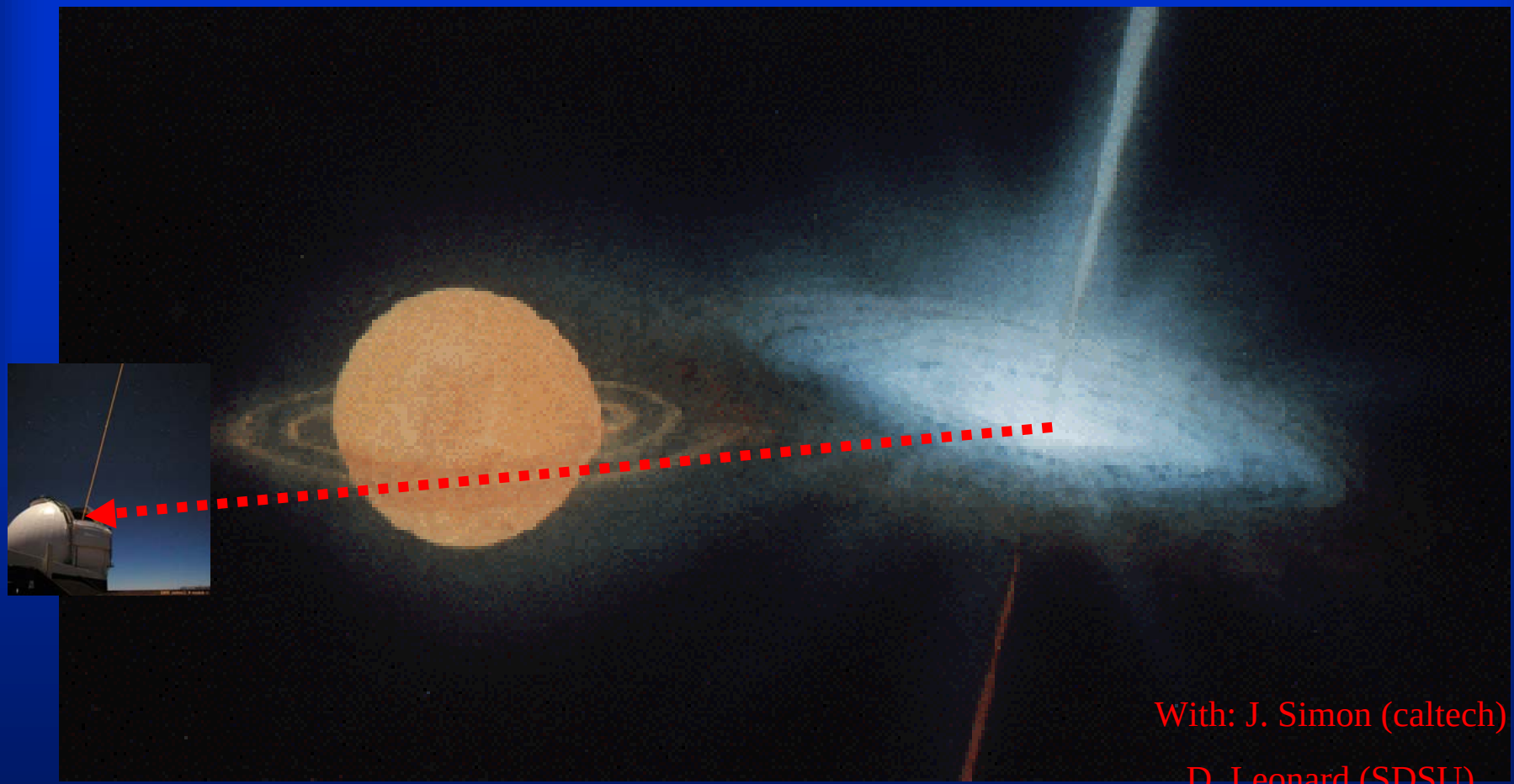
The Progenitors of SNe Ia: New Observational Clues



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D. Leonard (SDSU)

F. Patat and ESO team

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:

