# *The Peculiar Type Ia Supernova : SN 2005hk*

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# Type Ia Supernovae:

- Stellar explosions which do not have hydrogen in their spectra, but, intermediate mass elements Si, Ca, Co, Fe are present.

**Characteristic feature strong Si II at ~ 6150Å**

***Standard candles***

***a. very similar light curves***

***b. exceedingly luminous***

***c. small dispersion about their peak absolute mag (б < 0.3 mag)***

***d. width-luminosity relation – bright supernovae have slower decline rate than fainter ones.***

***decline rate ∆m15(B)***

***Progenitors***

***Thermonuclear explosion of a C-O white dwarf in a binary system***

***Companion – double degenerate scenario - another white dwarf or***

***single degenerate scenario - a non-degenerate star. From the***

- ***Explosion mechanism -***

***Deflagration – nuclear burning front remains subsonic***

***low 56 Ni and low K.E., unburned C and O  Detonation -***

***burning front supersonically, more iron peak elements  Delay***

***detonation – subsonic burning front turns supersonic***

***Type Ia SNe donot constitute a perfectly homogeneous***

***subclass  SN 1991T – p***

***max. spectra no Si and Ca lines, post-max. spectra***

***normal Type Ia, broader light curve and probably more***

***luminous  SN***

***1991bg – subluminous 2.5 mag, red colour and steep decline fro***

***maximum, no secondary peak, and low vel. of the ejecta***

***64% normal type Ia;  20% over luminous 1991T like***

***16% under luminous 1991bg like.***

- ***Peculiar events : SN 2002cx***

  ***a high ionization SN 1991T like max light spectrum, dominated b***

  ***Fe group elements, very low expansion velocity of the ejecta,***

  ***absence of the secondary maximum in the R & I band light curve***

  ***late time spectra – P-Cygni profiles.***

  ***SN 2003gq, SN 2005P, SN 2005cc, SN 2005hk - spiral hosts***

  ***SN 1991bg like events - E or SO hosts.***

- ***SN 2005hk – Early spectrum 1991T like event (Serduek et al. 20***

  ***Unusually low velocity of the ejecta – SN 2002cx like.***

# SN 2005hk

- **Host Galaxy *UGC 272 spiral galaxy***

**Observations**： HCT at IAO, HFOSC

**Photometry** - *UBVRI* bands

Nov. 4, 2005 (-4 days)

Sep. 20, 2006 (+320 days)

