A Twin of SN1987A: Progenitor and CO formation in SN2018hna

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ABSTRACT

We report UV, optical and near-IR observations of supernova SN 2018hna in UGC7534, a faint and metal-poor galaxy, using SWIFT, the Las Cumbres Observatory (LCO) network and IRTF/SPEX. SN2018hna was discovered on 2018 10-22 by K. Itagaki (TNS #30529). It was reported that the optical light curves have a long rise up to day 35 (ATel #12258). Our light curves show that SN 2018hna has a long rise time of 90 days both in the optical and UV, similar to those of SN1987A. SWIFT UV light curves reveal a rapid drop in flux at early times, which is consistent with the adiabatic cooling after shock breakout. The LCO optical spectra include bright H alpha, H beta, H gamma and Ca lines with the hydrogen lines showing P-Cygni line profiles with broad high-velocity components (~9000 km/s on day 42). Based on the long-rise light curves and hydrogen lines, we classify SN2018hna as Type II-peculiar, making it one of the closest (10.5 Mpc) SNe of this type. Near-IR spectra detect first overtone CO emission at 2.3 microns on days ~153, 171 and 201. The CO mass on day 153 is estimated to be ~0.0002 Msun with a velocity of 3500+-500 km/s and a temperature of 3500+-500 K by using an LTE model. The CO detection may indicate the forthcoming onset of dust formation in the SN ejecta.

