Optical and near-infrared observations of Type Ia SN 2018gv from early phase

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1. Introduction

It is widely known that Type Ia supernovae (SNe Ia) are used to measure the distances of their host galaxies. However, it is still lack to understand the detail of the progenitor systems and explosion mechanisms, as well as how differences in initial conditions create the diversity in observed properties of SNe Ia. To solve these problems, detailed multi-band observations of dozens of SNe Ia are required.

Recently, diversities of the color evolution in early phase of SNe Ia were reported (Jiang et al. 2018; Stritzinger et al. 2018). The distribution of the energy source, ^{56}Ni, in the ejecta could be a key to probe the diversity. On the other hand, near-infrared (NIR) properties of SNe Ia are still ambiguous (Yamanaka et al. 2016, but see also Li et al. 2019).

In this poster, we present optical and NIR light curves, color evolution, and spectra of SN Ia 2018gv appeared in a nearby galaxy, showing a characteristics of a slowly rising in pre-maximum phase. We compare the observed properties with other SNe Ia and try to discuss the distribution of ^{56}Ni in the ejecta.

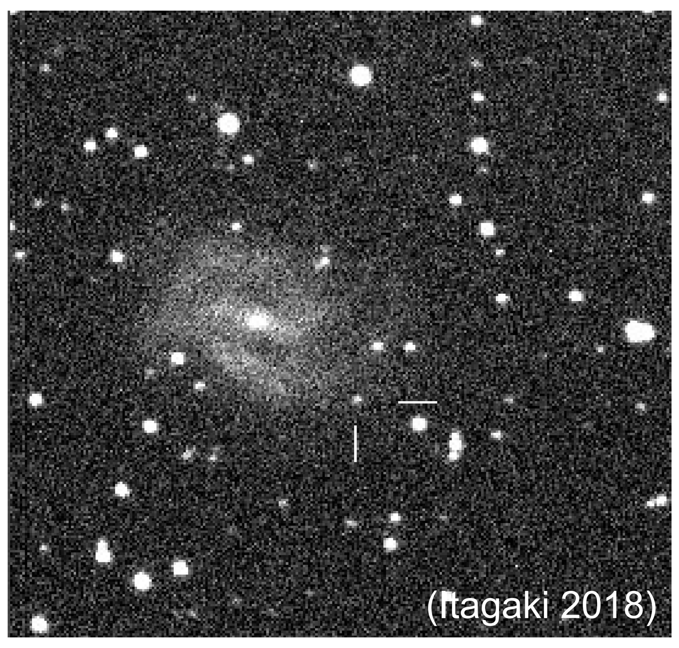

Fig 1. PSN2018gv

RA : 08:05:34.610 Ref. TNS database *1
DEC : -11:26:16.30
Redshift : 0.0053
Discovery date : 2018 January 15
Discovery Magnitude : 16.5
Discoverer : Koichi Itagaki

*1) https://wis-tns.weizmann.ac.il/object

2. Observations & data reduction

1. Observation
- We observed the SN2018gv through 1.5m-Kanata telescope from 2018 January 17th to May 14th.
- We got BVRIJHKs-band photometric data and optical spectra with a wavelength resolution of R=400 and spectral coverage of 4500-9000A.

Fig 2. 1.5m - Kanata telescope *2

2. Light curve
- We got light curves through PSF photometry in IRAF.
- We did color term correction processes to calibrate the magnitudes of our reference stars.

3. Spectra
- We performed the data reduction according to the standard procedure for spectroscopy using IRAF.
- We made flux calibration of SN 2018gv spectra using the spectrophotometric standard stars taken in the same night.

*2) http://hasc.hiroshima-u.ac.jp/telescope/kanatatel-e.html

3. Results & Discussion

1. Light curve of SN2018gv (Figure 3)
- There are double peaks in I,J,H,Ks bands, commonly seen in SNe Ia.
- The B-band maximum date is 2018 February 2 (MJD 58151), and the B-band maximum magnitude is ~13.3 mag.
- The decline rates of the B and V-bands maximum are $\Delta m_{15}(B)$ ~1.0, and $\Delta m_{15}(V)$ ~0.7.
- The second peaks of the I, J, H, and Ks-bands occur on 25days, 35days, 27days, and 24days after B-band maximum respectively.

