Uncovering the Progenitors of Short-duration Gamma-ray Bursts through HST Observations of Host Galaxies

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Introduction
We present the first comprehensive analysis of Hubble Space Telescope (HST) observations of short-duration gamma-ray burst (GRB) host galaxies. Using HST data for 8 short GRB hosts, we determine morphological properties, measure GRB offsets relative to their host centers, and study the GRB locations relative to their host light distributions. We also compare our findings to those for long GRBs. Finally, we investigate the implications of our results for short GRB progenitors, such as NS-NS binaries.

Morphological Analysis of SHB Hosts
We use galfit (Peng et al. 2007) to construct two-dimensional models of each galaxy image using a Sérsic profile characterized by an index n. Six of eight hosts are well-characterized by exponential disks and only two (050724, 050509b) have elliptical morphologies.

Radial Surface Brightness Profiles
We generate elliptical isophotes for each epoch/filter combination and fit Sérsic profiles. We compare the short GRB distribution of n and r_e (effective radius) to that of long GRBs. With the exception of GRBs 050509b and 050724 which are elliptical galaxies, the remaining short GRB hosts have a similar distribution of n values to that of long GRBs (n=1.3-1.6). However, short GRB hosts are on average twice as large as long GRB hosts.

Light Distribution
We study the local environments of 6 short GRBs using a comparison of their afterglow location brightness to their host light distributions. We calculate the fraction of host galaxy flux fainter than the afterglow location’s flux for each observation. We find that short GRBs under-represent their host’s UV light but marginally track their hosts’ optical light; long GRBs, however, are concentrated on the brightest regions of their hosts (Fruchter et al. 2006, Kelly et al. 2008).

Conclusions: Implications for Progenitors
Based on our results, we conclude that:
1. The majority of short GRB hosts are late-type galaxies and are systematically larger (commensurate with higher luminosities and masses) than long GRB hosts, suggesting that the two populations arise from different environments.
2. Short GRBs have a projected physical offset distribution that is consistent with the predicted distribution for NS-NS binary mergers. However, the observed distribution does not rule out partial contribution from other progenitor systems.
3. Short GRBs appear to under-represent their hosts’ UV light. Thus, short GRB progenitors may arise from an older stellar population than long GRB, core-collapse SN, and Type Ia SN progenitors.

References

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