***Subaru Observations*** (FOCAS):

Dec 27, 2005

June 30 and Nov. 27, 2006

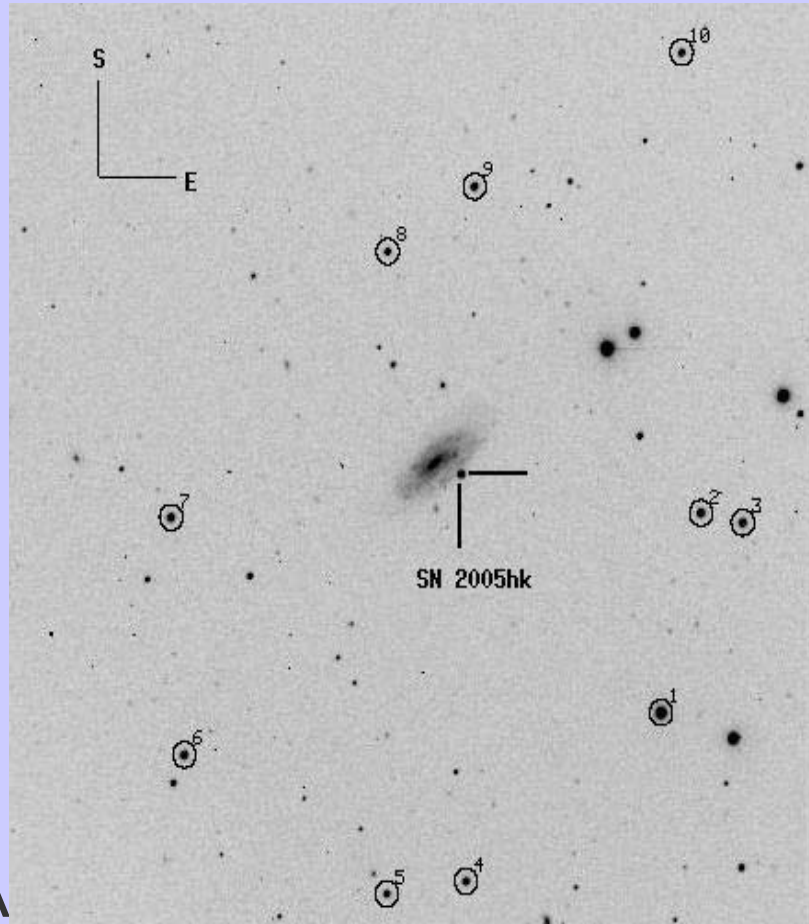
**Spectrosopy** -

HCT Nov. 4, 05-Jan 12, 06

Spectral resolution ~ 7 Å

Late phase spectra with ***Subaru***

4700 – 9000 Å, Spectral res. 11Å



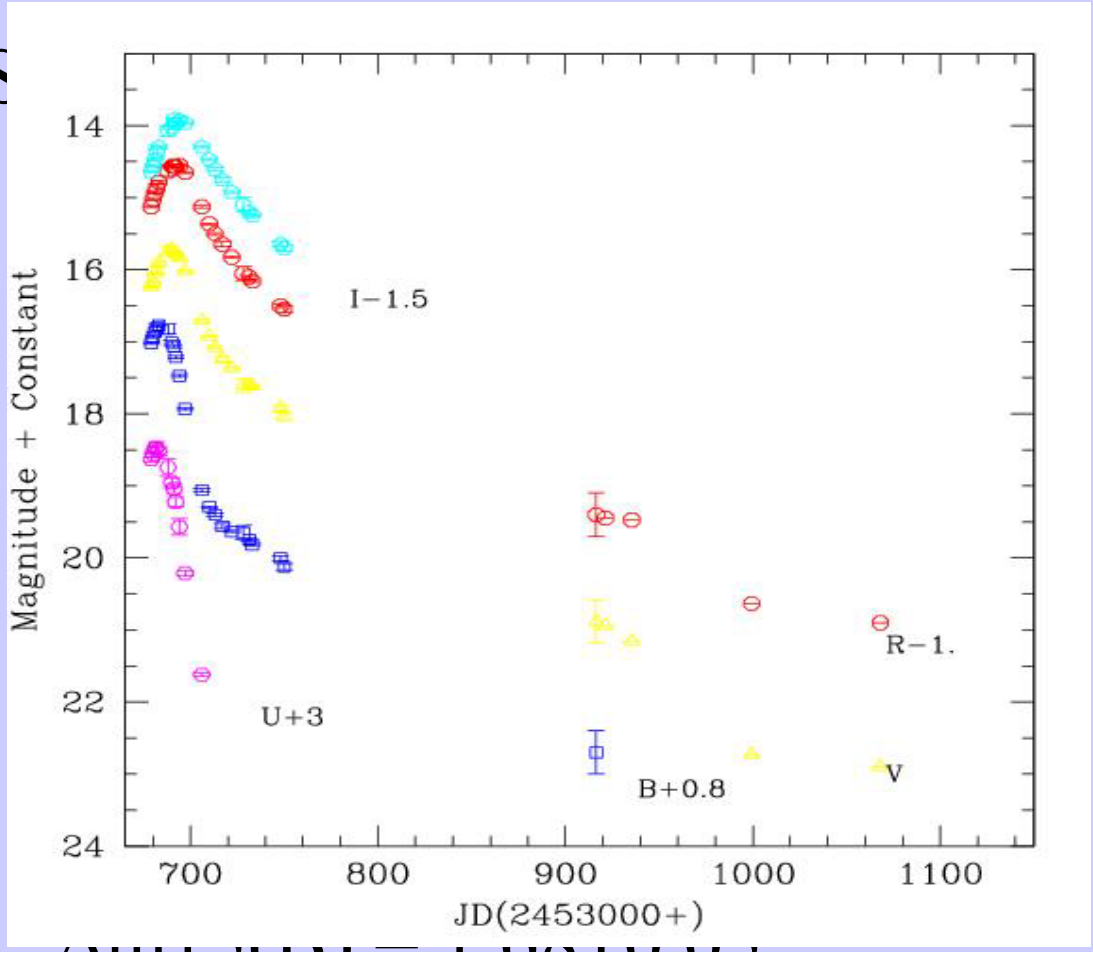


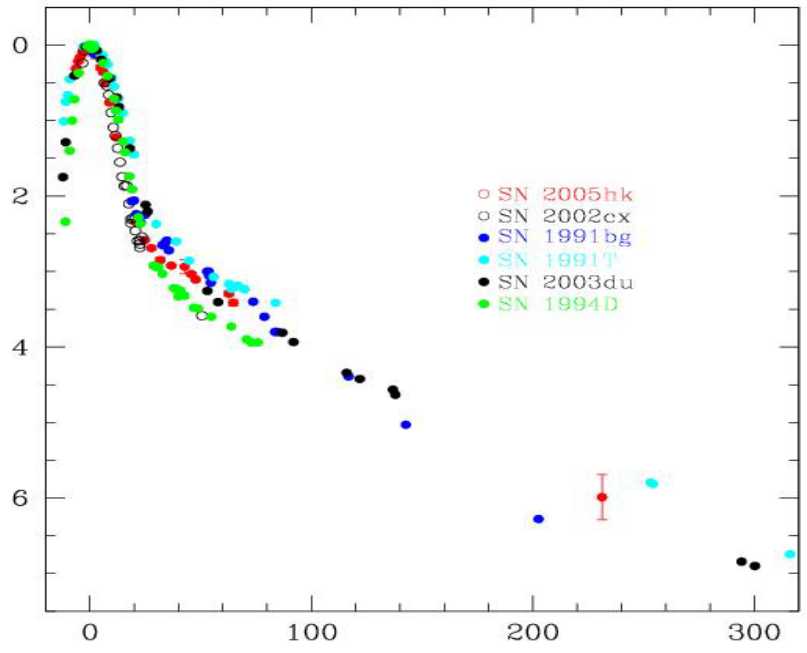

Table 4: Photometric parameters for SN 2005hk

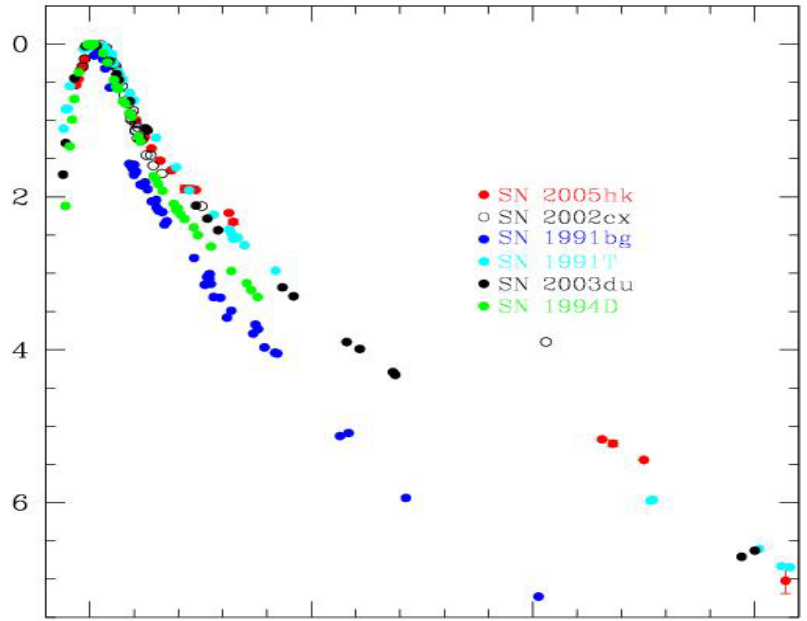
| Data | $B$ | $V$ | $R$ | $I$ |
|---|---|---|---|---|
| epoch of max* | $685.34 \pm 0.4$ | $689.49 \pm 0.8$ | $691.78 \pm 0.2$ | $693.93 \pm 0.3$ |
| magnitude at max | $15.905 \pm 0.03$ | $15.711 \pm 0.04$ | $15.553 \pm 0.02$ | $15.429 \pm 0.03$ |
