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

Yun JeUng, Koji S. Kawabata, Masayuki Yamanaka, Miho Kawabata, Tatsuya Nakaoka
(Hiroshima University)

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, and others, detailed multi-band observations of many hundreds 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). Near-infrared properties of SNe Ia are still ambiguous (Yamanaka et al. 2016, but see also Li et al. 2019). In this poster, we present light curve, color evolution, and spectra of Type Ia SN2018gv, and compare with other SNe Ia.
From these information, we mention multi-band (BVRIJH Ks-bands) and spectra properties of the SN2018gv from Its early phase.

Reference :
http://www.k-itagaki.jp/
https://wis-tns.weizmann.ac.il/object

Fig 1. PSN2018gv

RA : 08:05:34.610
DEC : -11:26:16.30
Redshift : 0.0053
Discovery date : 2018 January 15
Discovery Magnitude : 16.5
Discoverer : Koichi Itagaki

2. Research method

1. Observation
- We observed the SN2018gv through 1.5m-Kanata telescope from 2018 January 17th to May 14th.
- We got BVRIJHKs-bands and optical spectra.
- Resolution of the 1.5m-Kanata telescope is R=400 and coverage is 4500-9000A.

2. Light curve
- We got light curves through processes of PSF photometry and sigma clipping in IRAF.
- We used reference star magnitudes from the AAVSO and the 2MASS catalogues to calibrate the magnitude.

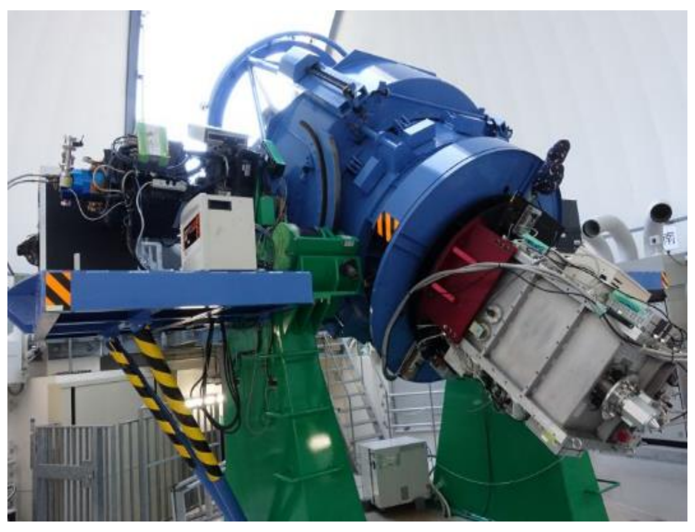

Fig 2. 1.5m - Kanata telescope

3. Spectra
- We performed the data reduction according to the standard procedure using IRAF.
- Due to the red shift effect of host galaxy, we have to convert the observed wavelength into the rest wavelength.

Reference : http://hasc.hiroshima-u.ac.jp/telescope/kanatatel-e.html

3. Results & Discussion

1. Light curve of SN2018gv
Filled circles : SN2018gv
Open circles : SN2011fe
- The decline rates of the B and V-bands maximum are Δm_{15}(B) ~0.97, and Δm_{15}(V) ~0.7.
- There are prominent first and second peaks in I,J,H,Ks bands.
- Magnitudes of H and Ks-bands increase around 60~70 days.
  → This increased magnitude suggest that the third peaks are existed in the near-infrared wavelength.
- The second peaks of the I, J, H, and Ks-bands are 25days, 35days, 27days, and 24days after B-band maximum respectively.
- The absolute magnitude of SN 2018gv is -19,006±0.05mag.
- Through the Phillips relations, we can estimate the absolute magnitude from ÅÅ ~0.97. The estimated absolute magnitude is -19.3±0.15mag. Thus, the SN 2018gv shows a little bit faint absolute magnitude.
- Although the overall light curve shapes of SN2018gv and SN2011fe seem to be similar around the B-band maximum date, the magnitudes show some differences in the late phase.
  → The SN2011fe is one of the most famous typical type Ia supernova. Although the SN 2018gv shows similar light curve shapes in the maximum date, the SN 2018gv shows some differences in the late phase. Thus, we suggest that SN2018gv is a transient type Ia supernova.
- We successfully derived very long coverage near-infrared light curves.
- The time between first and second peaks is proportional to the luminosity. Thus, the SN 2018gv shows features of luminous type Ia supernova.

