

When Stars Explode:

GRBs and SNe

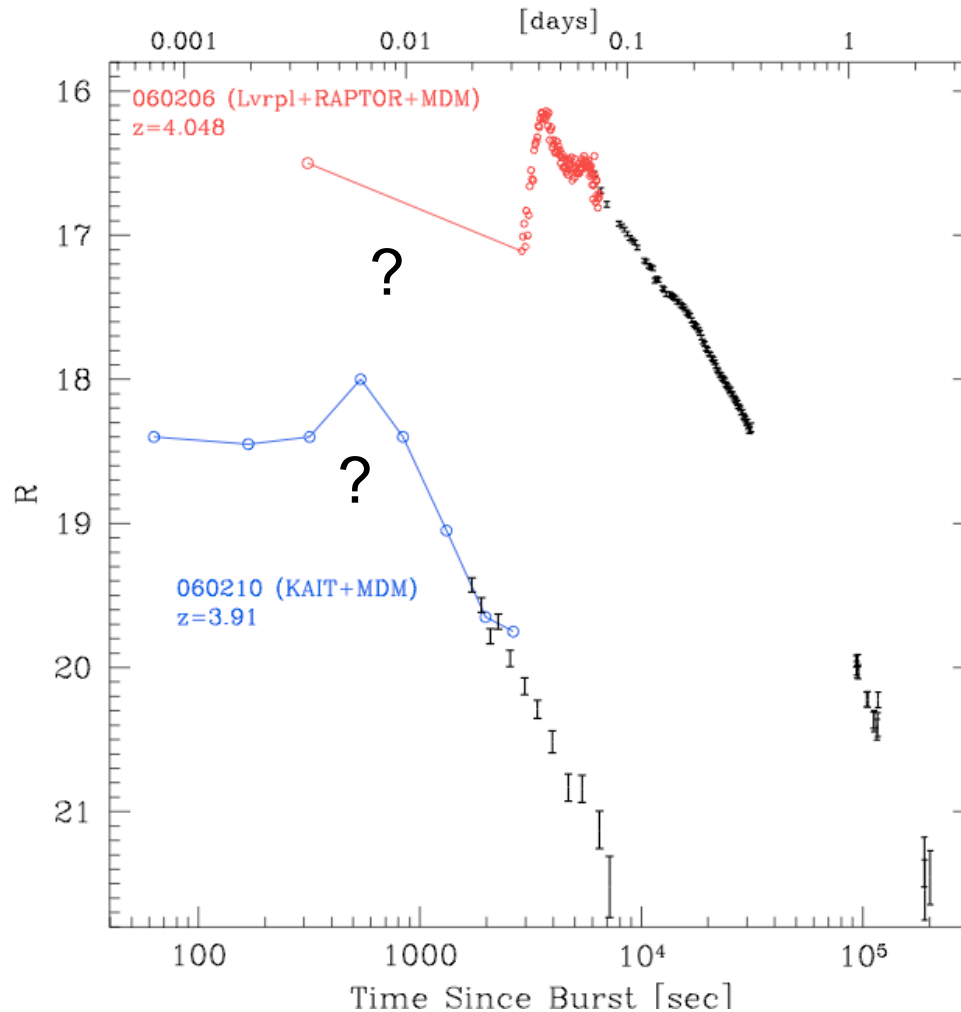
(Novae might fit in here too)

GRBs and SNe

- GRBs and SNe can occur at any time and location on the sky
- Ideally, we need several telescopes equipped with a diverse set of instrumentation around the globe ready to observe at a moments notice (requires international collaboration + mechanism)
- At least some of the telescopes and desired instrumentation are in place, but the means of using them efficiently for target-of-opportunity (ToO) observations is lacking
- In recent years many large telescopes have been used to perform ToO observations, however, the process for triggering those observations has been relatively slow (only Gemini among the large telescopes can provide the immediate response required)
- In addition, the instrument configurations are often constrained, limiting ToO requests
- Polarimetry/Spectropolarimetry and NIR spectroscopy have the potential to tell us much more about the phenomena, but few such observations have been obtained to date

GRB-specific issues

- The fast fading nature of GRB afterglows requires early observations (<10 minutes from outburst) to maximize the signal-to-noise and the derive information on jets and progenitors



SNe-specific issues

- SNe differ from GRBs in that they can take anywhere from hours to weeks to rise to maximum light, and SNe can often be observed for months or even years
- Distant SNe ($z > 0.1$) are being well-observed using existing public/private facilities
- Understanding the physics of SNe will only be accomplished by concentrating on nearby ($z < 0.05$) events
- Current searches have supplied interesting SNe, but many nearby SNe are still undiscovered, especially in the southern hemisphere
- SkyMapper, PanSTARRS, and LSST will eventually provide such capabilities

