Early Phase Observations of the Extremely Luminous Type Ia SN 2009dc

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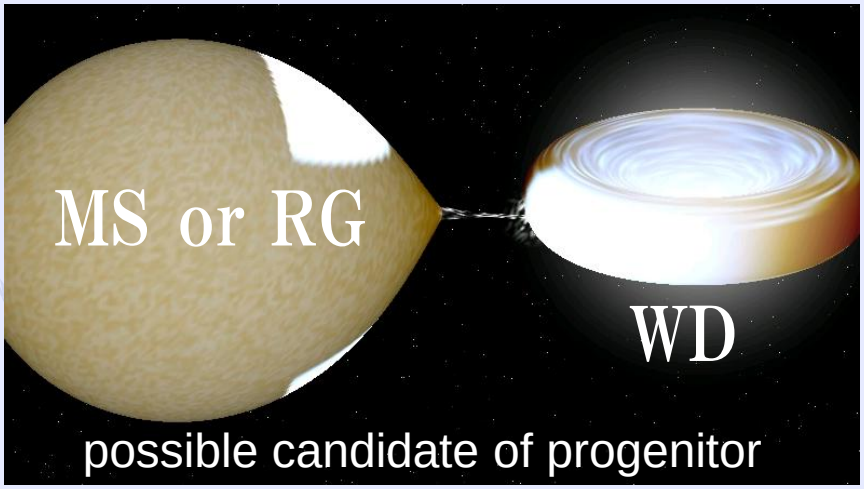
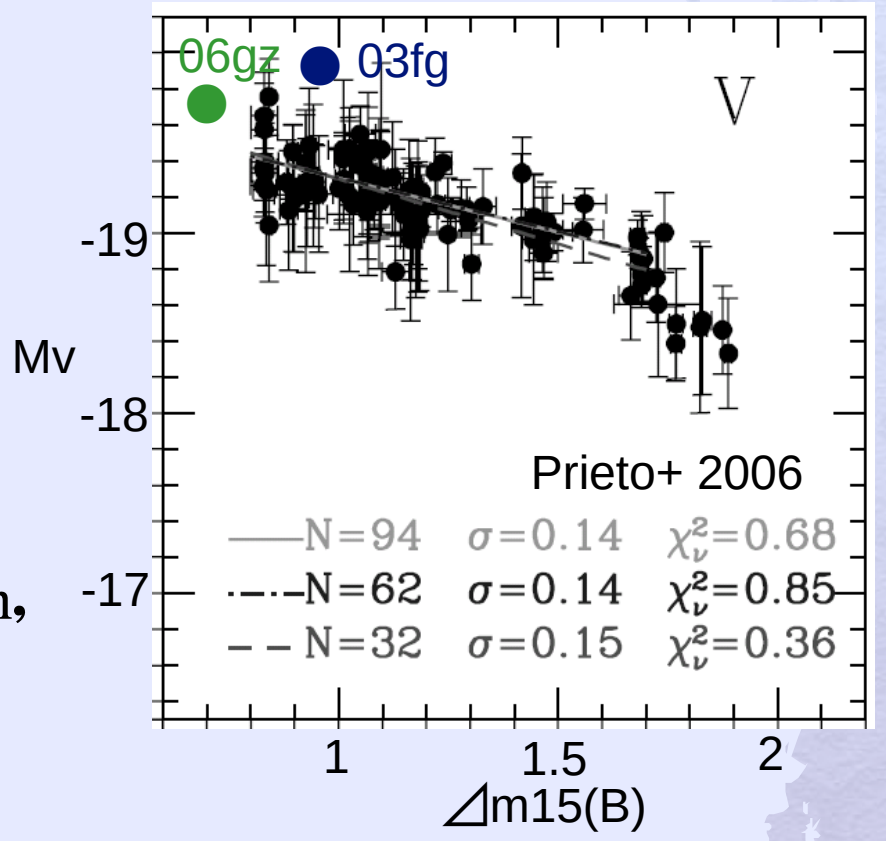
and
Many observers in Japan !

