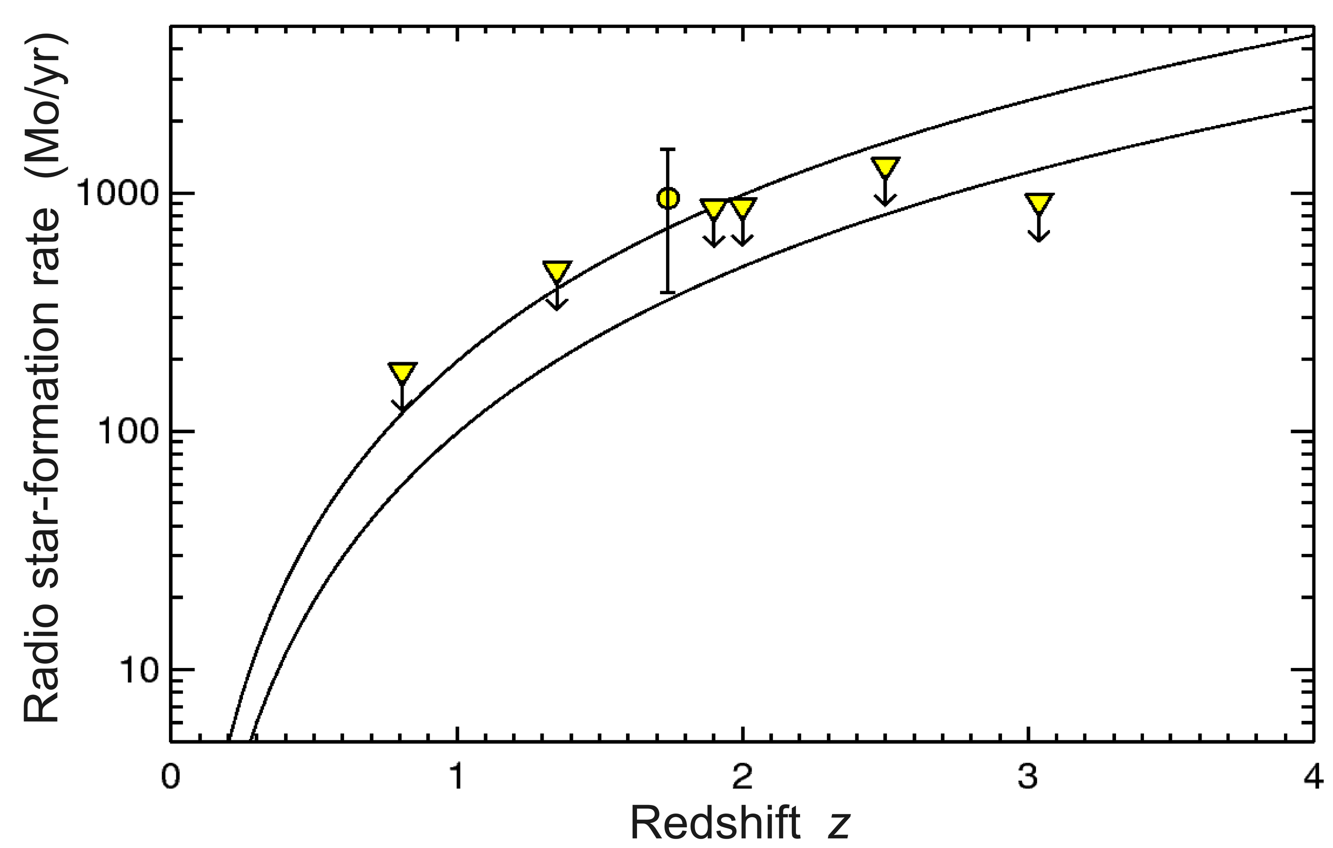
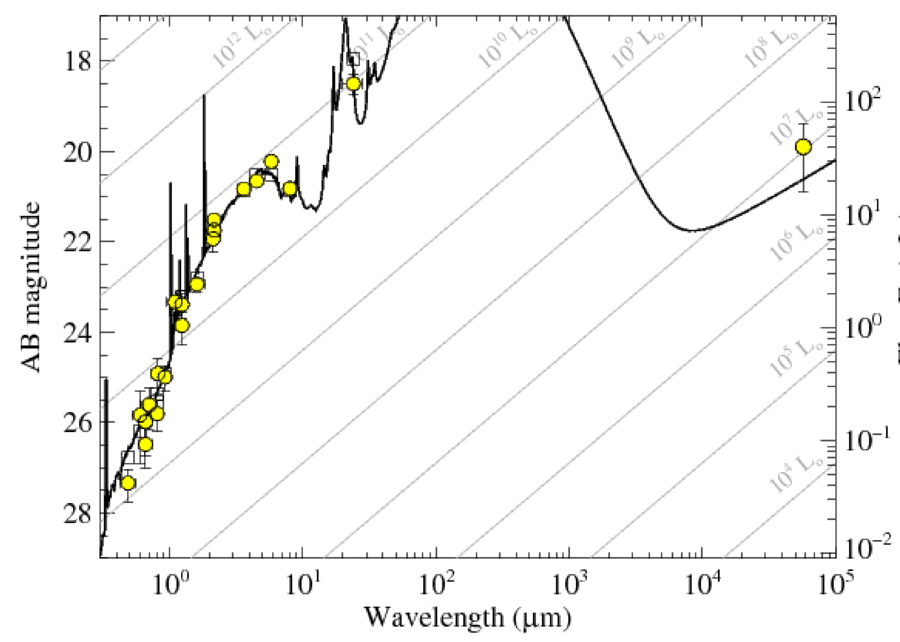