| $\Delta m_{15}(B)$ | $1.68 \pm 0.05$ | | | |
| colours at B max** | | $B-V$ | $V-R$ | $R-I$ |
| | | $-0.03 \pm 0.04$ | $0.08 \pm 0.03$ | $-0.02 \pm 0.06$ |

* JD 2453000+

**colours are corrected for reddening $E(B-V)_{total} = 0.112$

# SN 2005hk : Light curves




SN 1991T Δm15(B) = 0.95

lbg Δm15(B) = 1.93

4D Δm15(B) = 1.31

Δm15(B) = 1.29 (1.7)

3du Δm15(B) = 1.04

***of SN 2005hk is very***

***om the light curves of***

***SNe except SN 2002cx***

V LC – pre maximum

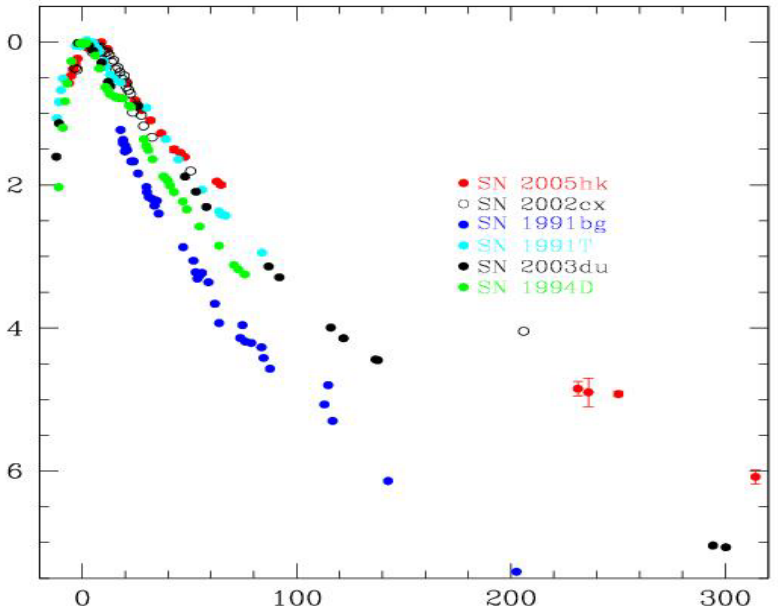
faster than SN 1991T,

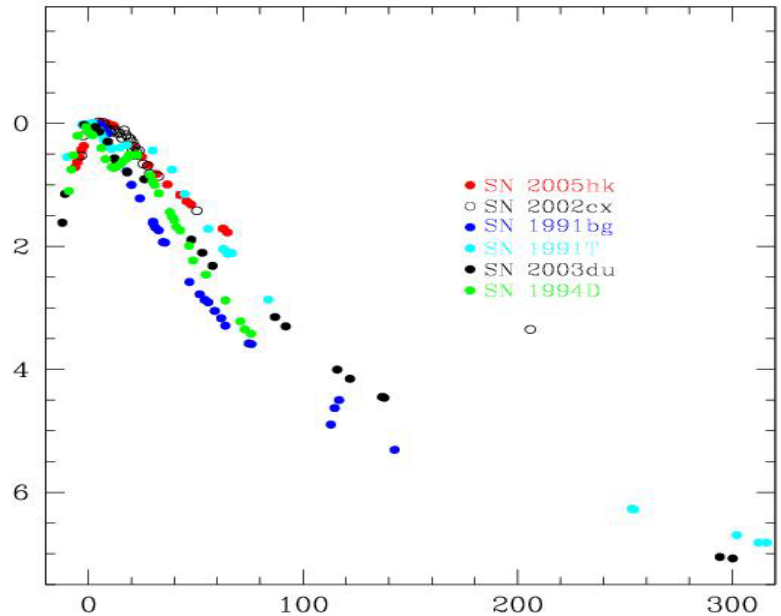
to other type Ia SNe.

faster than other SNe.

lower de- cline.