IAP Workshop 2010 (Paris, June 28 – July 2)
"Progenitor and environments of the stellar explosions "

Explosions of Type Ia Supernovae



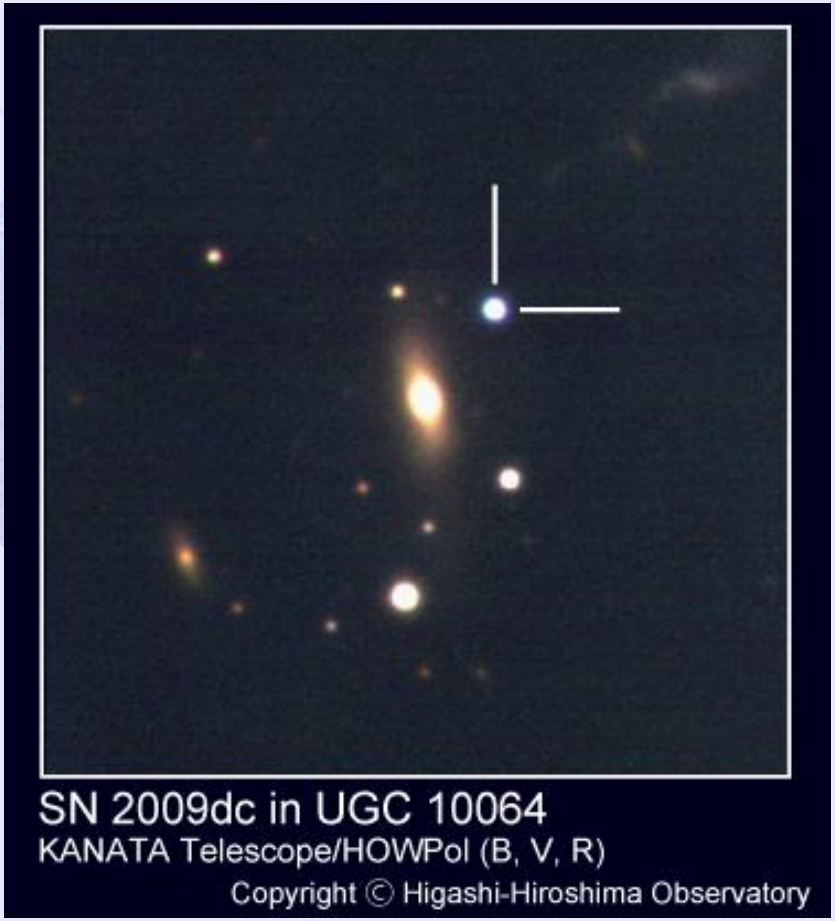
When the mass reaches near the Chandrasekhar-limiting mass of 1.4MSun, the white dwarf explode as a Type Ia supernova. More luminous Type Ia SNe show slower decline rates.



Recently, two extremely luminous SNe Ia, 2003fg and 2006gz have been confirmed (Howell et al. 2006; Hicken et al. 2007). Interestingly, these SNe showed strong carbon absorptions in their spectra, although typical SNe Ia do not.

We present the another extremely luminous Type Ia SN 2009dc and discuss the possibility of its super Chandrasekhar-limiting mass.

SuperNova 2009dc



SN 2009dc was discovered at 16.5 mag in lenticular galaxy UGC 10064 on Apr 9.31(UT) (CBET 1762).

The follow-up observations were performed and the spectral features exhibit the absorption of CII, which is also seen in Super-Chandrasekhar SN 2006gz (CBET 1768).

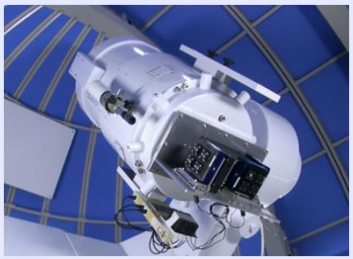
If SN 2009dc is much luminous as SN 2006gz, the object would be a third candidate of Super-Chandrasekhar Supernovae.

We performed multi-band photometry and spectroscopy of 09dc using the six telescopes in Japan.