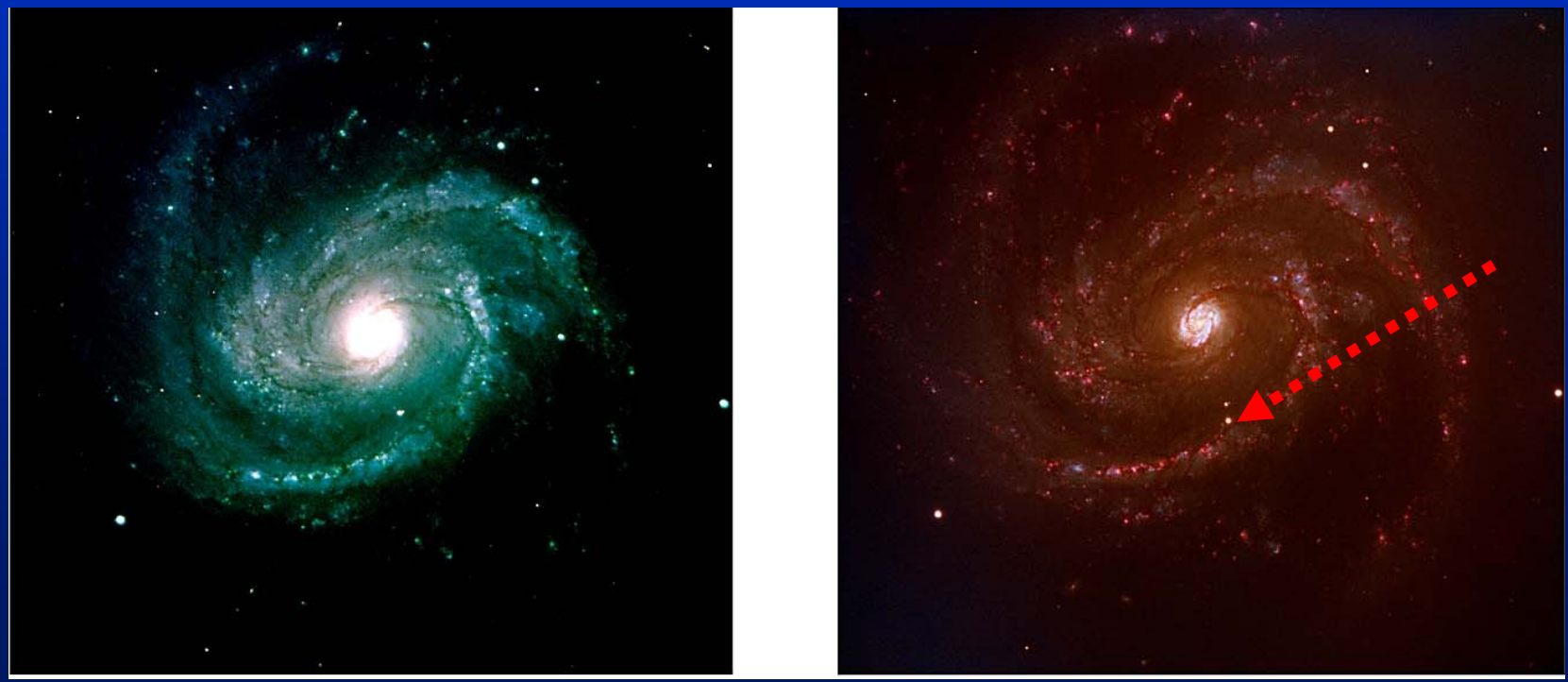
- Radio (Panagia et al. 2006): $< 3 \times 10^{-8}$ solar/year

- X-ray (Immler et al. 2006): $< 10^{-6}$ solar/year

- Optical lines (H, He; Mattila et al. 2005): $< 10^{-5}$ solar/year

SN 2006X:

