GRB 100206A: A short GRB associated with recent star-formation?

Daniel A. Perley (Caltech), M. Modjaz (NYU), A. N. Morgan (UC Berkeley),
S. B. Cenko, J. S. Bloom, A. V. Filippenko, A. A. Miller (UCB), N. R. Butler (Arizona)

arXiv:1112.3963

While circumstantial evidence clearly links at least some short-hard gamma-ray bursts with an evolved progenitor, the actual identity of the progenitor (NS-NS merger, NS-BH merger, accretion-induced collapse) or whether there is more than one such progenitor is unknown. Here we present observations of a short-hard GRB associated with high statistical confidence with a rapidly star-forming, luminous infrared galaxy (LIRG) at z~0.4, properties which could indicate an association with ongoing star-formation and a young stellar progenitor for this system. However, more detailed study of the system indicates a massive stellar disk is also present and provides no evidence for a recent starburst, suggesting that an association with an older progenitor is equally likely.

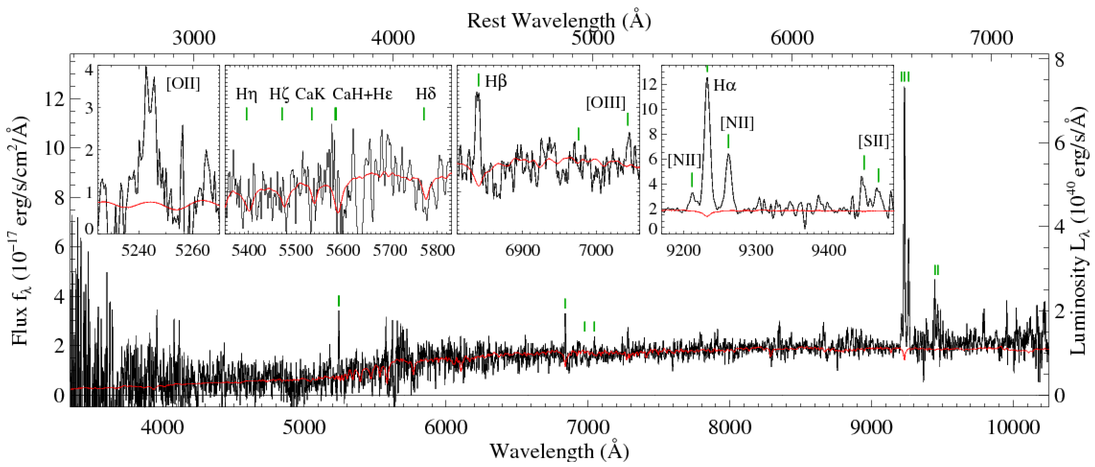

Figure 1 – Spectroscopy of the putative host (object "A" in figure 3) of GRB 100206A, a dusty star-forming galaxy at a redshift of of z=0.407. The object shows a bright red continuum with strong Hα and [NII] emission lines, indicative of a high extinction (Av = 2.5 mag) and high (super-Solar) metallicity.

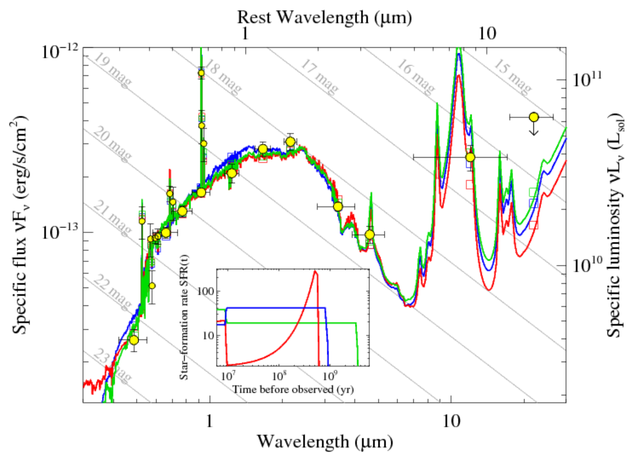

Figure 2 – SED modeling of the host galaxy using Keck spectroscopy plus photometry from Gemini, PAIRITEL, and WISE. Three different models of the star-formation history are shown. All models indicate a strongly star-forming, dusty host with an IR luminosity of L_{IR} ~ 4x10^11, making it the first short-duration GRB to be found in a LIRG.

