Circumstellar Material and SN 2002ic

Michael Wood-Vasey
University of California, Berkeley
Lawrence Berkeley National Laboratory
SN 2002ic - Hybrid, CSM, ...

- Type Ia with hydrogen emission!
  - Hamuy et al. (2003, Nature)
    - Si @ max but Hα increasing after max
  - Interaction with circumstellar material
  - Observation
  - Theory and Modeling
    - Chugai & Yungelson (2004, AstL)
    - Nomoto et al. (2004, astro-ph)
  - Possible link to some SNe II In events
Discovery of SN 2002ic

Discovered during the prototype search of the SNfactory

October 30  

November 12  

SN 2002ic
Reference Image for SN 2002ic
Redshift of SN 2002ic

z = 0.0666

z = 0.075

(Hamuy)
Spectra of SN 2002ic

Hamuy et al. 2003, Nature

Fig. 1.— The spectra of SN 2002ic are compared with those of SN 1997cy and SN 1999E. From top to bottom, the spectra of SN 2002ic, SN 1999E, and SN 1997cy. The SN 1997cy and SN 1999E spectra are at epochs where the Hα line is close to maximum (see Figure 2).
Spectropolarimetry of SN 2002ic

- Polarization of Hα
- separate source
- clumps?

Hα increases in strength w/ time

Lightcurve of SN 2002ic

NEAT unfiltered
Hamuy V-band

Days [JD-2452000]
Unfiltered magnitude

550 600 650 700 750 800 850 900 950
550 600 650 700 750 800 850 900 950
20.0 19.5 19.0 18.5 18.0 17.5 17.0

20.0 19.5 19.0 18.5 18.0 17.5 17.0

NEAT unfiltered
Hamuy V-band

Days [JD-2452000]
Unfiltered magnitude
Lightcurve of SN 2002ic

Unfiltered magnitude vs. Days [JD-2452000]

- NEAT unfiltered
- Hamuy V-band
Lightcurve of SN 2002ic

Results of Deng et al. (2004) not included
2002ic is brighter than normal

Template V-band  
\[ s = 1.5 \]
\[ s = 1.0 \]
\[ s = 0.5 \]
Modeling of CSM interaction

  - Modeled interaction of SN ejecta with CSM
  - power-law prescription lends itself to semi-analytic
  - solutions for ejecta velocity and CSM properties
  - Dependent on density structure of CSM

- SN 2002ic consistent with SN ejecta-CSM interaction
  - CSM has structure
    - early-time gap
    - density change after maximum light
Similarity to SN 1997cy

- Noted by Hamuy, Wang, Deng, and Wood-Vasey
- SN 2002ic light curve similar to SN 1997cy
  - Slow decay
    - 1997cy linear in magnitude space
    - 2002ic possible more complicated
  - Absolute brightness comparable
    - SN 2002ic: $z \sim 0.0666$
    - SN 1997cy: $z \sim 0.0642$
Comparison with SN 1997cy

1997cy adj. to $z=0.0666$
Even later-time comparison

(Courtesy of Mario Hamuy)
Other SNe IIn like SN 2002ic

- If SN 2002ic found in nebular phase would have been classified as a SN IIn
  - All found in nebular phase
  - If found earlier perhaps like SN 2002ic?
- SN 2002ic most visible representative of new subclass?
Summary

- SN 2002ic first SN Ia to show H and significant CSM
- Slow light curve decay consistent with SN ejecta-CSM interaction with density structure
- Gap before CSM of 15 shock velocity days
- Possibly representative of new subclass

Recommendation:
- Study more supernovae from early through late times