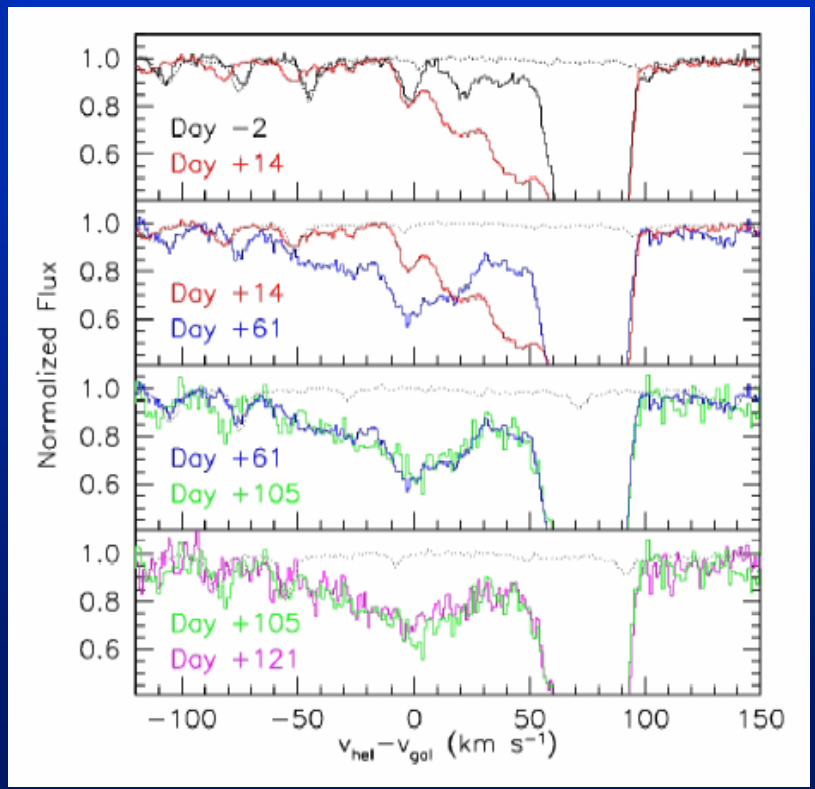
- Discovered during previous KITP SN program in NGC 4321 (M100)
- >1 week before max
- Substantial extinction
- Not detected in radio, X-ray to limits as above