# SN 2005hk – light curves




Pre-maximum R & I evolution faster th

SN 2003du and SN 1994D.

***y peak – similar to sublumi***

***ous SN 1991bg.***

***ter maximum R-band light***

***similar to SN 1991T.***

***urve shows slower decline***

***Early light curves are very similar to***

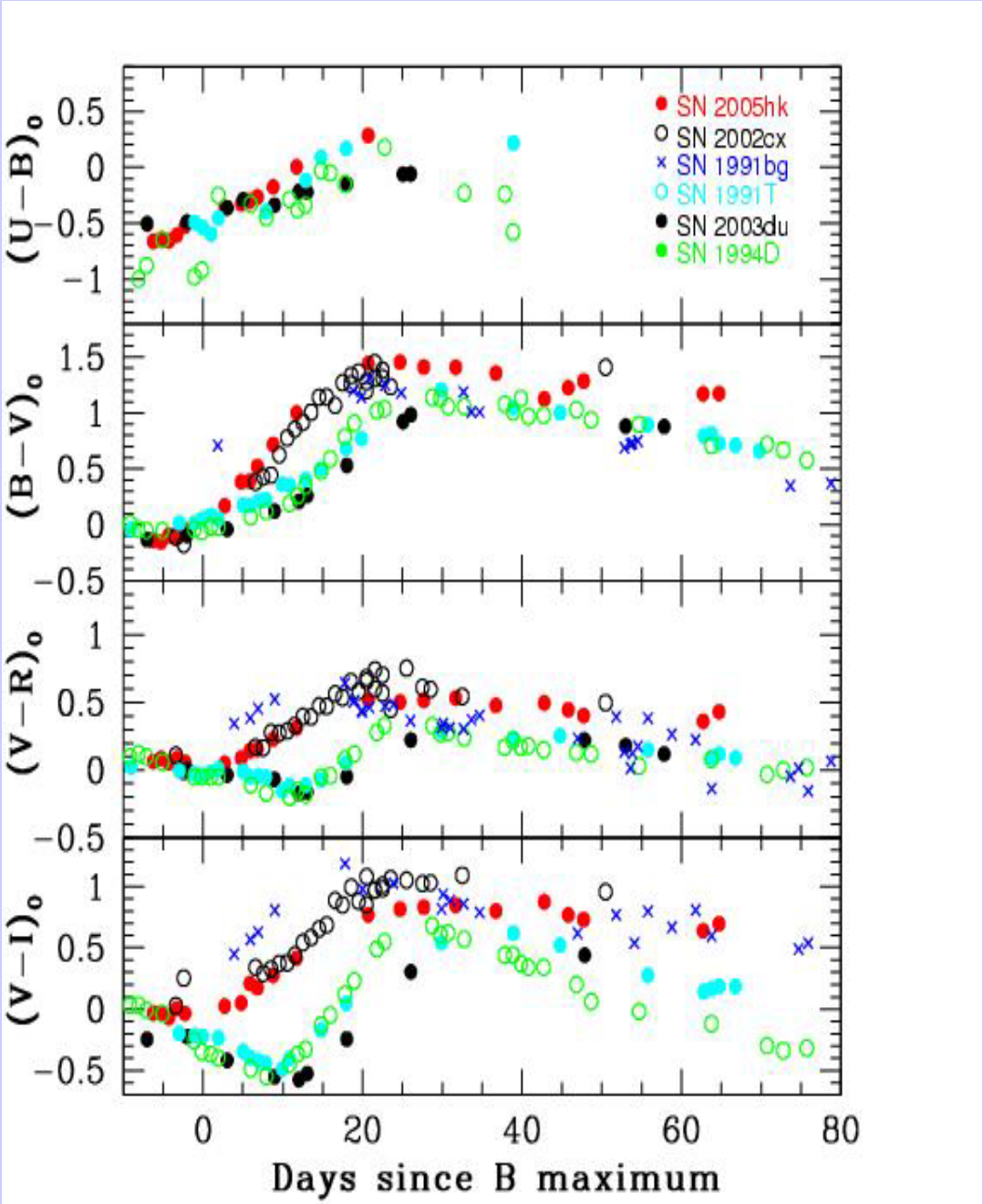