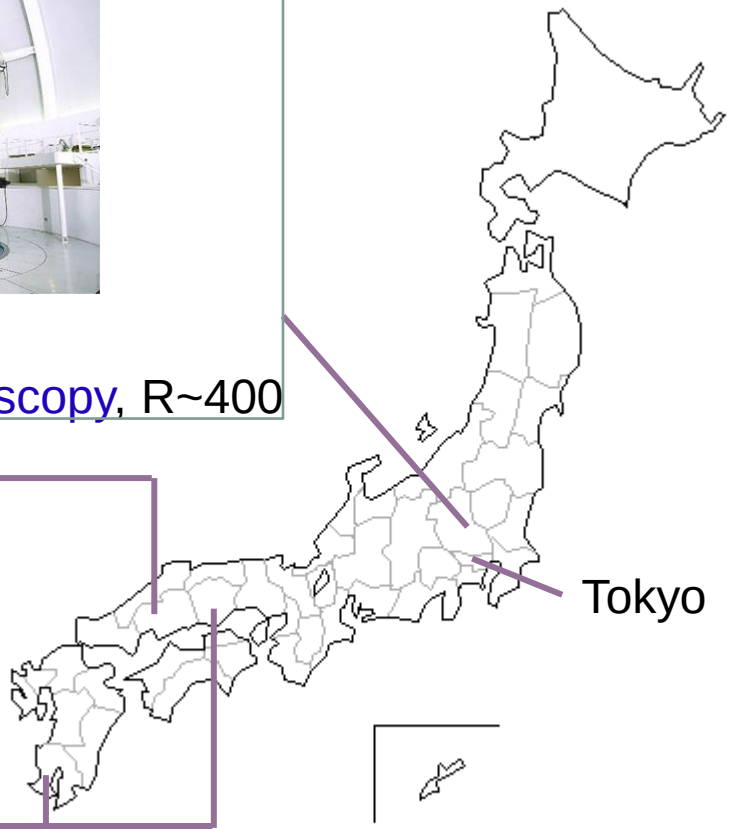
Campaign observations of SN 2009dc in Japan

Hiroshima
1.5m: optical photometry

Gunma
1.5m: spectroscopy, R~400



Okayama
0.5m: optical photometry
1.88m: near-infrared photometry



Kagoshima
1m:
near-infrared
photometry

In my talk, the following observations are presented

BVRcIc-band photometric observations

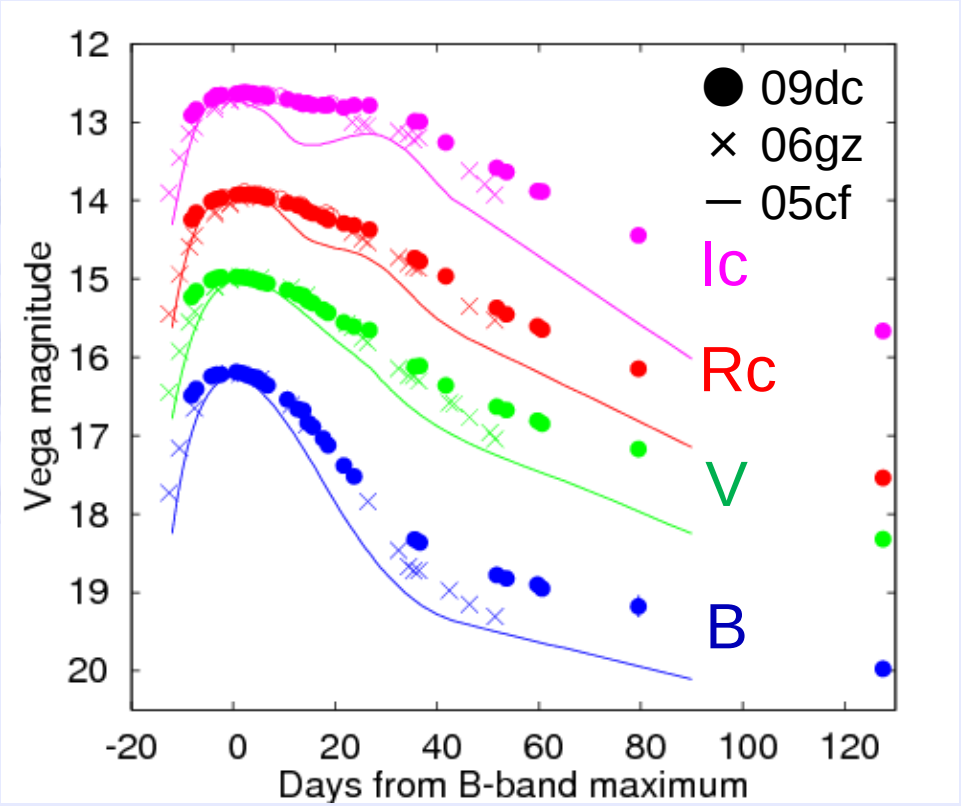
Light curves, absolute magnitude, Ni mass

