A WC star explosion: SN 2006jc

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Abstract & Conclusion

(1) First direct detection of the dust formation in Type Ib SN: SN2006jc is a first SN indicating the dust formation at early epoch (~60days) by the optical and NIR observations contributed by SUBARU and the AKARI observation at ~220days provides the evidence of the dust formation in SN2006jc.

(2) Early dust formation: the rapid cooling of the SN ejecta due to the high-energy and less-massive explosion realize the dust formation at the early epoch.

(3) A WC star explosion: we propose the consistent model for SN2006jc throughout the stellar evolution, the bolometric and X-ray light curves, and the dust formation.

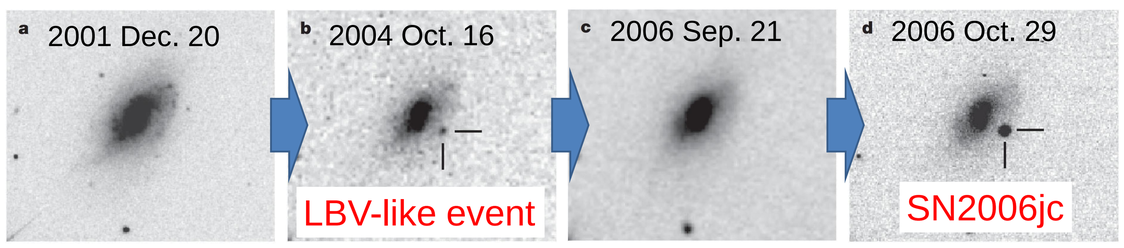
Reference

Tominaga et al. 07 (arXiv:0711.4782)
Sakon et al. 07 (arXiv:0711.4801)
Nozawa et al. 08 (arXiv:0801.2015)
Kawabata et al. in prep.
Anupama et al. in prep.

Observation

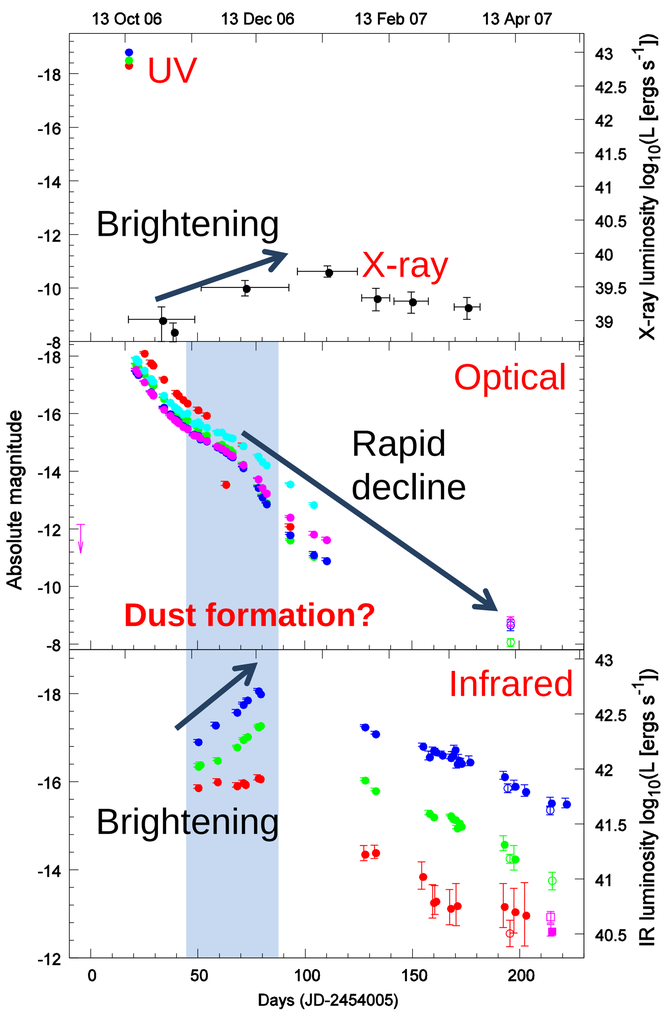
LBV-like explosion before SN2006jc

Pastorello + 07



Wide multiwavelength observation

X-ray to Midinfrared



X-ray & UV (Swift & Chandra) Immler + 07

X-ray luminosity brightens from ~40days to ~100days.

CSM interaction made progress gradually.

Optical (HCT, India) Anupama + in prep
(SUBARU & Kanata) Kawabata + 07, in prep

Optical luminosity declines rapidly at >70days.