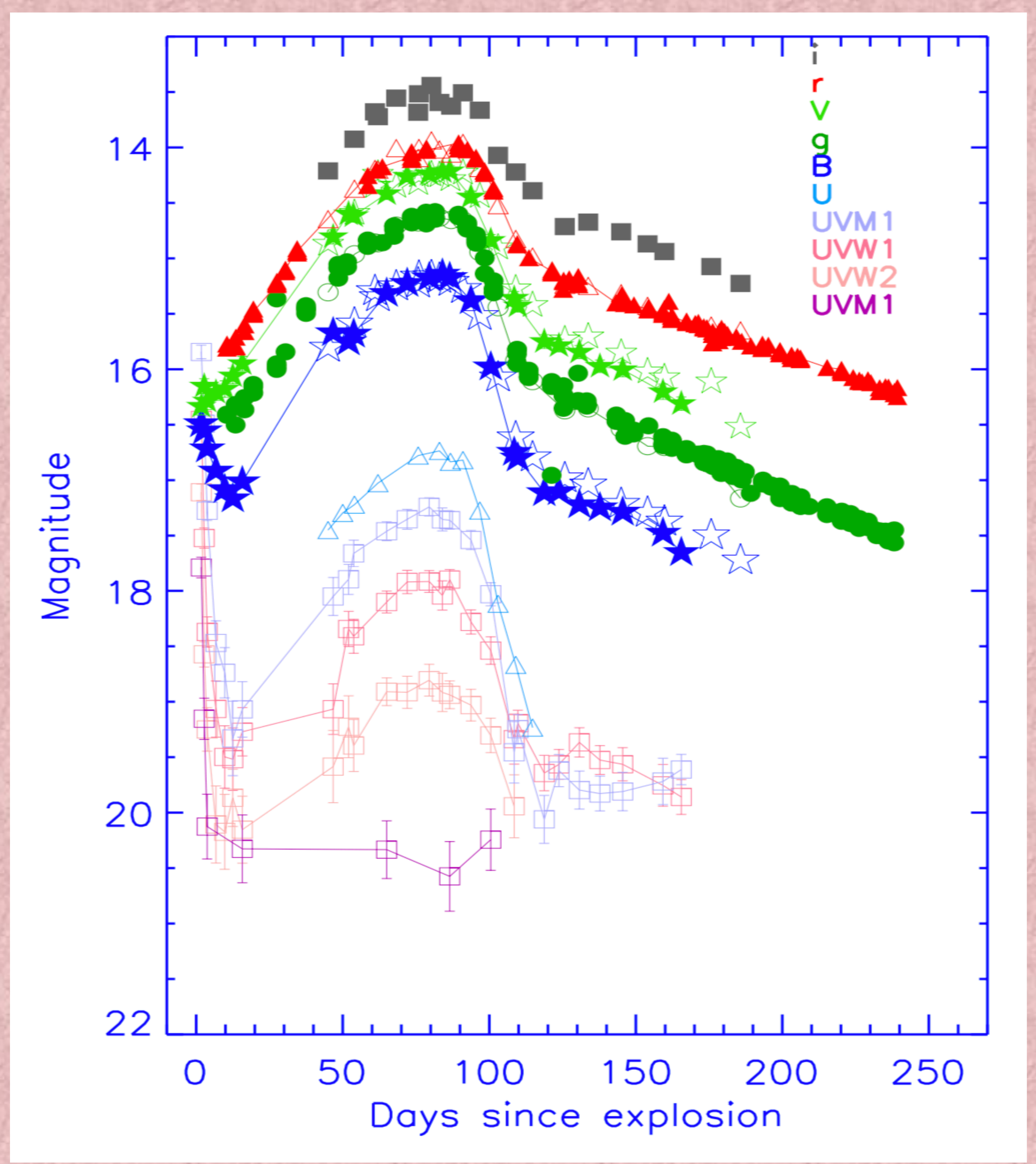


Fig. 1. Multi-color light curves of SN 2018hna using Swift/UVOT (U and B marked with filled symbols in additional to UV filters), LCO network (open symbols of B, V, U, g and r bands except i band [filled squares]) and ZTF (g and r bands with filled symbols).

Introduction: On 2018 October 22, a bright SN2018hna, was discovered in the galaxy UGC7534 with a redshift of 0.0024. It has been classified as Type II (TNS #30529). The position of the SN is 12:26:12.050, +58:18:51.10, and discovery mag is 16.3 VegaMag. The LC was rising at day 25 on 2018 November 16 (Prentice et al. 2018), and it is hosted in a faint dwarf galaxy UGC7534, which is possibly metal-poor (ATel #12258). SN2018hna shows the light curve shows unusual slow rising while the optical spectroscopy shows similar to those of SNII-P.

Observations: We report UV, optical and near-IR observations of supernova SN 2018hna in UGC7534, a faint and metal-poor galaxy, using SWIFT, the Las Cumbres Observatory (LCO) network and IRTF/SPEX.

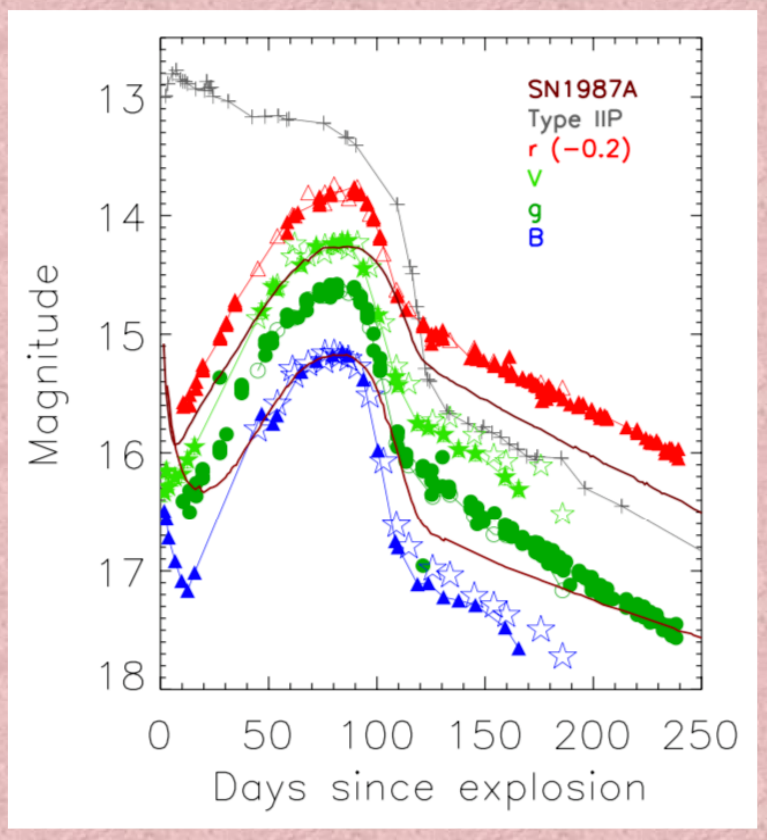


Figure 2. Comparison of light curves of SN1918hna (V: light green, r: red, g: green), SN1987A (solid line), and Type II-P (SN2018eaw).