Sepctroscopy

Carbon features, line velocity

(We do not show near-infared observations)

Optical light curves

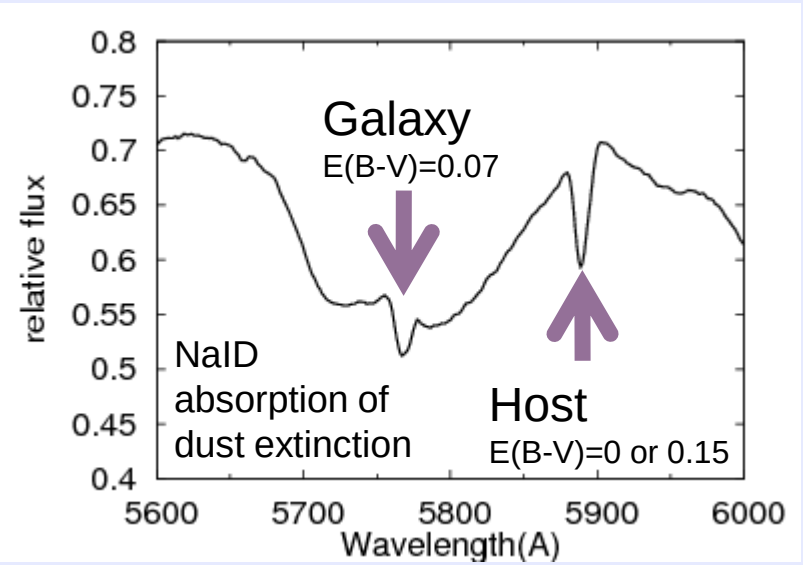


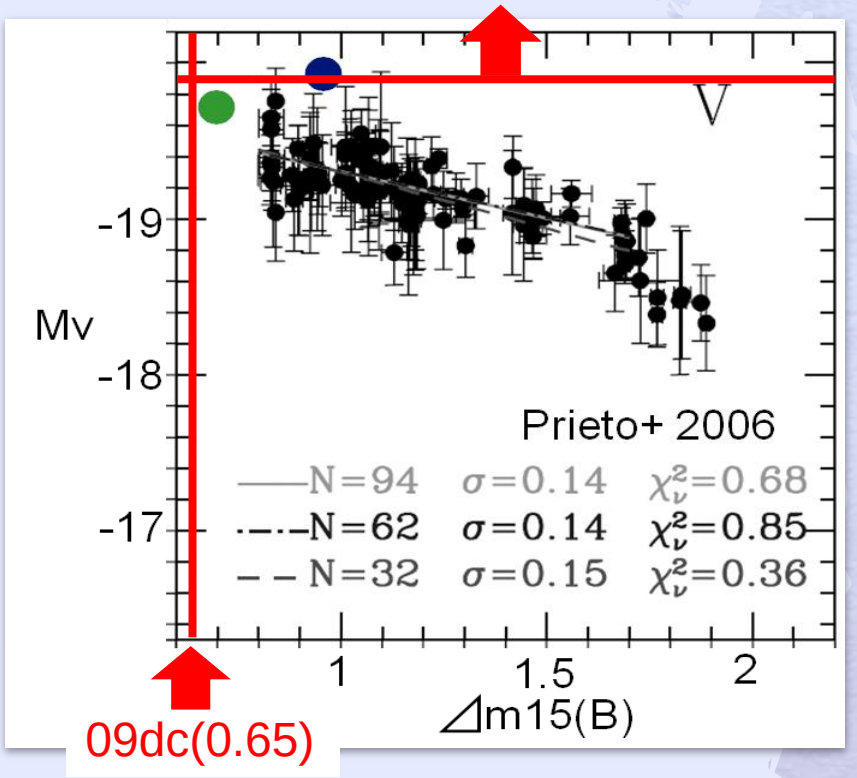
The decline rate of 09dc is very slow comparing to that of a typical SN Ia (⊿m15(B)=1.05 of 05cf).
The ⊿m15(B) was estimated to be 0.65+/-0.03, which is comparable to 0.69+/-0.05 of 06gz.