Infrared

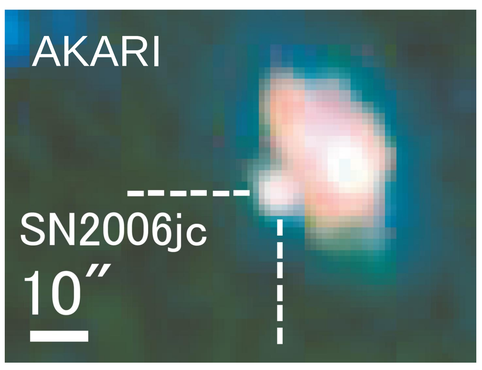
NIR(AZT-24, Italy) Di Carlo +07
NIR(MAGNUM) Minezaki + 07
IR(AKARI) Sakon + 07

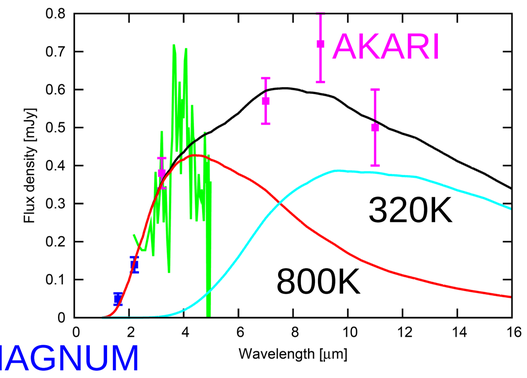
NIR luminosity brightened from ~50days to ~80 days.

Dust was formed rapidly.

Detection of the dust formation

Sakon + 07



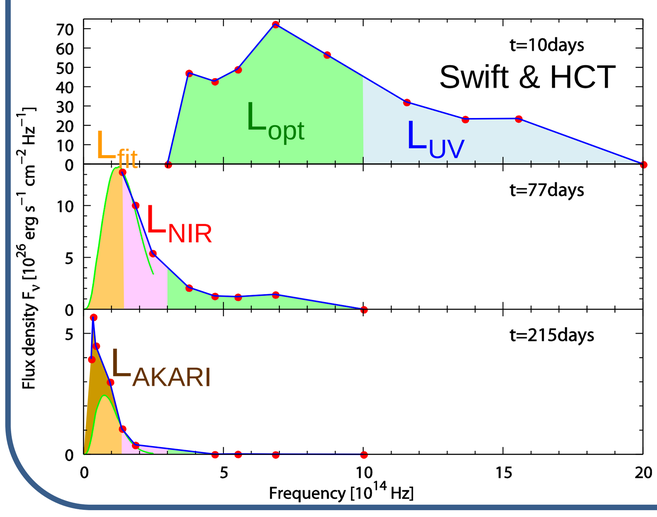


MAGNUM

IR SED is reproduced by 2-temp. carbon dust with 800K (~7x10^{-5}M$_\odot$) and 320K (~3x10^{-3}M$_\odot$). Origins of dust might be the SN ejecta and CSM.

Bolometric construction

Tominaga + 07



L_{UV}~0.8L_{opt}

For other epochs, we assume L_{UV}~0.8L_{opt}.

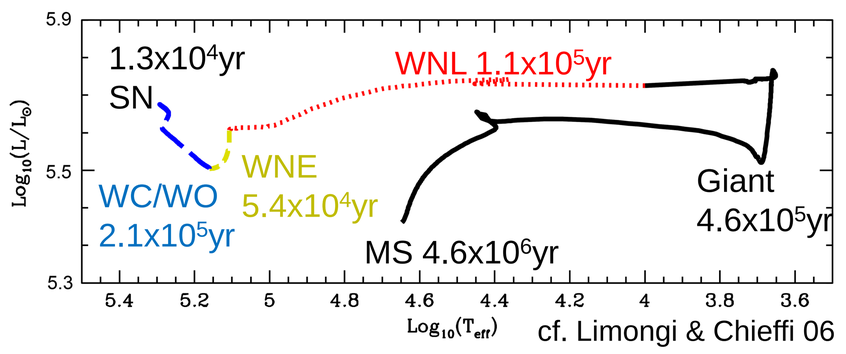
L_{fit} is estimated from NIR SED.

L_{fit} fits well L_{AKARI} obtained by AKARI.

Progenitor star & SN explosion

WC Wolf-Rayet star

Tominaga + 07



cf. Limongi & Chieffi 06

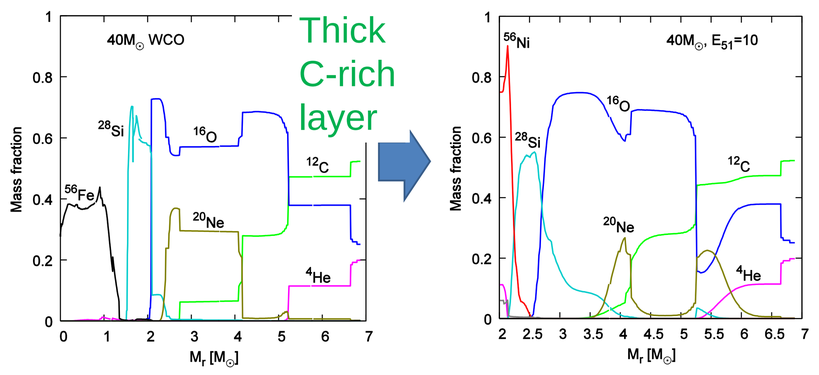
Dust formation in SN ejecta & CSM

C-rich CSM

WC star explosion (typically M_{ms}>40M$_\odot$)