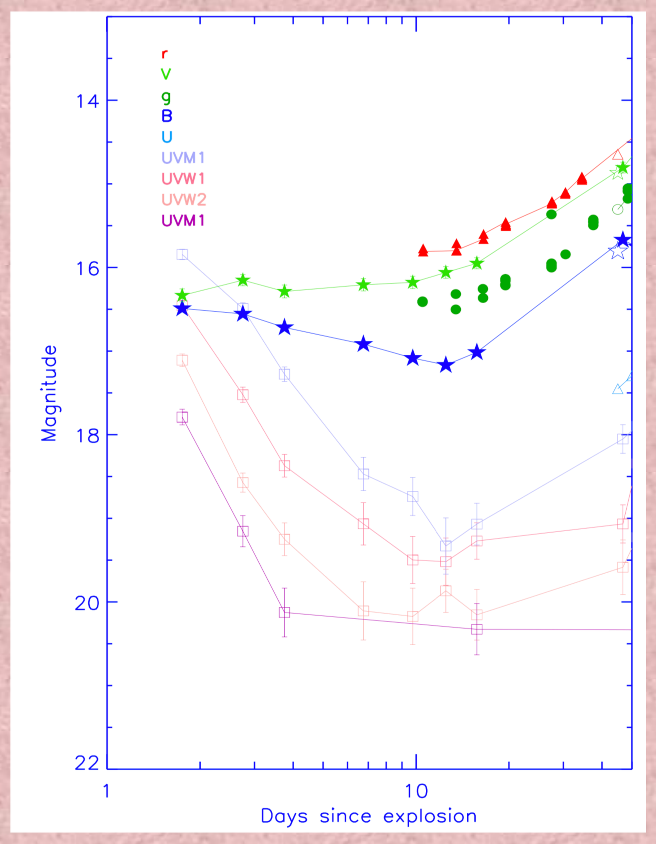


Figure 3. Zoomed light for the first 50 days showing the breakout and reaches in minimum around 10 d.

Light Curves: Fig. 1 shows multi-color light curves. **(1)** The light curves (LCs) show optical light curves have a long rise up to ~90 days both in the optical and UV (except UVM1 band). The LC are very different from those of SNII-P and are remarkably similar to those of SN1987A, as shown in Fig. 2. **(2)** SWIFT UV light curves reveal a rapid drop in flux at early times, which is consistent with the adiabatic cooling after shock breakout.

A Twin of SN1987A as SN-peculiar: SN2018hna
Based on the long-rise light curves (Fig. 2) and hydrogen lines (Figs. 3 and 4), we classify SN2018hna as Type II-peculiar, making it one of the closest (10.5 Mpc) SNe of this type. SN2018hna has narrower broad peak than those of SN1987A, which shows the difference in the radius of the mass, explosion energy, the degree of mixing.