Figure 1: Radio star-formation rates as a function of redshift. Points indicate actual measured fluxes for sources of known redshift, while the curves indicate the limit of a typical observation from our sample for a mildly extended source (upper curve) or a point source (lower curve).

GRB 080207 (z~1.8)

A radio-bright super-starburst



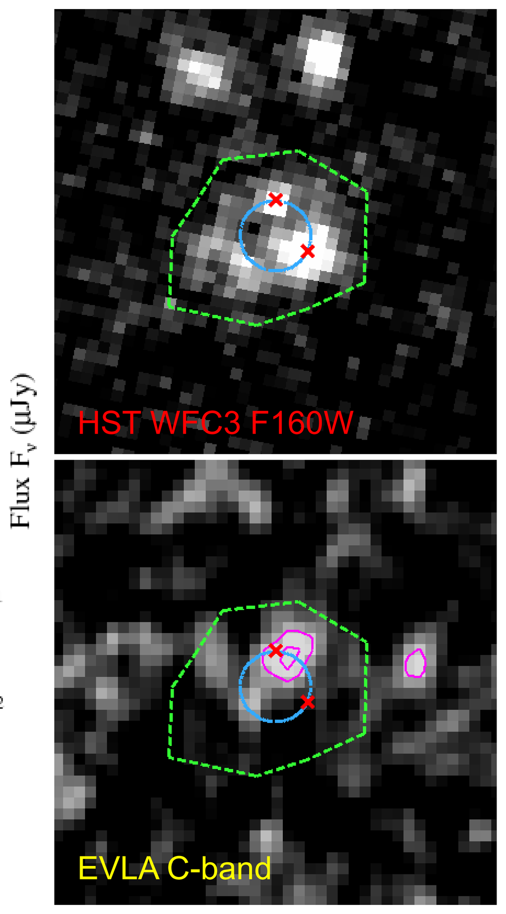
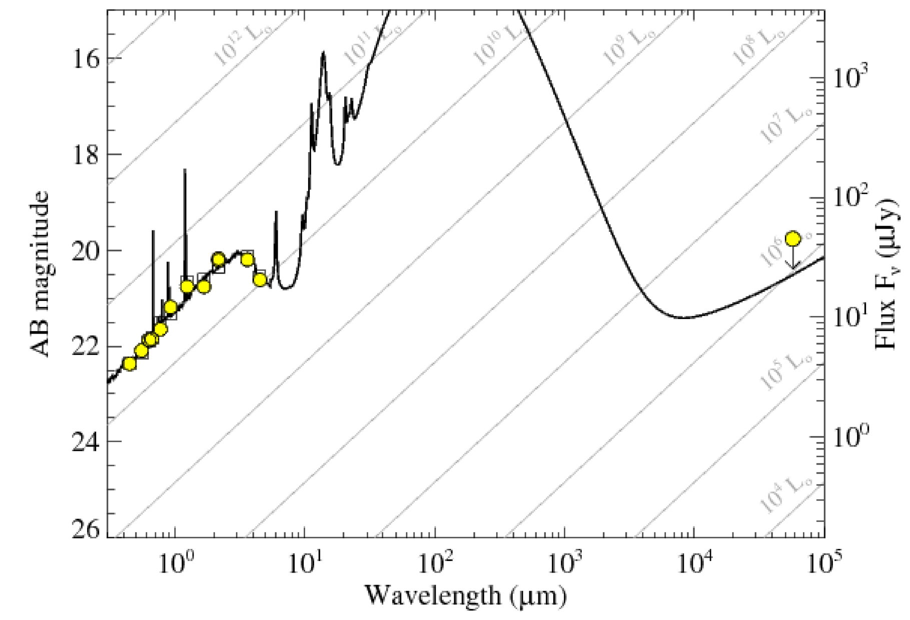


