

SN 2008ax AND ITS HOST GALAXY ENVIRONMENT

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We describe the result of our analysis of SN 2008ax and its host galaxy NGC 4490 from 14-bands optical observation using University of Tokyo's Dichroic-Mirror Camera (DMC). Photometric measurements were carried out to selected regions in the host to derive their respective spectral energy distributions (SED). We made estimates of the age of stellar populations around SN 2008ax in the host based on comparison of our SEDs with simple stellar population models.

1. Overview of SN 2008ax and NGC 4490 host

Discovery:

- Mostardi et al. (2008) on 2008 March 3.45 UT
- Nakano & Itagaki (2008) on 2008 March 4.62 UT
- No detection at the position of the source ~6 hours before discovery (Arbour 2008). → **one of the earliest-detected supernovae**

Physical properties:

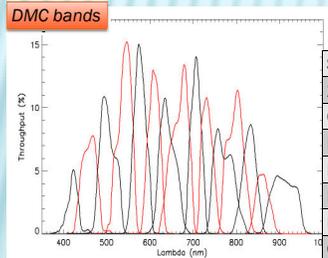
- 2 months coverage of photometric and spectroscopic evolution of SN 2008ax by Pastorello et al. (2008) shows ordinary spectral evolution of a **type IIb supernova**
- Quite similar with another SN IIb, SN 1993J, in terms of the shape of optical light curves, bolometric luminosity, and line velocities.
- Crockett et al. (2008): detection of a **possible progenitor** star of SN 2008ax in pre-explosion Hubble Space Telescope (HST) images
- Two possible candidate of the progenitor system: either a single massive helium-rich Wolf-Rayet star with a residual hydrogen envelope or an interacting binary in a low-mass star cluster.

The host galaxy NGC 4490:

- SB(s) pec morphological type, ~8.7 Mpc away
- Apparently interacting with the neighboring NGC 4485
- Both galaxies are embedded in a very extended neutral hydrogen envelope extending up to ~60 kpc perpendicular to the NGC 4490 plane (Clemens et al. 1998)
- **High, constant star formation rate for the current 100 Myr** (Clemens et al. 1999)

2. DMC overview

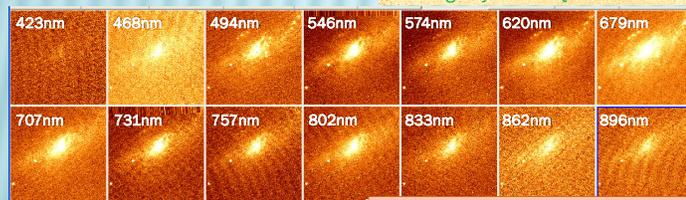
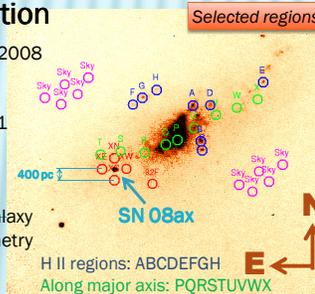
- DMC: Dichroic-Mirror Camera, a 15-band simultaneous imager utilizing dichroic mirrors (Doi et al. 1998, 2008)
- Developed at the Institute of Astronomy, the University of Tokyo, Japan
- Used with Kanata 1.5m telescope at Higashi-Hiroshima Observatory, Japan



Spectral response	390-950 nm
$\lambda/\Delta\lambda$	~20
CCD array	15 x 1000 x 1018
Pixel size	12 μ x 12 μ
Field of view	4.5 arcmin
Pixel scale (2x2 bin)	0.52 arcsec/px
Readout noise	15 e ⁻ RMS
CCD temperature	< -80 C

3. Observation & data reduction

- DMC observation of SN 2008ax: 11 March 2008
- Little hazy condition
- Seeing size ~1.5 arcsec
- 4 exposures of SN 2008ax at airmass ~1.11 (180s each in 14 bands)
- Standard star: Feige 66
- Reduced using IRAF
- SN 2008ax and other regions in the host galaxy were measured with IRAF's aperture photometry package *apphot*, 7px aperture radius