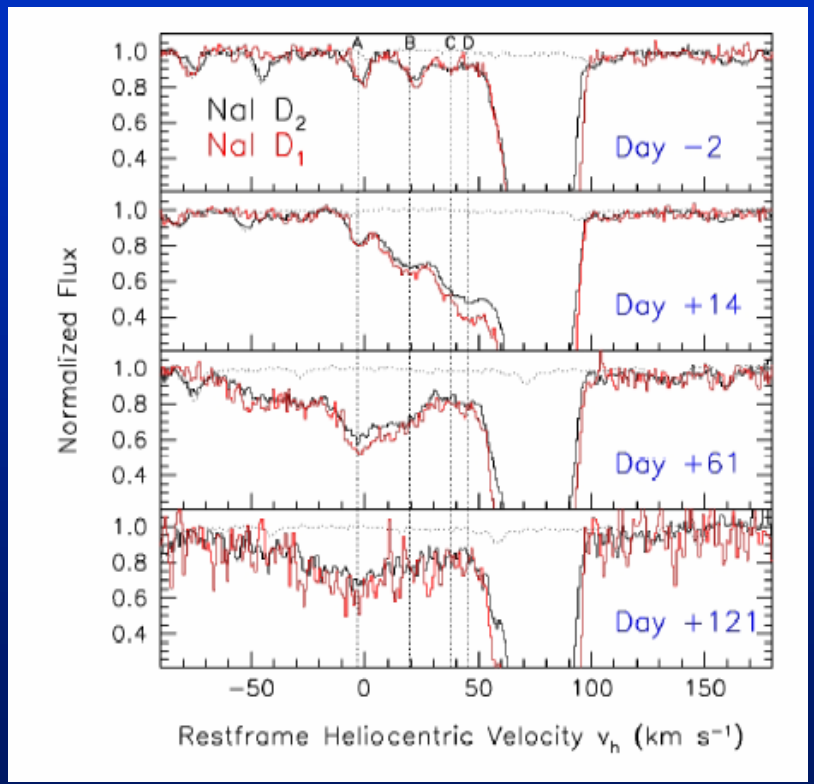


SN 2006X: Observations

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

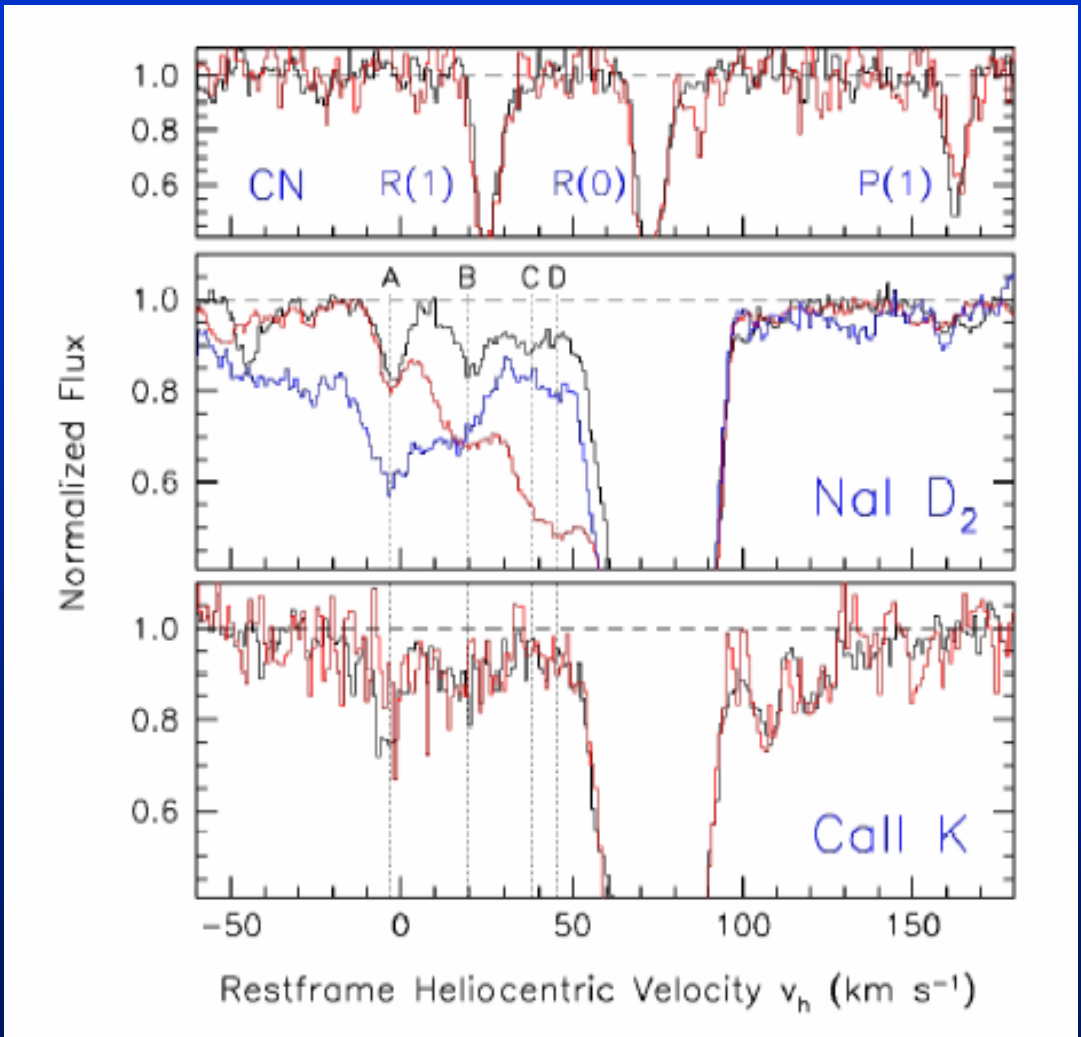
Result: Na D lines evolve with time !





SN 2006X:

- Complex structure

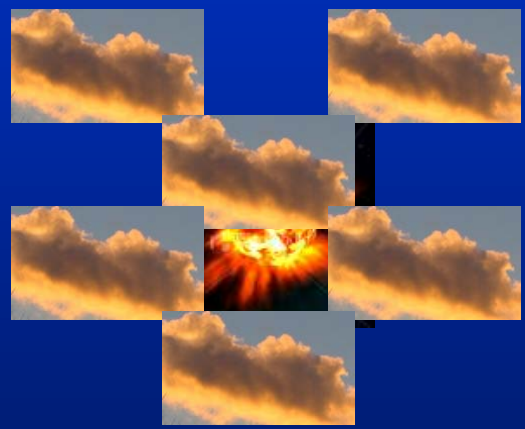


Possible explanations I: line of sight

Moving cloud

Expanding photosphere
+ small cloud

Expanding photosphere
+ patchy sheet

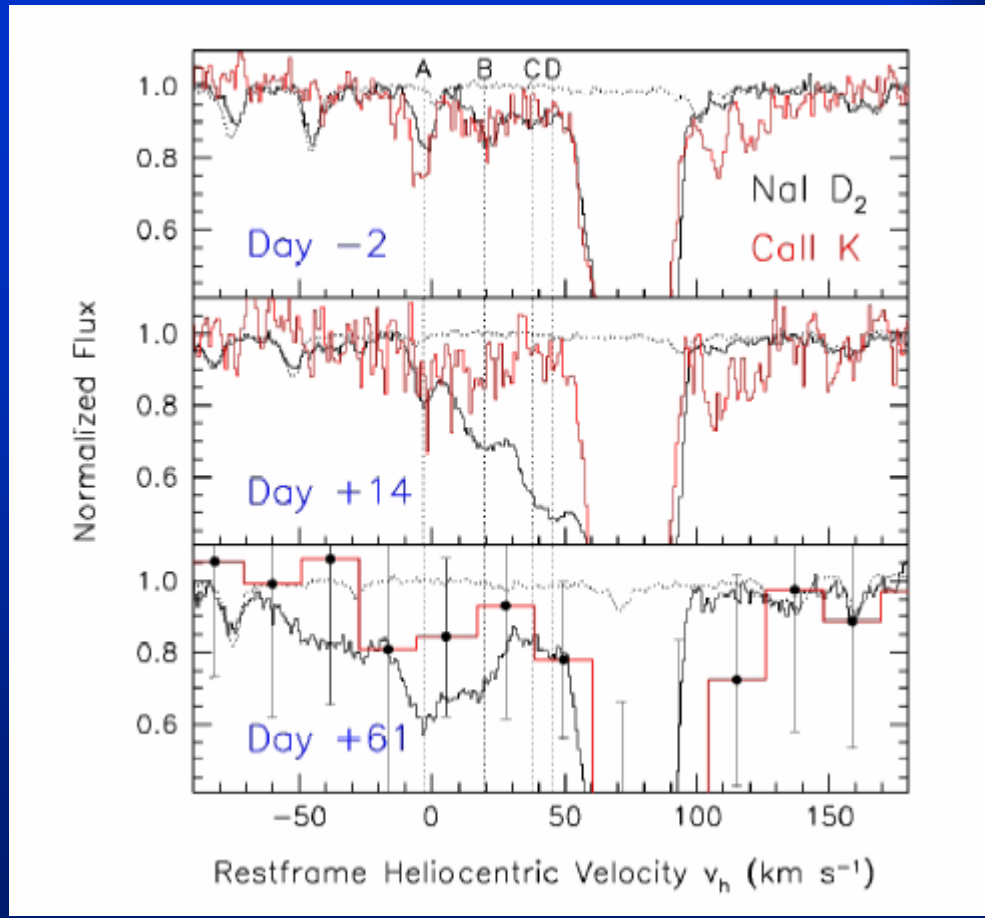


Line of sight: why not?