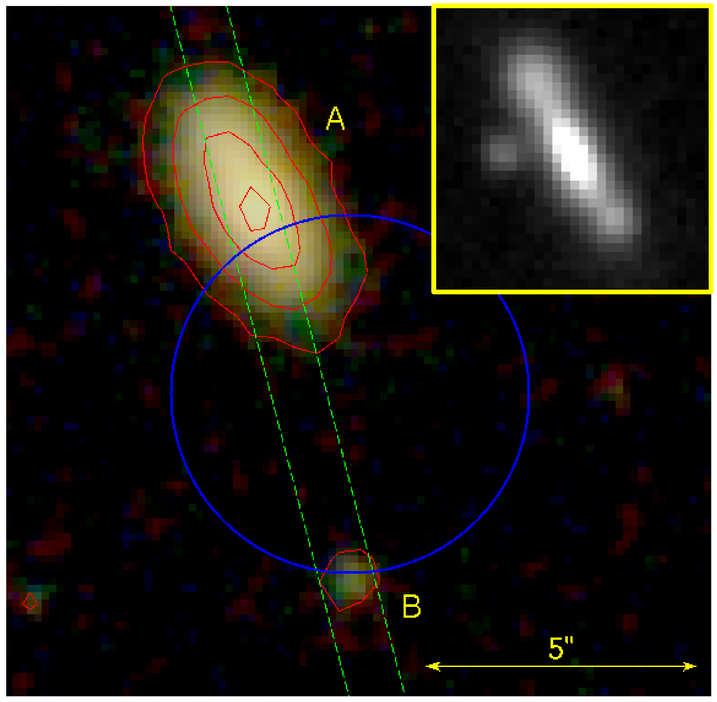

Figure 3 – Deep Gemini (GMOS-N) imaging of the host galaxy and surrounding object. The afterglow of GRB 100206A was quite faint and only a relatively crude XRT position is available, leaving it ambiguous whether the GRB occurred in the disk of galaxy A, its halo, or background galaxy B (at z=0.80.) Probabilistically, the association with galaxy A is quite strong (P_{chance} < 1%), whereas the presence of nearby galaxy B is not statistically significant (P_{chance} ~50%). The inset shows a partial deconvolution of the i-band image, showing a nearly edge-on disk with no obvious merger features.

Discussion

GRB 100206A is **an unambiguous short-duration burst** detected by *Swift* and *Fermi* (GBM) with T90 of 0.12 seconds and no detectable extended emission following the burst [1,2]. Its faint afterglow was only detected in X-rays at early times from the XRT, and despite extensive early ground-based follow-up, optical observations are unconstraining given the X-ray faintness.

However, a bright nonfading object is evident overlapping the XRT error circle, even in images taken with small telescopes (Figure 4). Keck spectroscopy (Figure 1) shows this object to be **a luminous red galaxy at z=0.4068** with a **high SFR and very strong dust obscuration**. A galaxy of this type has never been previously associated with a gamma-ray burst (long *or* short) at low redshift, and the probability of positional association due to random chance is low (P_{chance} = 0.1%-5% depending on the wavelength chosen.)

The association of a short GRB with an intensely star-forming host would be important, since the association of short GRBs with an older progenitor has not been shown to be universal: for example, some modeling has indicated a possible need for a short delay-time component to explain the observed short GRB redshift and logN/logS distributions [3]. The need for a broad delay-time distribution with both old and young components has also been shown for Type Ia supernovae [4].

However, it is not clear that the GRB is actually associated with the *recent* rapid star-formation in its host, rather than **its *past* star-formation**, which **also appears to have been substantial given its stellar mass**. Models of the host star-formation history show no unambiguous evidence for a dramatic recent upturn in the star-formation rate (Figure 2), and its specific SFR is unremarkable (~0.5 Gyr-1). Deconvolution of the Gemini imaging of the host (Figure 3) shows no evidence for a disturbed morphology indicative of a recent major merger, and despite the bright WISE W3 detection the mid-IR flux does not indicate that a dust-enshrouded super-starburst (such as that inferred in SMGs and local ULIRGs) is present.

We conclude that despite the hints associating this event with recent star-formation, **it is fully consistent with the prevailing model in which all short-hard GRBs originate from an older progenitor.**

GRB	z	SFR	Mass	Z
050509B	0.226	<0.1	400	
050709	0.161	0.2	0.6	8.5
050724	0.257	<0.05	60	
051221	0.547	1.0	2.5	8.8
060801	1.130	6.1	1.3	
061006	0.438	0.2	1.0	8.6
061210	0.410	1.2	4.0	8.8
061217	0.827	1.5	1.3	
070429B	0.902	1.1	25	
070714B	0.923	0.4	2.5	
070724	0.457	2.5	13	8.9
071227	0.394		25	
090510	0.903		5.0	
100117A	0.92		20	
100206A	**0.407**	**30**	**50**	**9.2**

Table 1 – Fundamental properties of the host galaxy of GRB 100206A compared to several other short-hard burst host galaxies with known redshift. (SFR is given in solar masses per year, the mass in 10^9 solar masses, and the metallicity Z in terms of the oxygen abundance 12+log[O/H]). The mass is within the middle of the range of previously-studied short GRB hosts, but the star-formation rate is over an order of magnitude higher than that of any other system at similar redshift. Data on previous bursts are from [4,5,6,7].

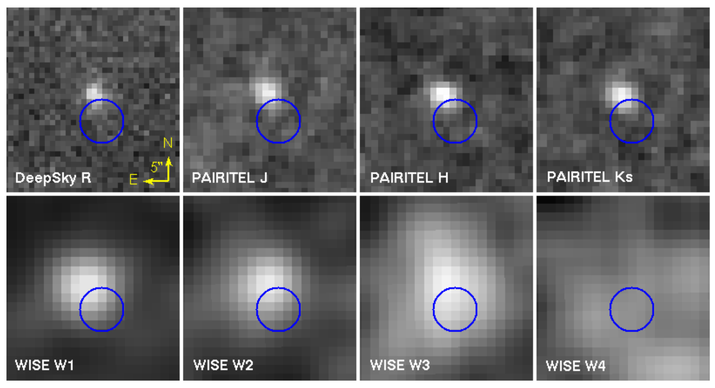

Figure 4 – Unresolved imaging of the host galaxy with PAIRITEL and WISE. The host is clearly detected in WISE and is particularly bright in W3, indicating strong PAH emission features from the host (see also Figure 2), directly indicating significant obscured star-formation.

References

[1] Sakamoto et al., .GCN Circulars 10379
[2] von Kienlin et al.,. GCN Circular 10381
[3] Virgili et al. 2011, 2011, ApJ, 727, 109
[4] Scannapieco & Bildsten 2005, ApJ, 629, L85
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