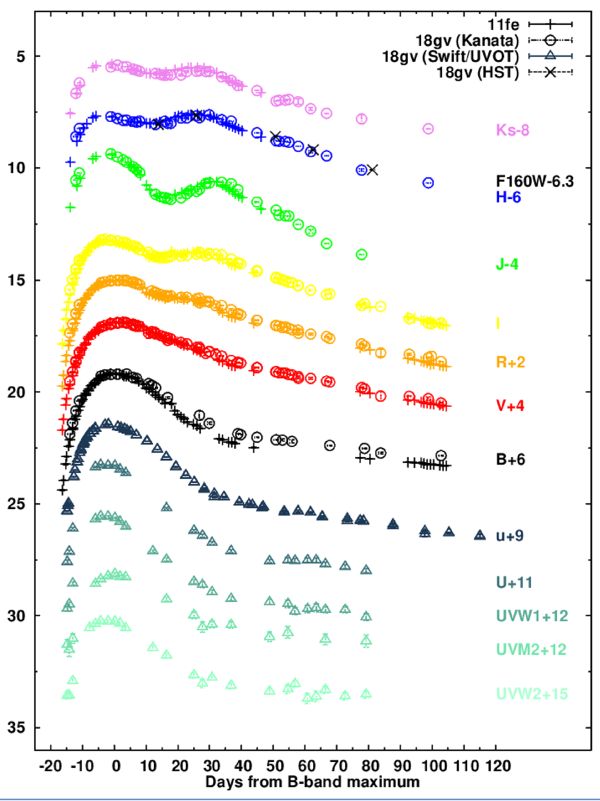

Fig 3. Light curve comparison

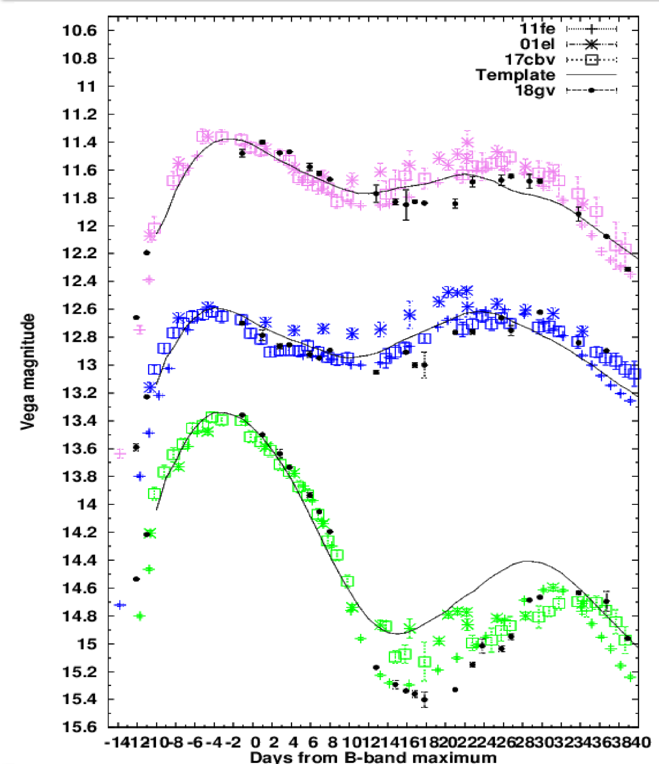

Fig 4. Near-infrared light curve

2. Color evolution comparison
Filled circles : SN2018gv
Open circles : SN2011fe
- The overall shape of color evolution of the SN2018gv and the SN2011fe seems to be 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.
- It is very interesting that 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, but the mixing is rather predicted from the double-detonation model, not consistent with the standard delayed detonation.)
- The period of inclination change in the V-I color evolution is same with the time when the third peaks is appeared in the near-infrared wavelength.
- In the Yang et al. 2019, the r-i color evolution also shows a peculiar bump during the third peak period.
- The steep V-I color inclination and peculiar bumps are appeared in SN2000cx which is a luminous and peculiar type Ia supernova. Therefore, we guess the third peaks are also appeared in the type Ia supernova which shows peculiar color evolution such as SN 2000cx.