DMC images of SN 2008ax & NGC 4490

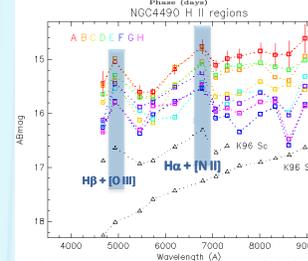
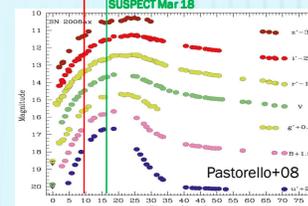
References

Arbour. 2008. CBET 1286, 2
 Bruzual & Charlot. 2003. MNRAS 344, 1000
 Clemens et al. 1998. MNRAS 297, 1015
 Clemens et al. 1999. MNRAS 307, 481
 Crockett et al. 2008. MNRAS 391, L5

Doi et al. 1998. SPIE 3355, 646
 Doi et al. 2008. SPIE 7014, 14
 Kinney et al. 1996. ApJ 647, 38
 Mostardi et al. 2008. CBET 1280
 Nakano & Itagaki. 2008. CBET 1286, 1
 Pastorello et al. 2008. MNRAS 389, 955

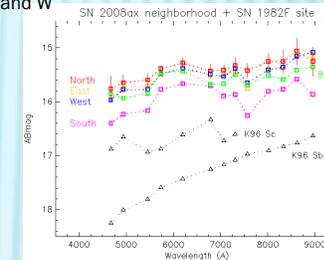
4. Results

DMC photometry of SN 2008ax is consistent with other observations



• DMC photometry of selected NGC 4490 regions along major axis, and galaxy spectrum templates of K96

• The regions generally show bluer SED compared to K96 Sb template, mostly without emission contamination except regions U, V, and W



• Color-color diagram of all regions to separate active (with line emissions) and passive (no line emissions) regions

• Solar-metallicity SSP models of Bruzual & Charlot 2003 (BC03) is superposed, with several values of reddening

- All of the H II regions appear in the lower left part of the diagram
- Regions U, V, W show signs of emission contamination
- The rest of along-major axis regions appear in the upper right part
- SN regions show no emission contamination

• Color-color diagram of all regions, in relatively emission-free DMC bands

to estimate the ages of the stellar population within the regions

• Solar-metallicity SSPs of BC03 is superposed, with several values of reddening

• Two possible solutions for SN 2008ax environment:

- Intermediate age (500~700 Myr), low reddening ($E(B-V) = 0.1 \sim 0.0$)
- Younger age (200~300 Myr), higher reddening ($E(B-V) \sim 0.3$)

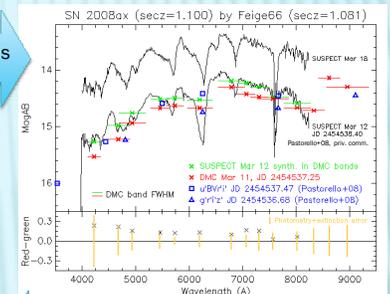
• Crockett et al. (2008): $E(B-V) = 0.3 \sim 0.5$ → young-age estimation is more favorable

5. Summary

- Environment of SN 2008ax shows relatively young age (200~300 Myr) although there are no signs of recent star formation (which is indicated by the presence of emission lines)
- Implication to progenitor model: may indicate massive star origin, considering the young age of the surrounding stellar populations → consistent with type-IIb classification

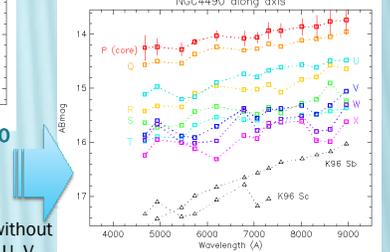
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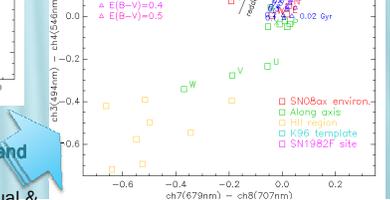
• DMC photometry of NGC 4490 H II regions and galaxy spectrum templates of Kinney et al. 1996 (K96)

• DMC photometry could be used to detect important emission line regions in the spectrum such as H α + [N II], H β + [O III]



• DMC photometry of regions ~400pc north, east, south, and west of SN 2008ax, and of SN 1982F explosion site

• Result: rather quiet regions with no signs of emission lines



• Color-color diagram of all regions, in relatively emission-free DMC bands

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