***15 days after B maximum***

***nt difference in the Lcs.***

***5hk declines slower***

***and I than SN 2002cx.***

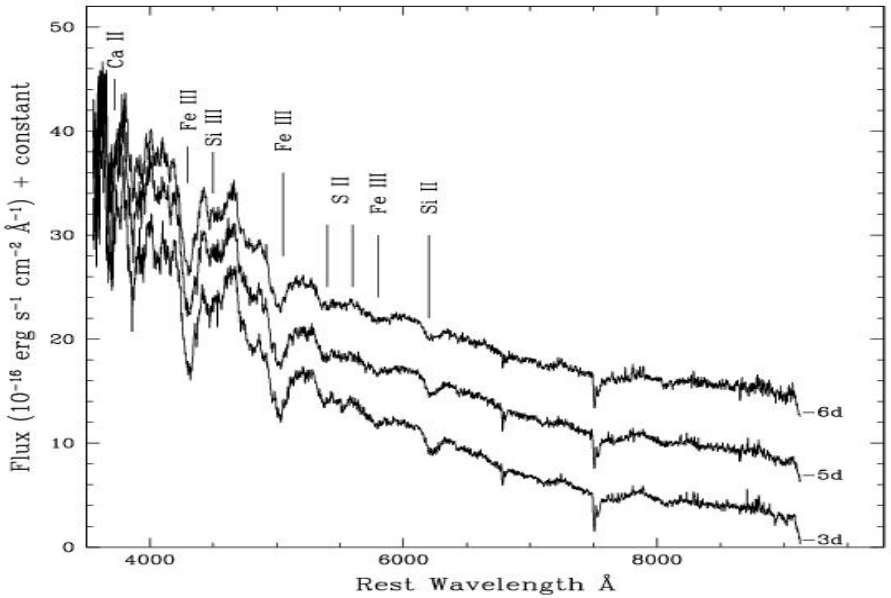
# SN 2005hk – colour curves

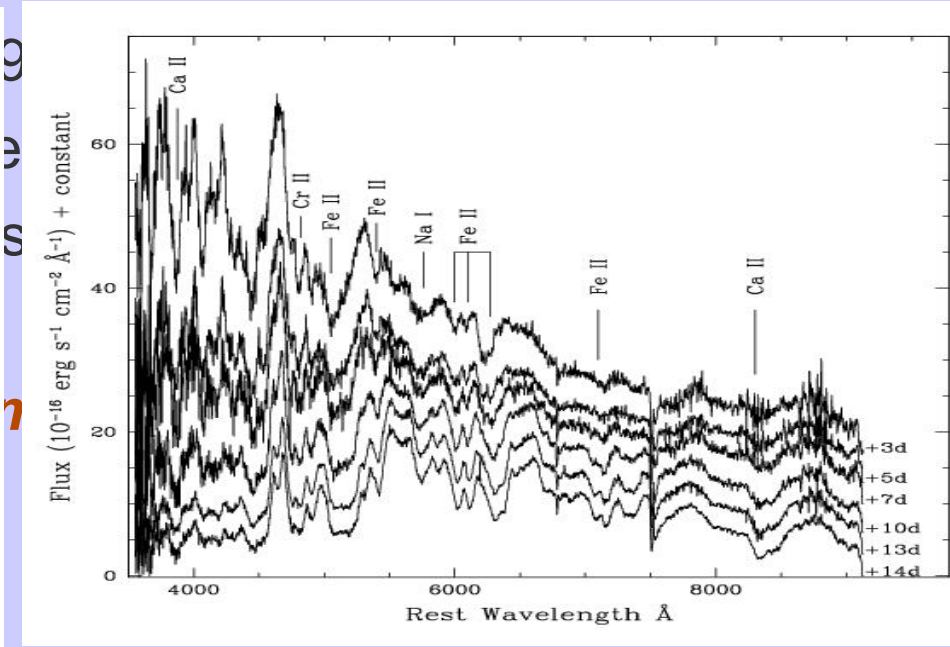


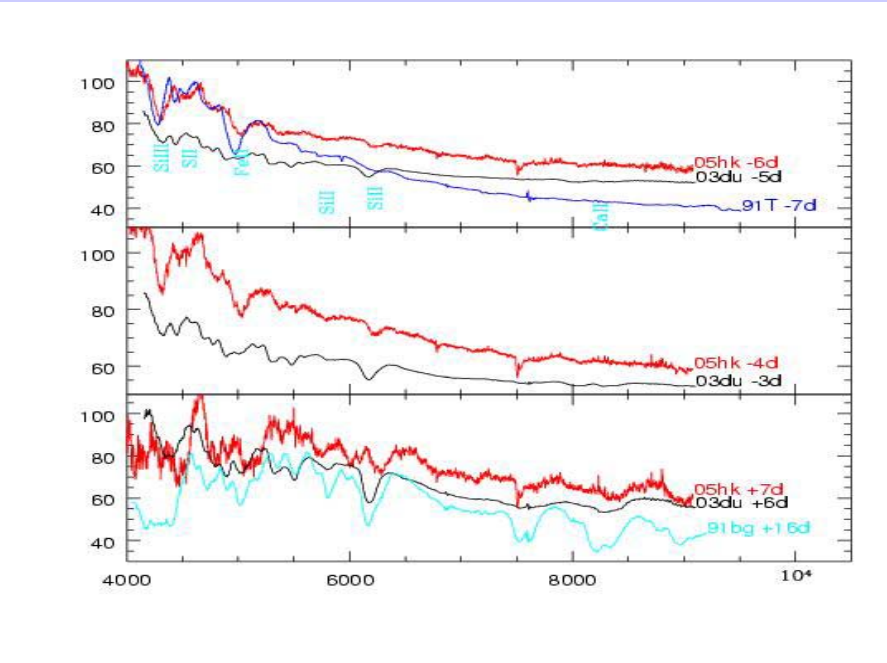