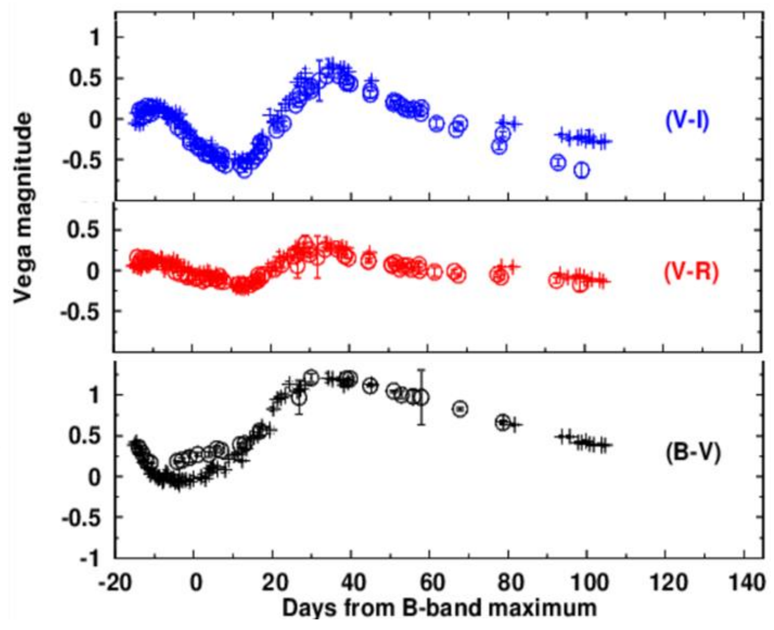

Fig 5. Color evolution comparison

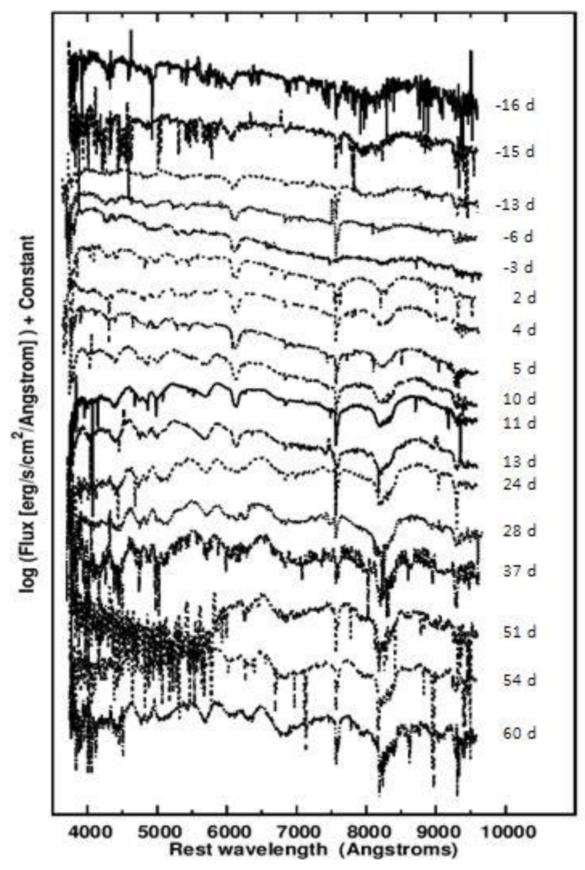

Fig 6. Spectral evolution

3. Spectral evolution
- After the maximum light, Fe II 5169Å begins to develop. Fe II 5169Å is narrow rather than SN 2011fe. After 2 weeks later from the maximum light, Fe II 6500Å shows broad emission in the SN 2018gv.
- Based on the EW of Si lines, the SN 2018gv is located near the boundary between SS and CN subclass. The CN subclass indicates normal type Ia supernova. Moreover, luminous type Ia supernovae such as SN 1999T and SN 1999aa belong to SS subclass.
- In the result of the Si II 6355Å velocity gradient versus Δm_{15}(B), the SN 2018gv belong to low-velocity-gradient (LVG) sub-group.
- The result of SI line depth ratio compared to Δm_{15}(B) shows that the SN 2018gv is located near the SN 1991T which is luminous type Ia supernova. As a result, the SN 2018gv is LVG sub-groip type Ia supernova, and it shows very similar silicon line properties with luminous type Ia supernova like SN 1991T.