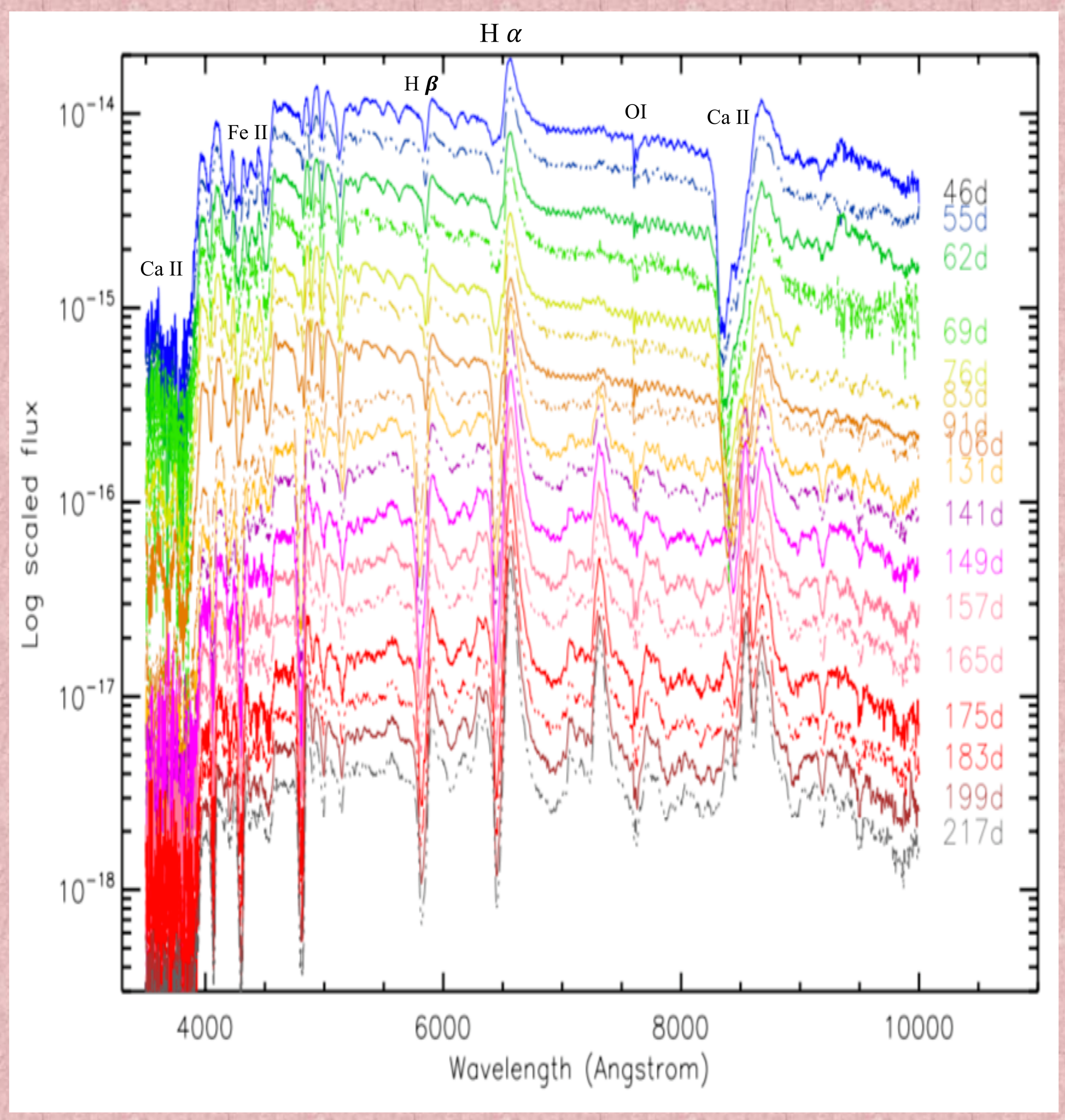
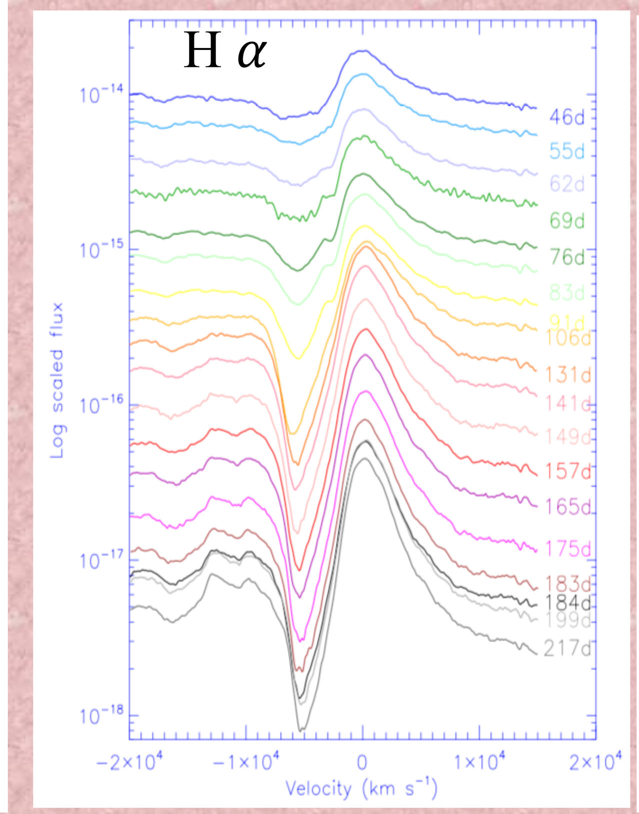