The very slow light curves indicate that SN 2009dc is intrinsically luminous as SN 2006gz.

The extinction and absolute magnitude

We estimated to be absolute magnitude of −19.90+/−0.05 mag from the extinctions of zero.



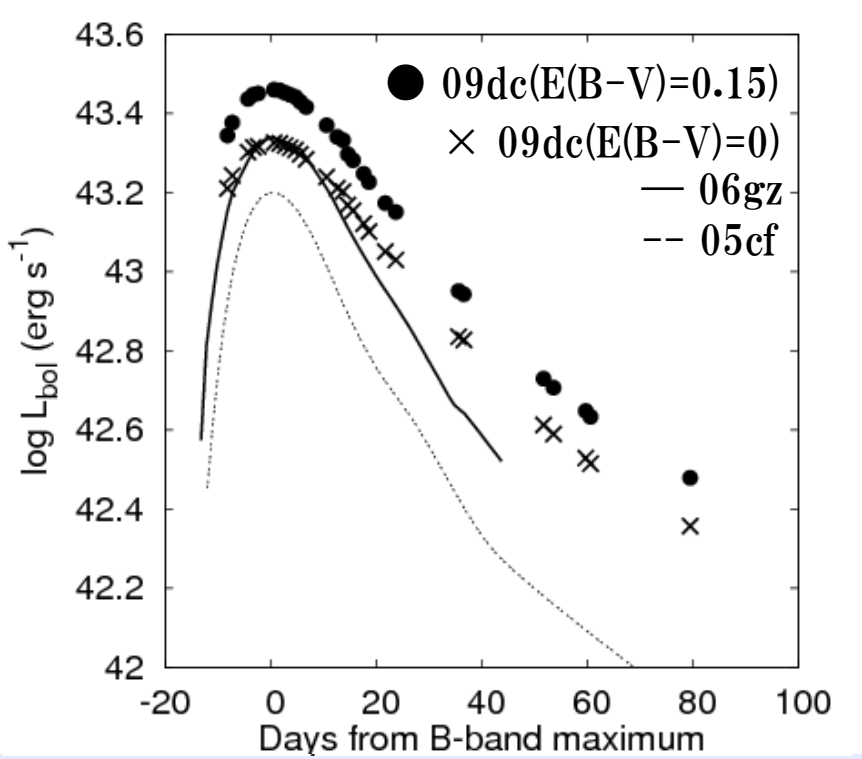


E(B−V)	Rv	Av	Mv
0			−19.90+/−0.05
0.15	2.1	0.29	−20.19+/−0.19
0.15	3.1	0.43	−20.32+/−0.19

06gz (E(B−V)=0.18):
Mv=−19.90+/−0.21

Even if we neglect the extinction of the host, SN 2009dc is one of the most luminous Type Ia Supernovae.

Bolometric luminosity and ^{56}Ni mass



Assumption
60% from the optical regions.
rising time of 20 days

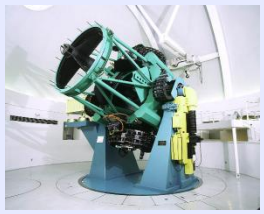
Even if we regrect the host extinction, the luminosity of 09dc is 1.5 times as that of typical 05cf.

The peak luminosity is proportional to ^{56}Ni mass. SN 2009dc synthesized the one of the largest Ni mass.