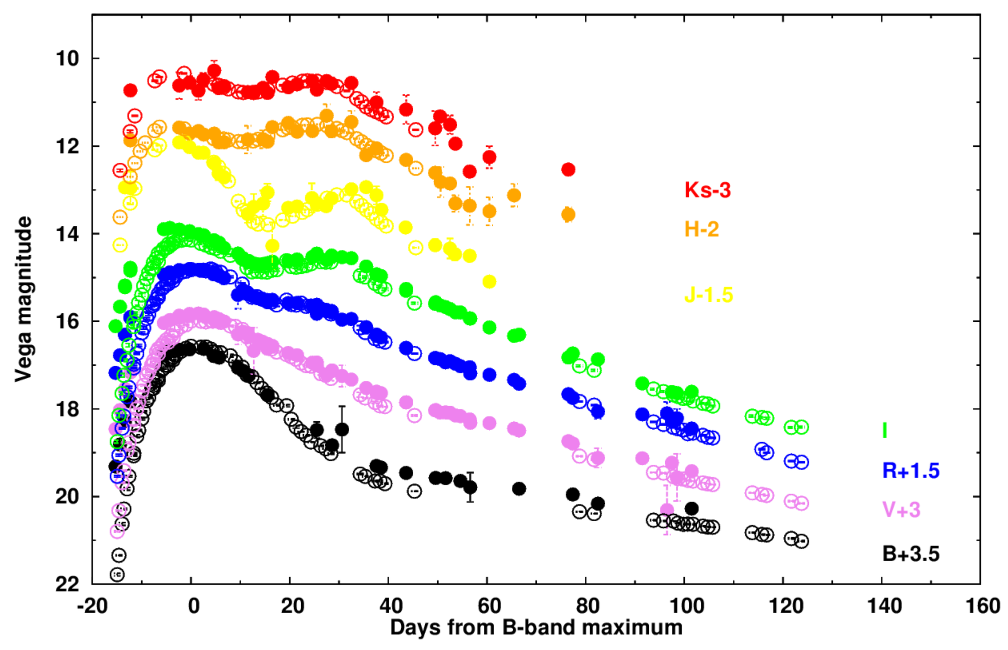

Fig 3. Light curve comparison

2. Light curve comparison with typical SN Ia 2011fe (Figure 3, 4, and 5)
filled circles : SN2018gv
open circles : SN2011fe

- The SN2011fe is one of the most famous typical SN Ia.
- The overall light curve shapes of SN2018gv and SN2011fe seem to be similar.
- The light curves show similar shapes in SN2018gv and SN2011fe. Thus, we suggest that SN2018gv is a normal SN Ia.
- In B,V,R,I-bands, the light curves of SN2018gv show slightly slower evolution than those of SN 2011fe in the overall period.

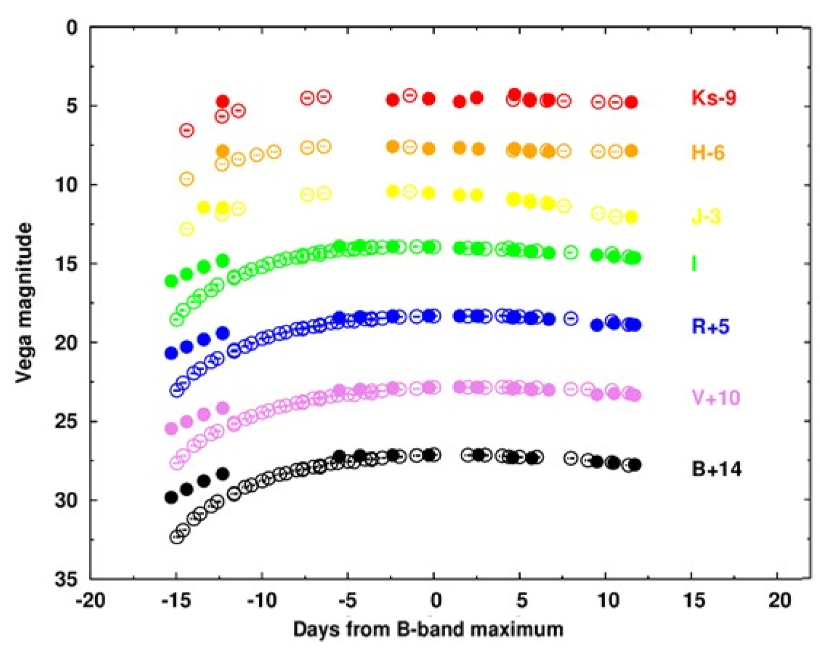

Fig 4. Light curve comparison in the early phase

- At the pre-maximum phase, the rising time of SN2018gv show large difference with SN2011fe.
→ Generally, SNe Ia have quite homogeneous features around maximum. Ganeshalingam et al. (2011) found that normal SNe Ia are distributed 16~20 days in the rising time from the statistical study. Although the SN2018gv is considered as normal SN Ia, the magnitude increased relatively slowly in the early phase. Thus, we consider that this property is one of the remarkable points in SN 2018gv.