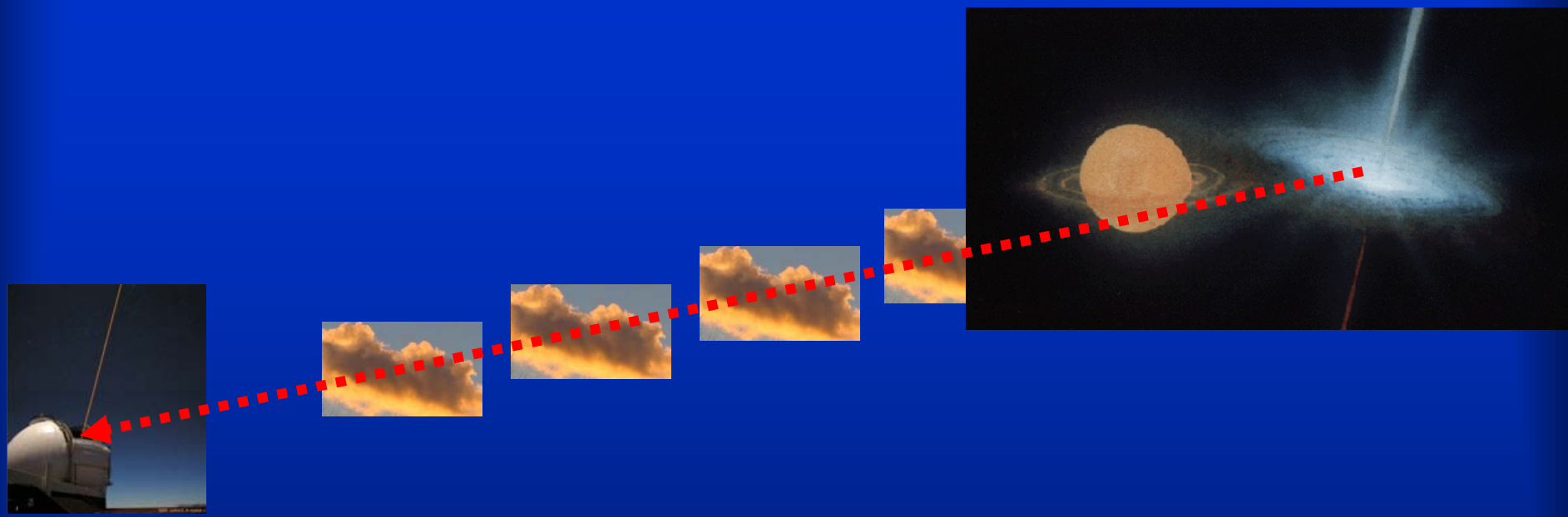
- Temporal coincidence with SN peak (argues against moving cloud)

- 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

$n_e = 10^5$ cm^{-3} , $r_i = 3 \times 10^{17}$ cm

M(H) < $n_e = 3 \times 10^{-4}$ Msolar

Hα < $n_e = 4 \times 10^{34}$ 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

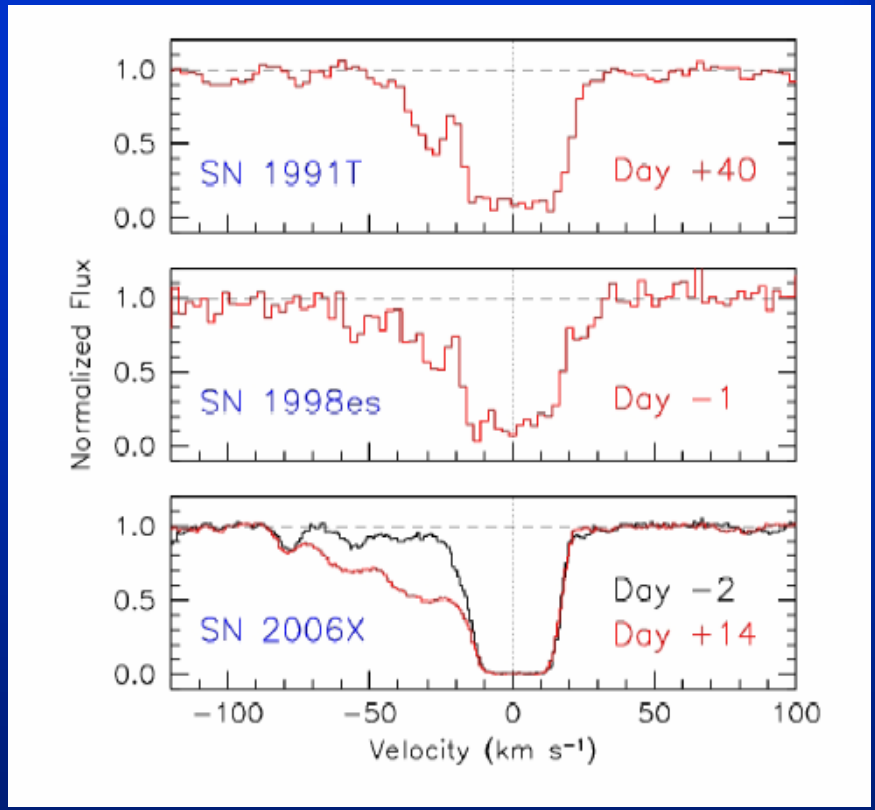
Patat, Chandra, Chevalier, Justham, Podsiadlowski, Wolf, Gal-Yam, Pasquini, Crawford, Mazzali, Nomoto, Benetti, Cappellaro, Elias-Rosa, Hillebrandt, Leonard, Pastorello, Renzini, Sabbasin, Simon, Turatto, Submitted to Science