Common Desired Capabilities

- Robotic 1-2.5m telescopes providing UBVRIYJHK (or ugrizYJHK) imaging (a few exist, not necessarily public or do they cover southern hemisphere)
- 2.5-4m telescopes dedicated to optical spectroscopy (telescopes and spectrographs exist, but not in this mode)
- 4-10m telescopes with ToO NIR spectroscopic capability (Gemini has capability; suitable instruments being built on other telescopes, but ToO mode probably won't be available)
- ToO access to 6.5-10m telescopes with optical polarimetry or spectropolarimetry capability (instruments exist, but ToO access does not) [GMOS on Gemini?]
- High-dispersion optical/NIR spectroscopy (instruments exist or being built, but ToO access does not)

GRBs

Observation	Response Time	Frequency of Observation	Science	Telescope Requirement	Priority
Optical/IR Imaging (UBVRIJHK or ugriz etc.)	Within first minutes of outburst (automatically triggered)	Continuous short exposure monitoring during first hour or two	Fluctuations in early time can tell us something about progenitors and explosion mechanism	Optical: 1-2.5m NIR: 2.5-4m (6.5-10m for faintest ones)	1
Optical/NIR Low-resolution (R~500-1000) spectroscopy	Within first hour of outburst; at later epochs to observe associated SN	Once at early epochs; any few days at later epochs?	Early spectrum gives redshift information (NIR needed for high-z or obscured events); later epochs provide information on nature of associated SN	Optical: Early 1.5-8m; Later 8-10m NIR: 6.5-10m	2

GRBs

Observation	Response Time	Frequency of Observation	Science	Telescope Requirement	Priority
Optical/IR Imaging (UBVRIJHK or ugri etc.)	Long-term monitoring	Daily-weekly (logarithmic time scale)	Identification of break time; appearance of SN	Optical: 2-4m NIR: 6.5-10m	3
Optical/NIR Low-resolution (R~500-1000) spectroscopy	Long-term monitoring	Daily (over first week)	Nature of afterglow; interaction with circumstellar medium	Optical/NIR: 6.5-10m	3

GRBs (cont.)

Observation	Response Time	Frequency of Observation	Science	Telescope Requirement	Priority
Optical Broad-Band Polarimetry	Within minutes of outburst	Frequent monitoring during first hour or two?	Polarization probes jet formation, orientation, structure, opening angle	1-2.5m telescopes (challenge is to figure out a way to take measurements quickly)	2
High-Dispersion (R ~40,000) optical/NIR spectroscopy	Within first days following outburst	Multiple epochs desired	Probes intergalactic medium (NIR needed for highest redshift GRBs)	Optical: 4-8m NIR: 8-10m	4

Low-z SNe

Observation	Response Time	Frequency of Observation	Science	Telescope Requirement	Priority
Optical/NIR imaging	Within hours of discovery	Continuous monitoring during first hours	Provides best opportunity to discover something about progenitors	Optical: 1-2.5m telescopes NIR: 4-8m telescopes	1
Low-dispersion (R ~500-1000) optical/NIR spectroscopy	Within first hours/days following explosion	Hourly/Daily	Spectral characteristics at earliest epochs completely unexplored	Optical: 3-6.5m NIR: 6.5-10m	1

Low-z SNe

Observation	Response Time	Frequency of Observation	Science	Telescope Requirement	Priority
Optical/NIR imaging	Long-term monitoring	Depends on type; anywhere from 1-2 days to weekly	Bolometric light curves, dust extinction, explosion physics, etc.	Optical: 1-1.5m telescopes NIR: 2.5-4m telescopes	1
Low-dispersion (R ~500-1000) optical/NIR spectroscopy	Long-term monitoring	Depends on type; for SN Ia every 2 days around maximum, every week after 2 weeks past maximum	SN typing, expansion velocities, nucleosynthesis, etc. etc.	Optical: 2.5-4m NIR: 6.5-10m	1

Low-z SNe (cont.)

Observation	Response Time	Frequency of Observation	Science	Telescope Requirement	Priority
Optical Spectro-polarimetry	Beginning within days of explosion	Weekly (but depends on type)	Provides only method to detect asymmetries in explosions	6.5-10m telescopes	2
High-dispersion (R ~40,000) optical spectroscopy	Beginning within days of explosion	Every few days?	Variations in interstellar absorption lines -- may probe circumstellar material?	Optical: 4-10m	3

What can be done?

- Automate a few 1-2.5 m telescopes for optical/IR imaging (transform or build?)
- Dedicate optical 4m telescope for optical transients (transform or build?)
- Provide ToO capability on 6.5-10m telescope for NIR spectroscopy
- Think about providing ToO access to 6.5-10m telescopes with specialized instruments such for polarimetry/spectropolarimetry and optical/NIR high-dispersion spectroscopy