ReddeningE(B-V)gal = 0.022

# Spectral evolution

- ***Early phase***



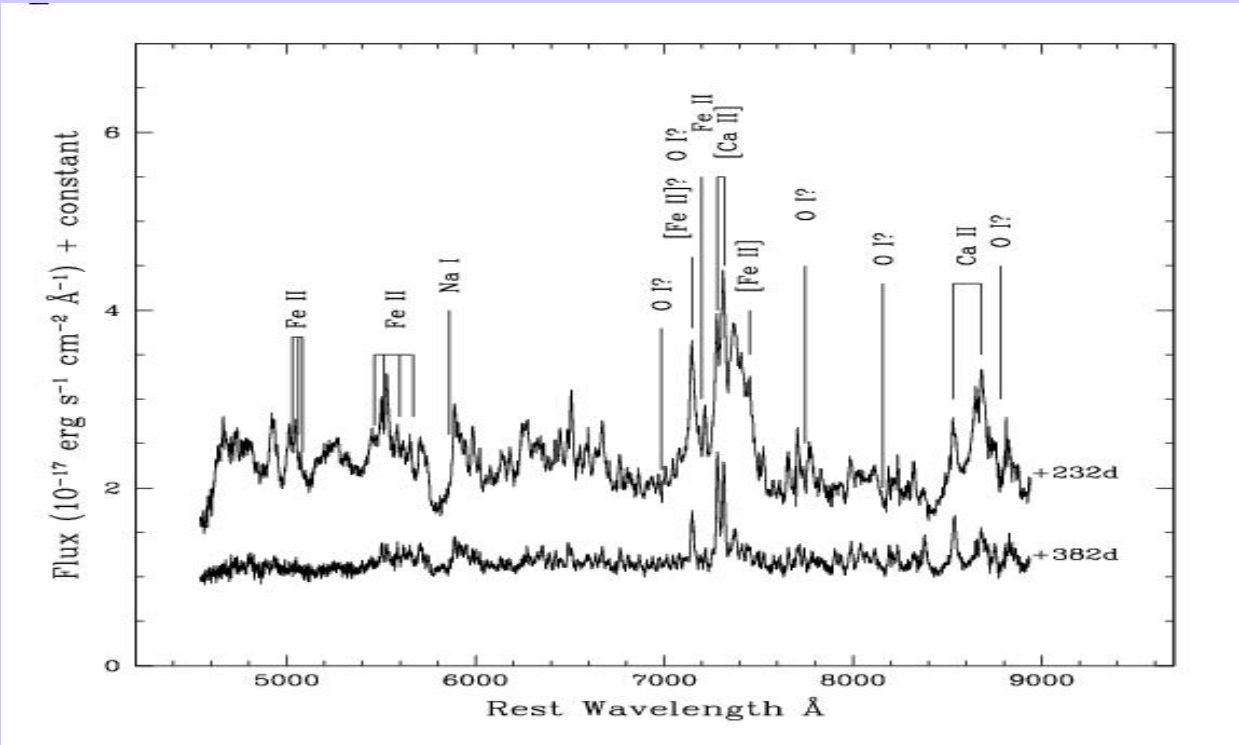



# Spectral evolution

- ***Nebular phase***

***Nebular spectrum***

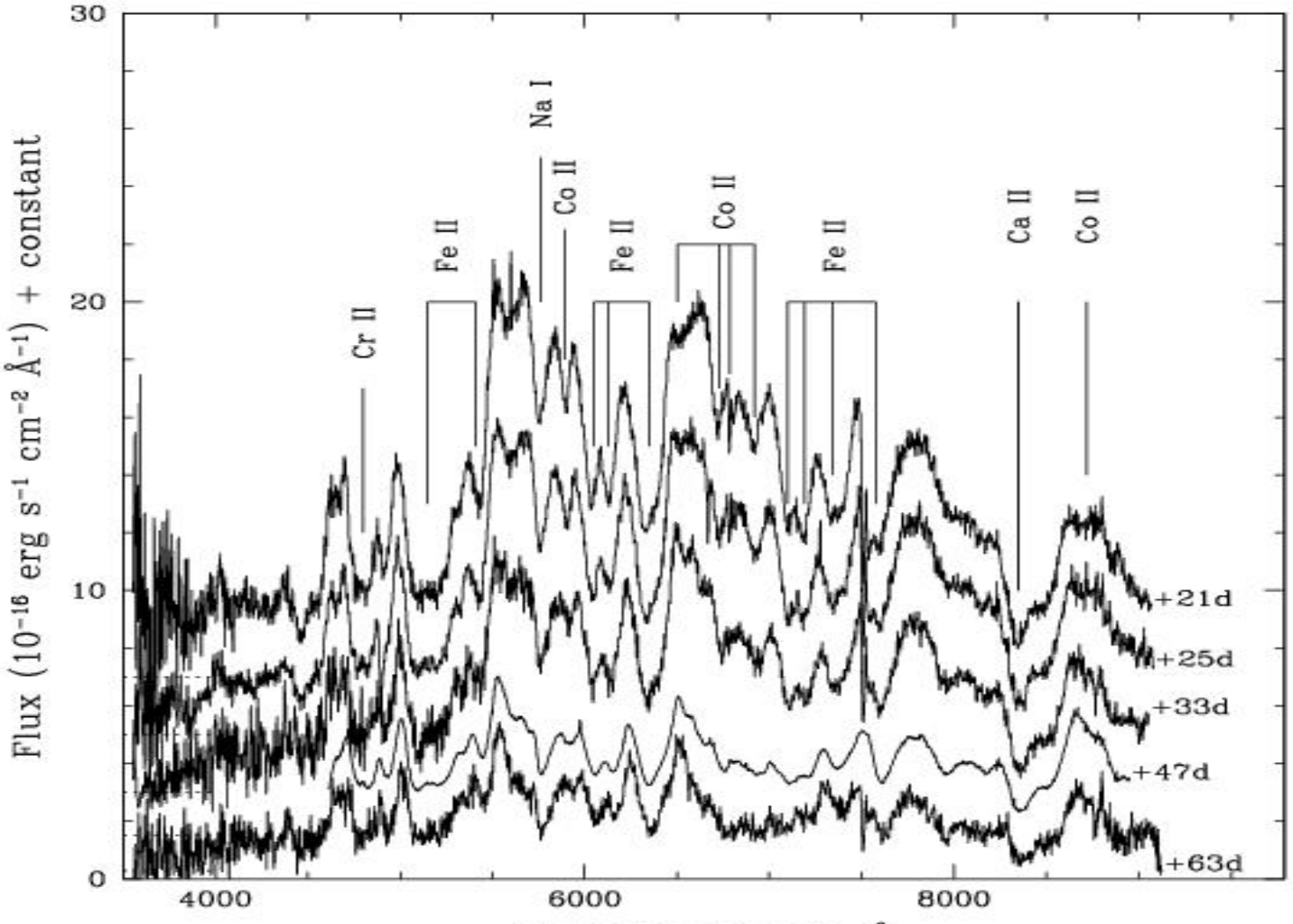



***[Ca II] higher expansion velocity (~500 km/sec) and lower