Caveats

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

Is SN 2006X typical or the exception?

Both can be tested by more observations

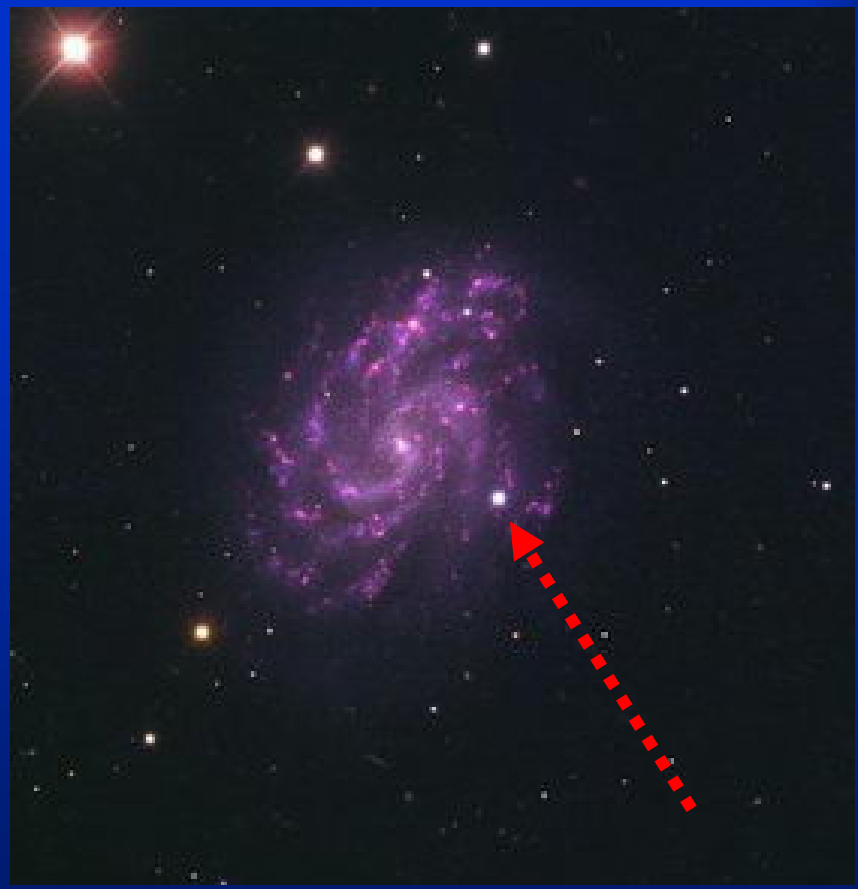


What's next?