Figure 4. Optical spectra of SN2018hna using LCO network (dereddened) obtained from 2018 October 22 to 2019 May 17 time order from 46 d to 217d (top to bottom). Hydrogen lines and [CII], and another typical type II spectra.

Optical Spectroscopy: Figs. 4 -6 show optical spectroscopy. The reddening is insignificant because Na lines of D1, D2 absorption could not be recognized. The Galactic reddening is E (B-V) = 0.03 mag, which is consistent with the direction of the host galaxy UGC 7534. We assume the reddening of 0.03 mag.
The broad and shallow absorption troughs at the H α, H $\boldsymbol{\beta}$, Ca II, OI, NI, many Fe lines, etc. The spectrum at 96d is remarkably similar to the SN1987A (Pun et al. 1995).



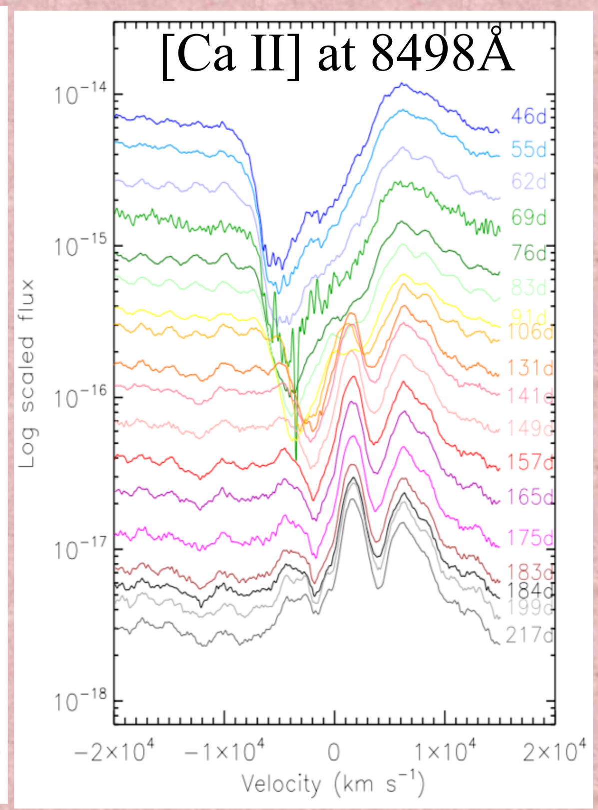


Figure 5. Evolution of the H α line profiles with the line width of 5000 km/s at zero km/s.

Figure 6. Evolution of the [C II] line profiles centered at 8498 Å.

Line profiles H alpha and Ca II triplet: Fig 5 shows H α line profiles of P Cygni profile and the maximum is at zero velocity. There may be optical notch around 100d like in SN1987A, but not too clear. The evolution of the Ca n IR triplet show interesting profiles in Fig. 6.. In the early spectra, only the broad Can 8662-Åline is detected. At the end of recombination the line at 8542 Å appears and then becomes prominent in the nebular spectra. The emission line at 8542 Å is than that at 8662 Å, caused by a partial absorption by the line at 8662 Å.