Figure 2a-c: SED (above) and HST+EVLA imaging (right) of the host of GRB 080207. See Figure 4 caption (bottom left) for details.

The most extreme dark GRB host yet known, the host of GRB 080207 is an extremely red, IR-luminous object and is one of very few high-z GRB hosts detected at 24μm. It is also the only target detected at >3σ in our sample: a faint, pointlike source is observed close to the northern optical clump of what appears to be a complex merger resolved by HST imaging. This detection is consistent with the large star-formation rate (400 M$_\odot$/yr) inferred for this host by Svensson et al. 2011 based on the Spitzer MIPS detection. It is significantly larger than would be predicted from the more modest SFR of Hunt et al. 2011. This confirms that the host of GRB 080207 is indeed a bright, SMG-like starbursting galaxy.

GRB 051022 (z=0.81)

An optically thin "low"-z merger



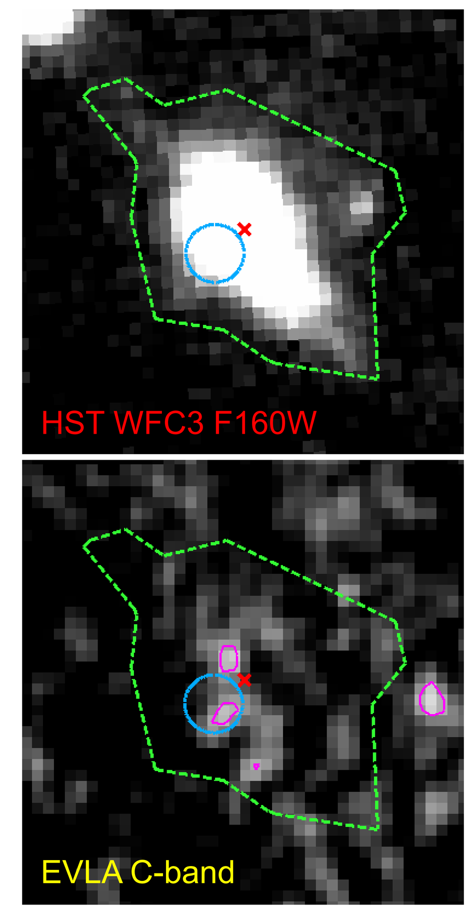


Figure 3a-c: SED (above) and HST+EVLA imaging (right) of the host of GRB 051022. See Figure 4 caption (bottom left) for details.

The host of GRB051022 is among the best-studied dark GRB hosts due to its relatively accessible redshift of z=0.809. The lack of a Balmer break in the SED indicates a very young stellar population and allows a relatively robust measurement of the optical SFR of about 90 Mo/yr. Surprisingly, this system is (at best) only marginally detected by the EVLA, placing a limit on the radio SFR of <160 Mo/yr and limiting any nuclear starburst component to <50 Mo/yr. There is very little highly-embedded (τ_{IR}>>1) star-formation in this galaxy.

Figure 4a-p: Optical or NIR (top panels) + EVLA (bottom panels) imaging for the remaining eight sources not shown in Figures 2-3. All images are 5" on each side. In each image, the **cyan** circle shows the afterglow position. The **green** circle shows the approximate extent of the optical/NIR disk. A **red** x shows the optical centroid if the host is clearly resolved. The **magenta** contours in the EVLA images show contours of 10 μJy and 15 μJy, roughly corresponding to 2 and 3σ for most images.