- 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



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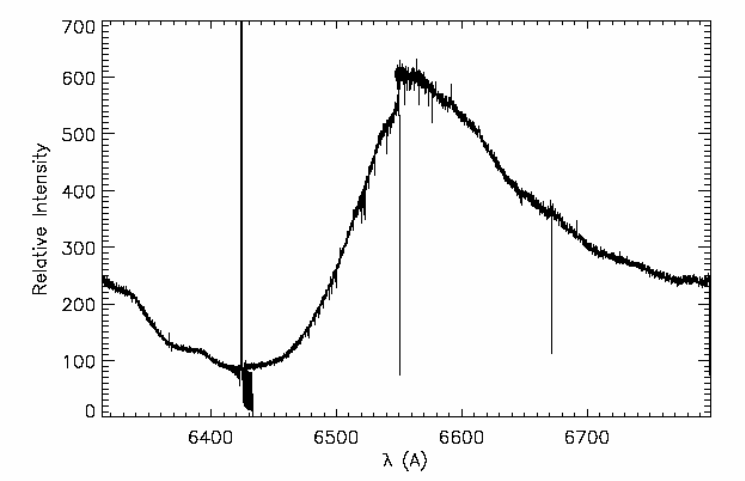
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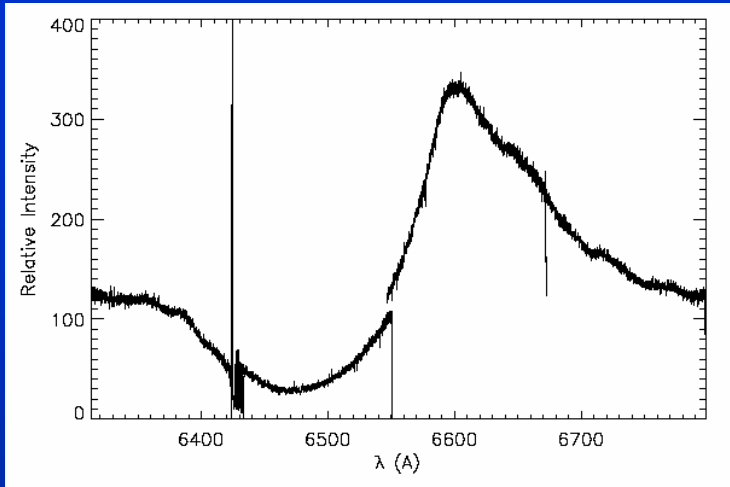
λ (A)
0
100
200
300
400
500
600
700
6400
6500
6600
6700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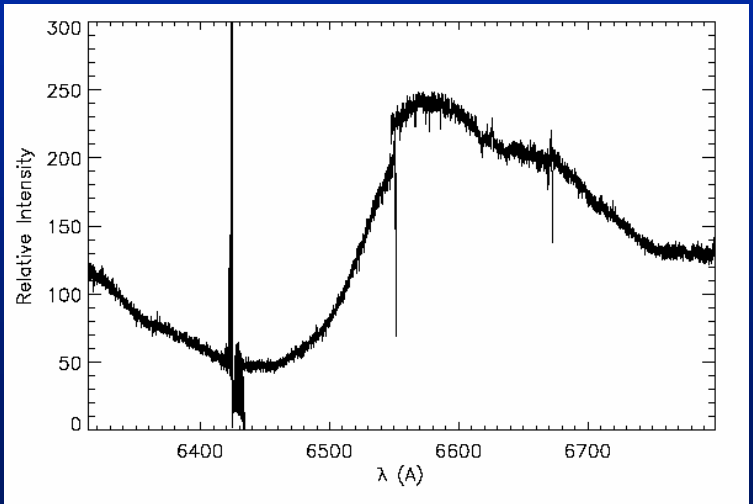
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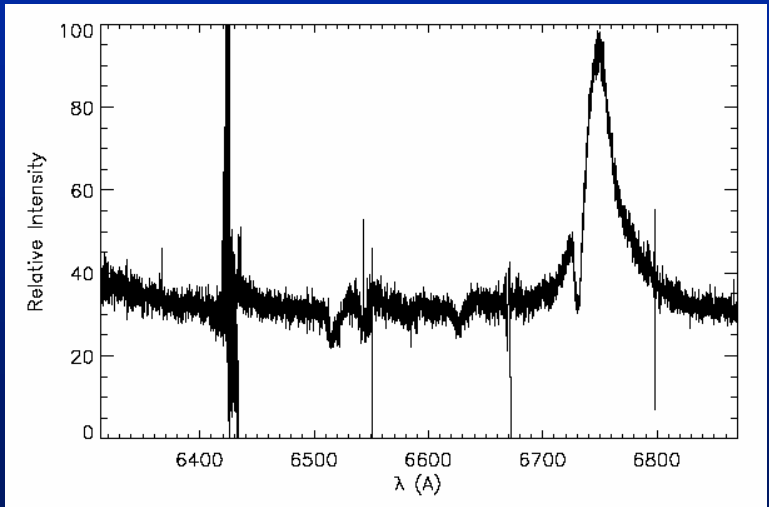
Relative Intensity
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6800

Thanks