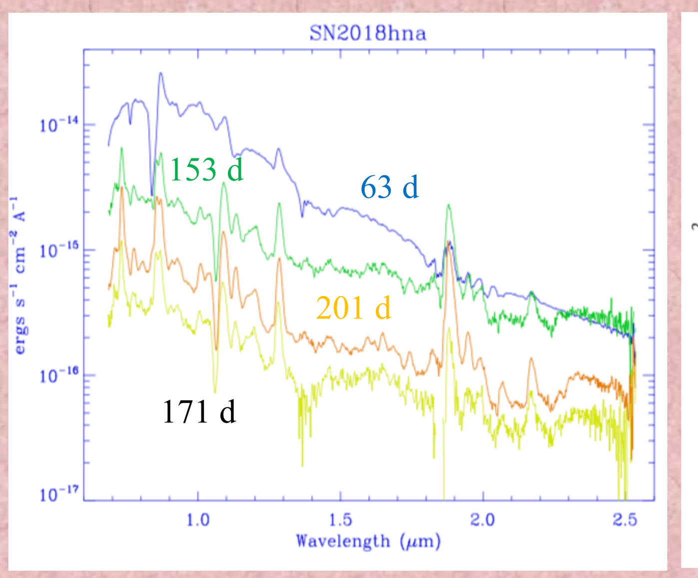


Figure 7. *IRTF/SPEX* 0.85–2.52 μm spectra (dereddened) of SN 2018hna, in time order (top to bottom). Plotted spectra are unscaled. The observed dates are on day 63 (blue), 153 (green), 171 (yellow) and 201 (orange). Note that optical flux at 153 d is brighter than at 63 d.

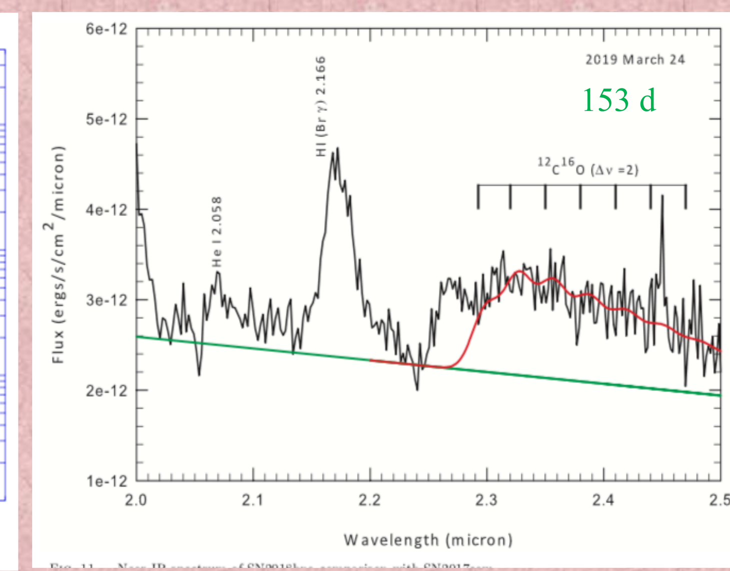


Figure 8. Zoomed-in CO first overtone band emission superposed on local thermodynamic equilibrium (LTE) model fits (red lines) at day 171. Observed spectra are in black. Green is a possible continuum.

Near-IR Spectroscopy: Near-IR IRTF/SPEX spectra are observed shown in Fig. 7, and detected first overtone CO emission at 2.3 microns on days 153, 171, and 201. With an LTE model shown in Fig. 7, the CO mass on day 153 is estimated to be 2x10-4 Msun with a velocity of 3500+-500 km/s and a temperature of 3500+-500 K.
The CO detection may indicate the forthcoming onset of dust formation in the SN ejecta.
CO molecules are detected on 63d, and the IR spectrum on 173d was too noisy to measure the CO properties. The measured CO mass provides the CO mass at an earlier time than those of SN1987A. The mass is similar to those in Type II (e.g., 2017eaw) and consistent with the CO predicted by Sarangi & Cherchneff model (2013).