veloci- ty dispersion (1100 km/sec) than Ca II line.***

***The absorption due to low velocity OI – velocity ~ 800km/se***

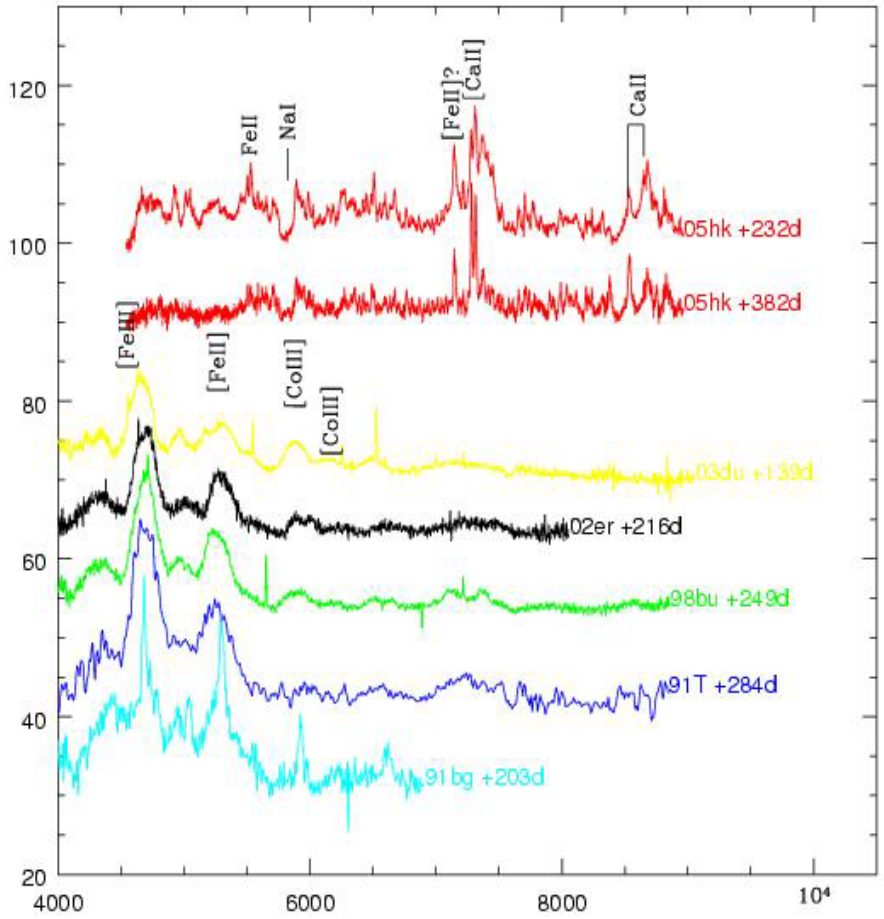
***Mass of the ejecta ~ 0.25 M_sun***

- Flux in the blue cont. declines steadily,
  spectra remains almost unchanged from day +10 to +25.