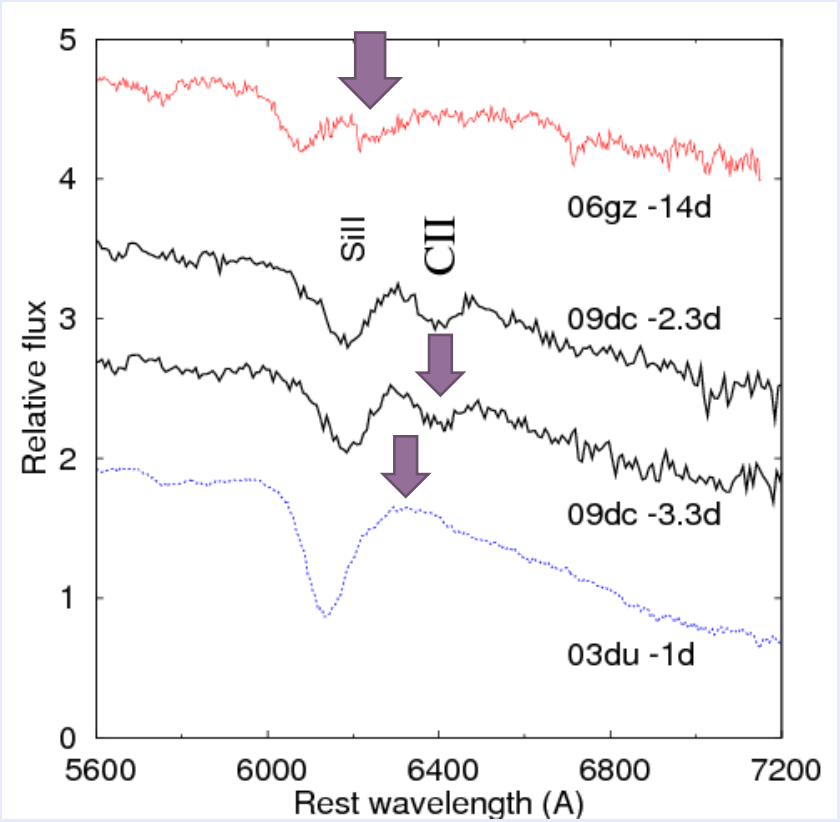
Considering the extinctions, the luminosity is much more.

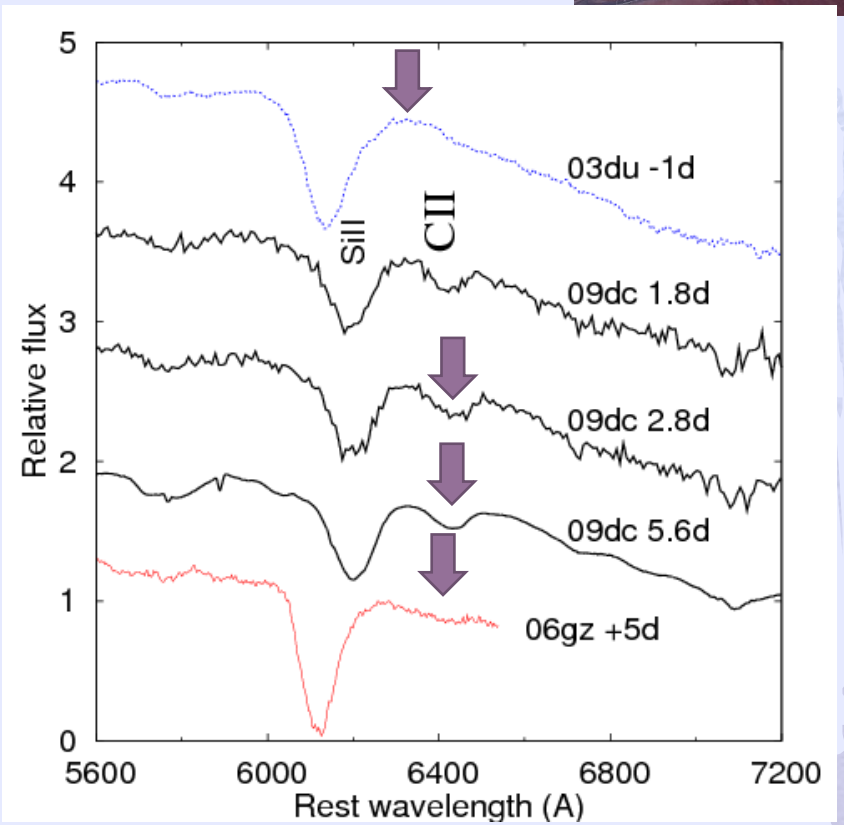
We estimated to be $1.2M_{\odot}$ of Ni mass in 09dc from the peak luminosity and the rising time. (Assuming Av=0.43, the Ni mass is $1.8M_{\odot}$.)