Supernova explosion

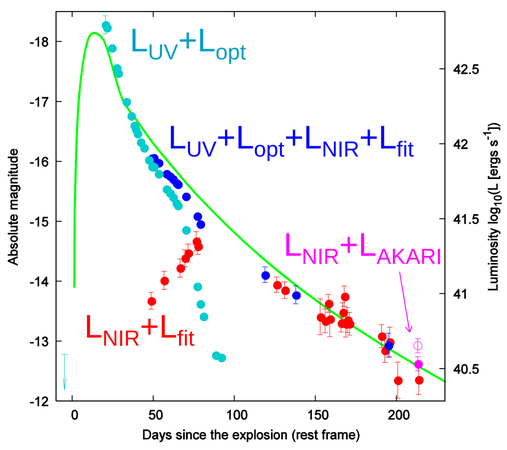
E=10^{52}ergs



The 40M$_\odot$ star became a WC star with M_{preSN}=6.9M$_\odot$ at the preSN stage.

Calculations
Hydrodynamics
Nucleosynthesis
Radiative transfer
CSM interaction
X-ray radiation

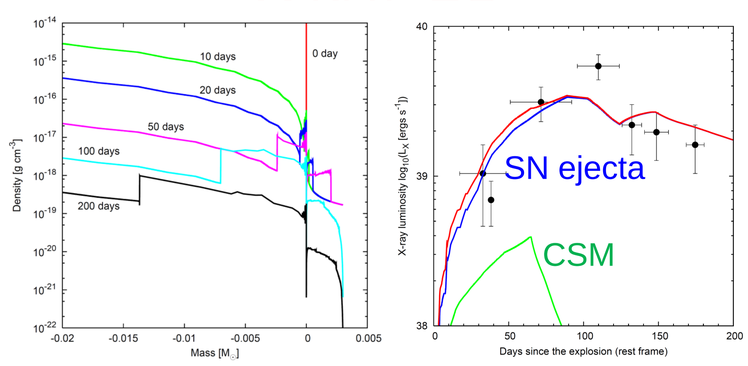
Bolometric LC



Bright hypernova-like explosion

M_{ej}=4.9M$_\odot$
E=10^{52}ergs
M(^{56}Ni)=0.022M$_\odot$

X-ray LC



Shallow CSM density gradient

$\rho = 1\times10^{-13}(r/3\times10^{10}\mathrm{cm})^{-1}$ [g cm^{-3}]

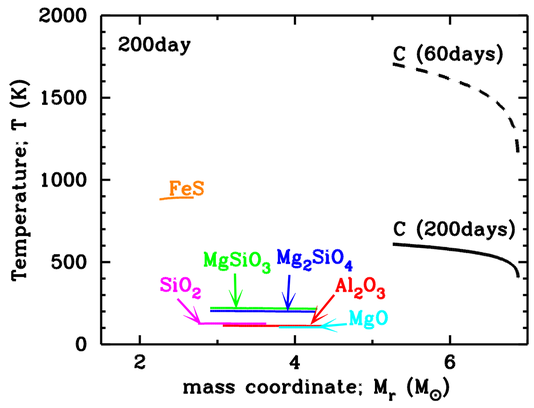
If wind velocity is v_w=2,800km/s, the mass loss rate changed in 2 yrs from ~3x10^{-3}M$_\odot$/yr to ~5x10^{-9}M$_\odot$/yr.

Consistent with the LBV-like event 2 years ago.

Dust formation

Nozawa + 08

Dust formation in SN ejecta



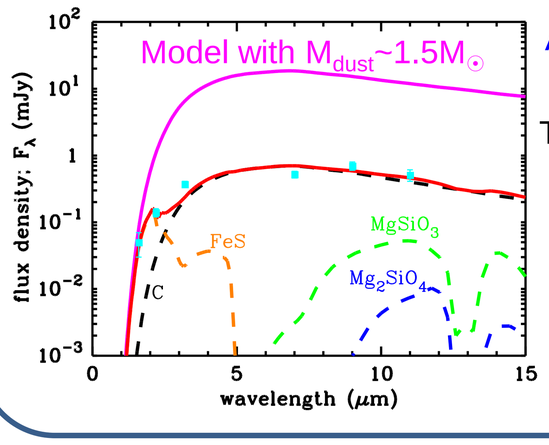
High-energy & less-massive explosion

Rapid cooling of the SN ejecta

Carbon dust formation at ~60days

However, the dust mass (M_{dust}~1.5M$_\odot$) is larger than the estimate of the AKARI observation.

Comparison with infrared observation



A dust destruction process by energetic γ & e$^-$ may reduce the dust mass.

The dust masses reproducing IR SED with T_{dust} are

Dust species	$M_{dust}/M_\odot$	T_{dust}/K
C	5.6x10^{-4}	~500
$MgSiO_3$	<0.157	~200
Mg_2SiO_4	<0.082	~200
FeS	0.002	~900