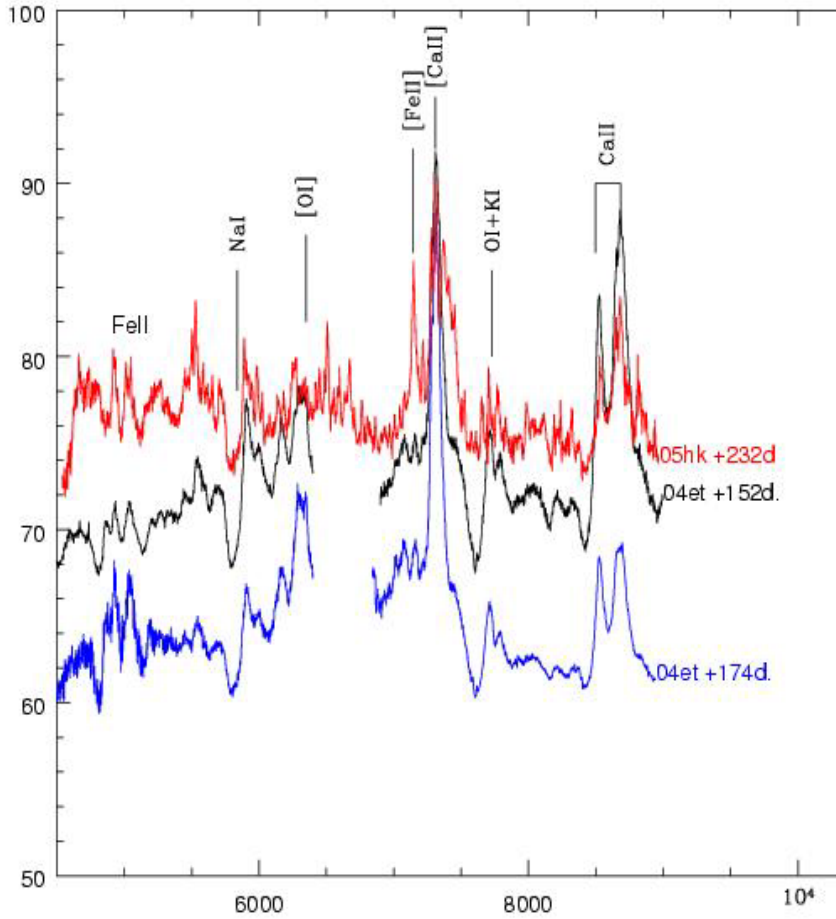


# *Spectral comparison*：

## Type Ia

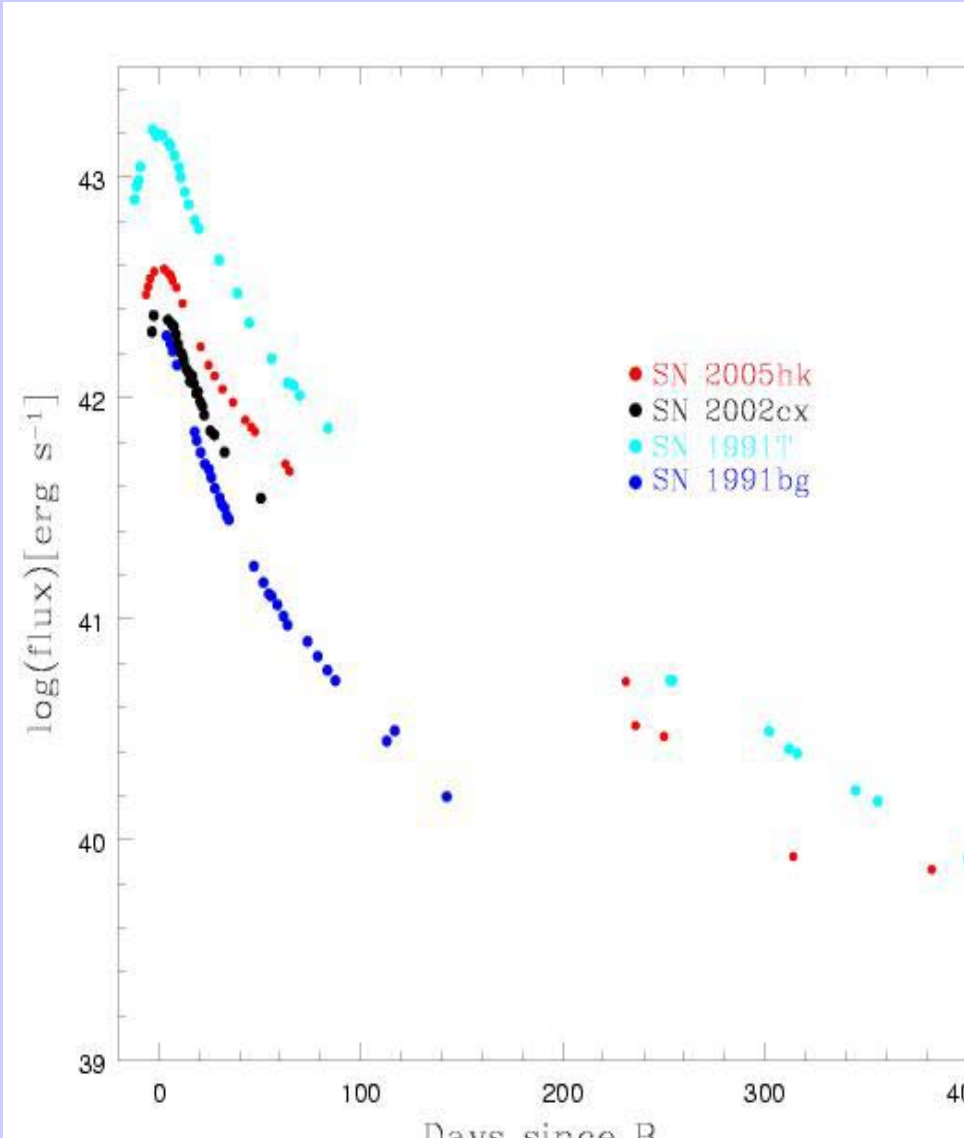



## Type IIP



# Bolometric light curve

- UBVRI JH (Phillips et al 2006) mag. reddening corrected monochromatic fluxes fitting spline curve to the monochromatic flux. integrating over 3100Å to 1.63 micron
  Bolometric corrections
  0.294±0.045 in V
  0.677±0.027 in R
  SN 2005hk brighter than SN 2002cx and SN 1991bg



- ***Nickel mass :***

  ***The amount of 56 Ni ejected may be estimated using the peak bolometric luminosity (Arnett 1982).***

  ***mass of 56Ni = 0.2 M_sun***

  ***Detailed modelling – an explosion with lower kinetic energy, whic is consistent with the low expansion velocity of the ejecta.***

***Summary :***

- ***SN 2005hk belongs to a new subclass of type Ia events, most of the properties can be explained with an explosion with lower K.E., that produced very low 56Ni in the explosion.***
- ***The similarity of the late type spectra with the Type IIP events needs detailed modelling of the nebular spectrum.***