e.x.
(super Chandrasekhar)
06gz : $1.2M_{\odot}$
(typical SN Ia)
05cf : $0.8M_{\odot}$

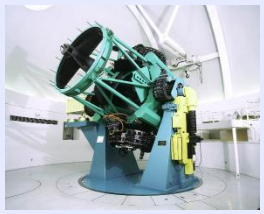


Spectral evolution

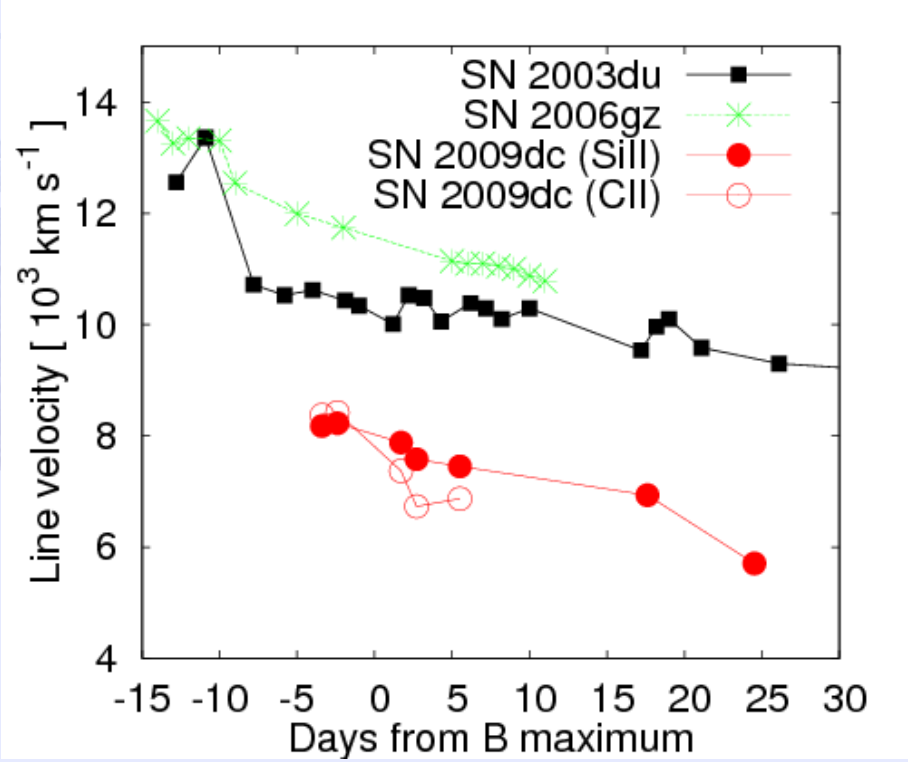




Carbon features are not seen in normal SNe Ia (c.f. 03du). But, the features are conspicuously seen in 06gz and 09dc in their early phase. Furthermore, absorption of CII λ6580 of 09dc is still seen in 09dc at the 5.6 days after maximum, while not in 06gz. This suggests that the outer CO layer is thicker comparing to that of 06gz.



