The Progenitors of SNe Ia: New Observational Clues

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Outline

- SN Ia progenitors
- Direct observational clues
- Na D absorption line evolution: the case of SN 2006X
- Future prospects
The Progenitors of SNe Ia: ?

SD  DD

Donor ?
Limits:

- Radio (Panagia et al. 2006): $< 3 \times 10^{-8}$ solar/year
- X-ray (Immler et al. 2006): $< 10^{-6}$ solar/year
- Optical lines (H, He; Mattila et al. 2005): $< 10^{-5}$ solar/year
SN 2006X:

- Discovered during previous KITP SN program in NGC 4321 (M100)
- >1 week before max
- Substantial extinction
- Not detected in radio, X-ray to limits as above
SN 2006X: Observations

- VLT/UVES (DD, PI Patat, +2, 14, 61, 121)
- Keck/HIRES (PI Gal-Yam, +105)

Result: Na D lines evolve with time!
SN 2006X:

- Complex structure
Possible explanations I: line of sight

Moving cloud
Expanding photosphere + small cloud
Expanding photosphere + patchy sheet
Line of sight: why not?

- Temporal coincidence with SN peak (argues against moving cloud)

- Variability timescale (weeks): requires small clouds/patches or very fast clouds

- Strongest argument (in my mind): Ca II vs. Na I
Possible explanations II: SN flash

Ionization energy: Na I (5.11 eV) vs. Ca II (11.9 eV)
Derived physical parameters

\[ n_e = 10^5 \text{ cm}^{-3}, \quad r_i = 3 \times 10^{17} \text{ cm} \]

\[ M(\text{H}) < n_e = 3 \times 10^{-4} \text{ M}_{\odot} \]

\[ \text{H} \alpha < n_e = 4 \times 10^{34} \text{ erg s}^{-1} \]

(two order of magnitude below limits)

Photoionization alone cannot explain the complex behavior – an additional process is required, perhaps CSM-ejecta interaction (which will still be undetected)
Model

Structure formed by successive Nova shells slowed by expansion in slow, thin wind from red giant donor (a-la RS Oph, but more - Podsiadlowski)

- Must be non-spherical (otherwise cannot slow typical nova shells)
- Line of sight must be close to binary plane: only a fraction (20-30%) of SNe will show these effects
- Or else: RG wind inhomogeneity

In any case: SD with RG donor

Caveats

- Is this real (weird ISM? sodium clouds?)

Is SN 2006X typical or the exception?

Both can be tested by more observations
What’s next?

- More examples: SN 2007af campaign in progress (Simon et al. in prep.): APO, HET, Keck

  Keck time to complete single-epoch snapshots of 20 SNe Ia applied for

  SNe with low extinction will allow to probe slower material
What’s next?
Thanks