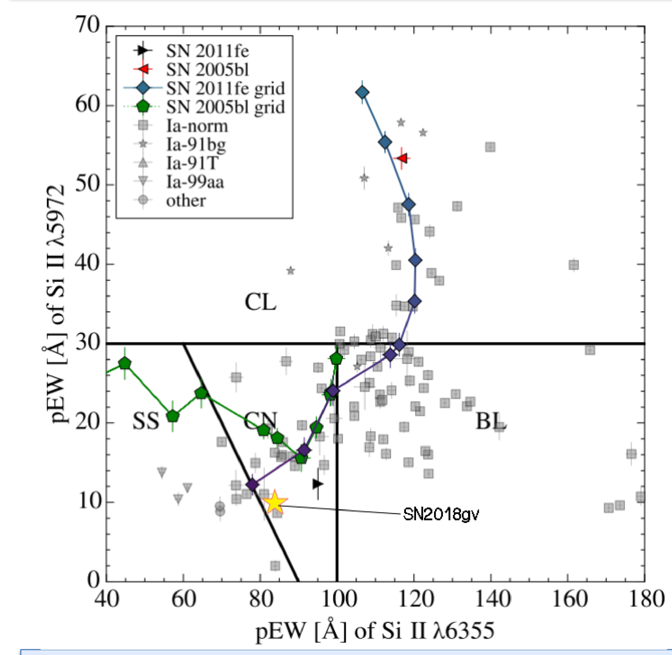

Fig 7. Sub-class of type Ia supernova

4. Third peaks in the near-infrared
- The third peaks in the near-infrared wavelength appear after 50 days from B-band maximum. When I matched data from Hubble Space Telescope (HST) to my light curves, the data show similar tendency. Because the HST is very powerful telescope and less affected by atmosphere, this is one of the strong evidence that the third peak is real.
- According to the Wood-Vasey et al. 2008, the inclination of light curves do not change after the second peak. However, the inclination of my light curve is changed after the third peaks.
- When I combined UV and NIR data, the magnitude shows quite constant tendency. Because UV re-brightening in NIR, this result is reasonable.

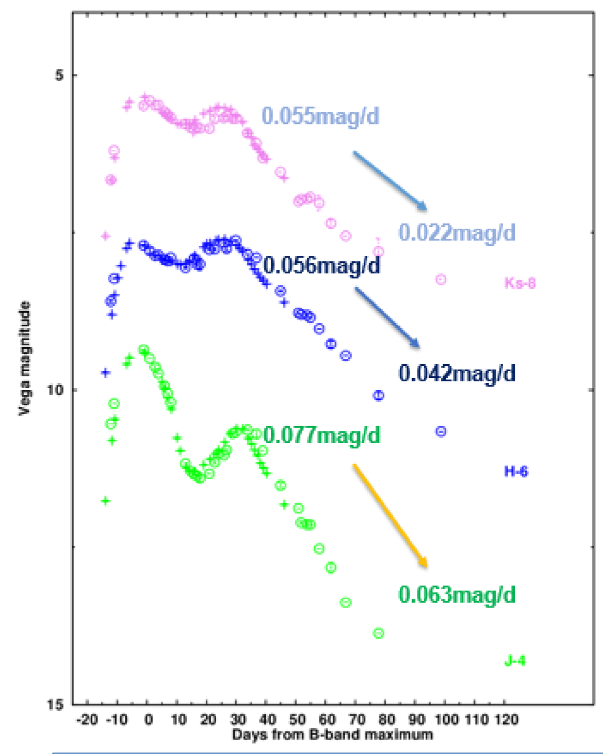

Fig 8. Inclination change

4. Conclusion

- The absolute magnitude of SN 2018gv is -19,006 mag. This value is different with the estimated absolute magnitude from Δm_{15}(B) by using the Phillips relation,
- From the light curve data such as color evolution, time between first and second peak in the near-infrared light curves, the SN 2018gv shows some features of luminous type Ia supernova.
- In the spectrum data such as subclass which is located between SS (bright group) and CN (normal group), ratio of EW of Si II 5972 and 6355, the SN 2018gv shows normal and luminous type Ia supernova features.
- We successfully derived very long coverage light curves in the near-infrared wavelength. Moreover, we observed third peaks in the near-infrared wavelength which are expected only in theoretical research.
- Various telescopes (Kanata, HST, Swift, and LCO network) shows similar tendency for the third peaks. Besides, light curves changes also prove that the third peaks are real.
- The third peaks may be observed from 02es-like SN or SN which has peculiar color evolution such as SN 2000cx.