Line velocity



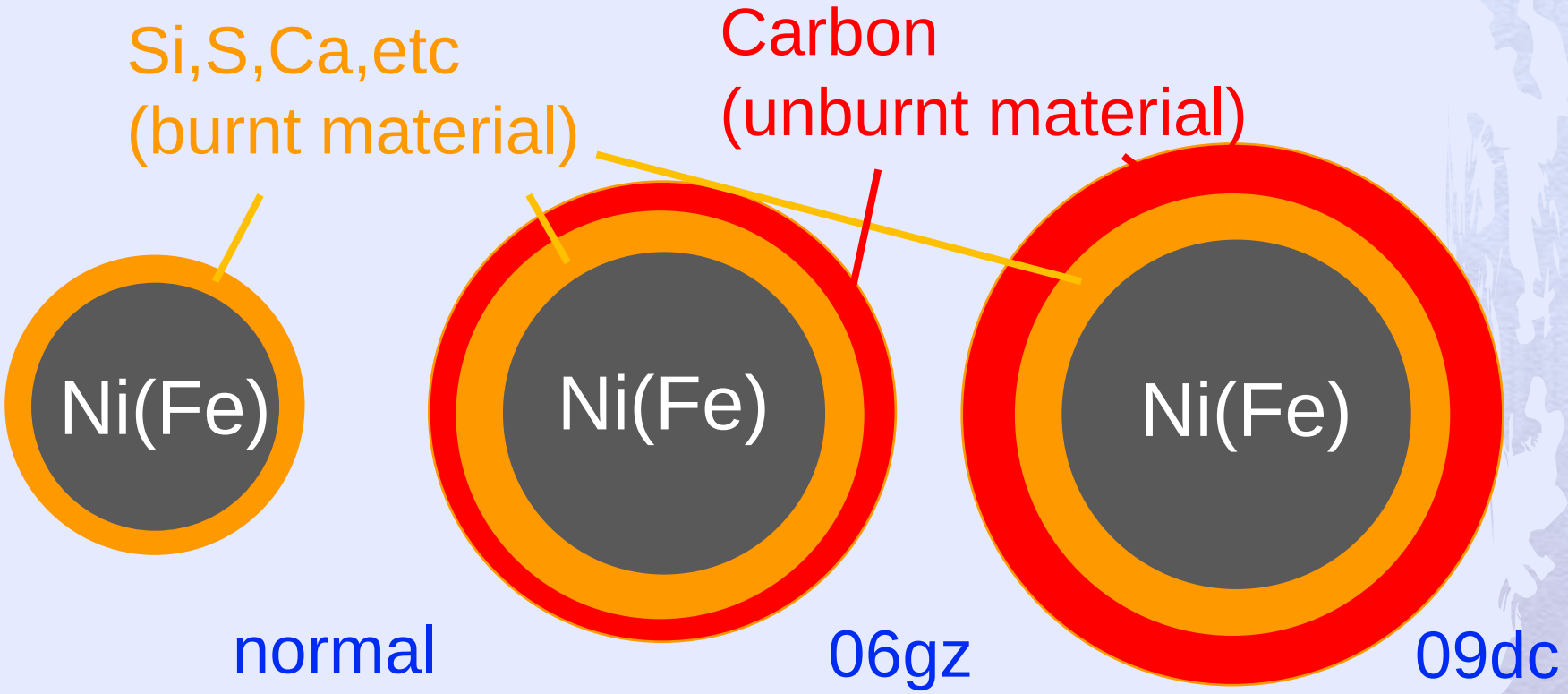
06gz：SiII 12000km/s

09dc：SiII,CII 8000km/s

(typical SN Ia：12000km/s)

The line velocity is much slow comparing to that of SN 2006gz.

Pictures of explosion



In a normal SN Ia, the absence of carbon features indicate that the nuclear burning reaches outermost layer. The carbon is originated from the unburnt material in the WD. In the case of 06gz and 09dc, thermonuclear burning in the WD would not reach outermost layer and outer material remains.

Conclusion：properties of the SN 2009dc

(1) One of the slowest decline rate
(⊿m15(B)=0.65+/−0.03)

(2) One of the most luminous Type Ia Sne
⇒ One of the largest synthesized Ni mass
(>1.2$M_\odot$. 1.8$M_\odot$ if host Av=0.43.)

(3) The CII features remain until 5 days after maximum
(indicating thick outer layer)

(4) Slow velocity comparing to that of 06gz

The total ejected mass of SN 2009dc likely exceeds the Chandrasekhar-limiting mass.

Thank you for your listening !