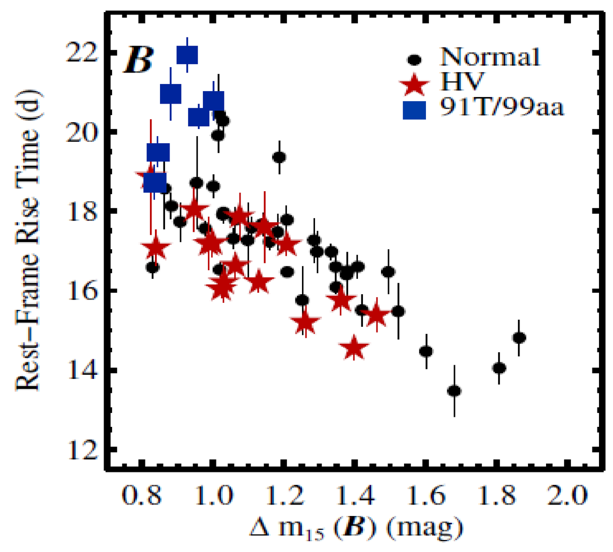

Fig 5. Rising time distribution (Ganeshalingam et al. 2011)

3. Color evolution comparison (Figure 6 and 7)
Filled circles : SN2018gv
open circles : SN2011fe

- The overall shape of color evolution of the SN2018gv and the SN2011fe are similar.
- In the case of V-I color evolution, the slope of SN2018gv is quite steeper than the slope of SN2011fe after 40days from B-band maximum.
- In the case of V-R and V-I color evolution, the SN2018gv is located below SN2011fe in the graph.
→ Because the overall shapes of SN2018gv are similar with SN2011fe, perhaps this problem is caused by error in the reference star magnitude.
- It is interesting that the two SNe show the same color evolution although there is the diversity in the rising time of the light curve. We think that this phenomenon should be related to explosion model (For example, the ^{56}Ni distribution is strongly mixed up, and this mixing prefers to the double-detonation model rather than the standard delayed detonation.)
- In B-V color evolution, values of SN 2018gv are different from SN 2011fe only around B-band maximum (Fig. 7).

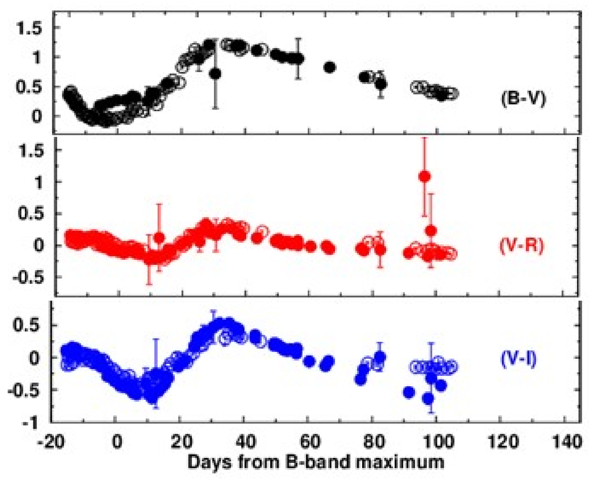

Fig 6. Color evolution comparison

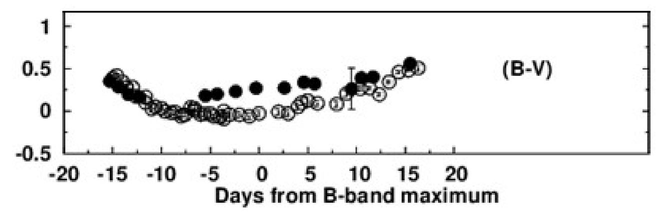

Fig 7. Color evolution comparison in the early phase

4. Spectra evolution (Figure 8)
- Si II (5972) is very weak around the B-band maximum date.
- S II W (4069, 4078) features are detected in our spectra.
→ Almost all of features of typical SNe Ia are appeared in our spectra of SN2018gv, but the C II absorption line is not detected.
- After B-band maximum, the Ca II and Fe II lines gradually developed.
- O I (7773) line has almost a constant width in the overall period.
- Fe III lines became wider gradually.
- R (Si II) is low (because Si II 5972 is very weak). Thus, we suggest that SN 2018gv is at a luminous end of normal SNe Ia. There is also very weak C II absorption lines, which is also consistent with the strong detonation in the outer-part ejecta.

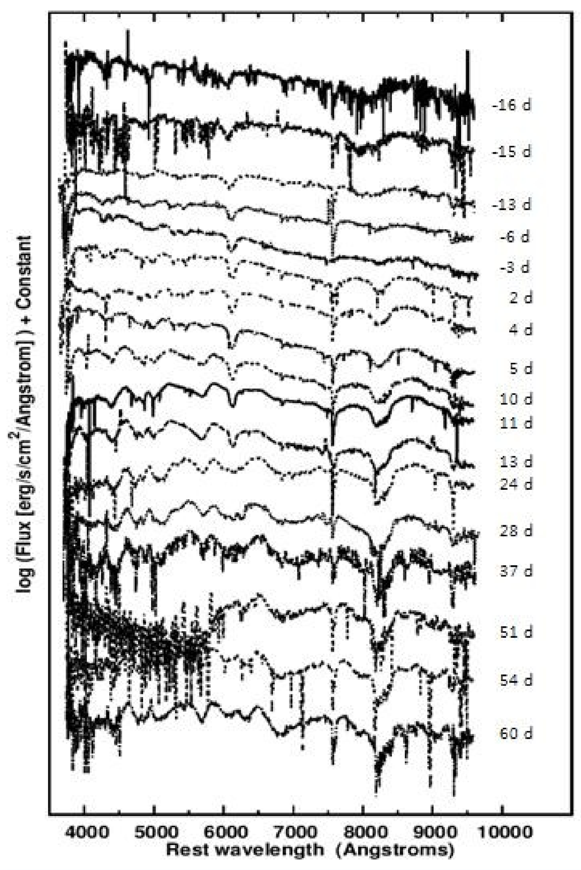

Fig 8. Spectral evolution

5. Spectra comparison in early phase (Figure 9)
- There is a w-shaped trough around 8000Å. The shape is similar with that of a prototype of luminous SN Ia 1991T. However, the trough of SN2018gv is deeper than that of SN1991T.
- The Si II line is similar with SN2011fe.
- Si II line of SN2018gv is shallower than SN1991T and SN2013dy. However, it is deeper than 11fe.

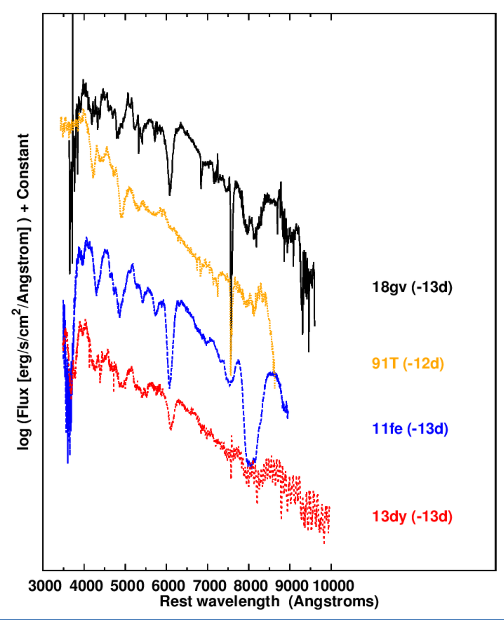

Fig 9. Spectra comparison in early phase

4. Conclusion & Future work

- Based on light curve and spectra, the SN2018g is normal SN Ia.
- In the early phase of light curve, the magnitude of SN2018gv increased quite slowly.
→ The early phase is very important for explosion model. It is related with ejecta, companion interaction, and ^{56}Ni distribution. Thus, we will analyze these relations detail.
- Although there is the diversity of light curve in the early phase, the color evolution is same.
→ We think this phenomenon should be related to explosion model such as the ^{56}Ni distribution.
- In the V-I color evolution, the SN2018gv showed steep slope compared with SN2011fe.
→ By using SN2018gv and other supernovae data, we will compare slope of V-I color evolution and other parameters.
- We will derive line velocity of Si II from the spectra. Then, we will analyze relations between luminosity, Si II, and ^{56}Ni mass of SN2018gv.
- We will analyze the irregularity of the JHKs-bands magnitude around 60~70 days in the light curve, and the magnitude difference of V-R and V-I in color evolution between SN2018gv and SN2011fe.