Nebular phase studies of
SN 2018oh (ASASSN-18bt)

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UCSC group, K2 mission team, KEGS, ASAS-SN, Pan-STARRS, PTSS/TNTS, Las Cumbres Observatory, Konkoly Observatory, ePESSTO, Steward Observatory and many more…

K2 rising light curve

Papers:

Dimitriadis et al. 2019a; Shappee, Holoien et al. 2019;

Li et al. 2019

Dimitriadis et al 2019b; Tucker et al. 2019

Ground-based observations

Nebular phase spectral analysis

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Outline

• Introduction

➤ The Progenitor Problem of Type Ia supernovae

➤ SN 2018oh

• Early “bumps” and nebular spectra

• Results from SN 2018oh

• Conclusions
The Progenitor Problem of Type Ia supernovae

Single Degenerate (SD) Scenario:
CO-WD accretes from MS or RG binary companion to approach Chandrasekhar Mass ($M_{\text{Ch}}$)

Double Degenerate (DD) Scenario:
Two CO-WDs lose angular momentum to gravitational waves and merge violently to ignite carbon fusion

Presence of hydrogen $\rightarrow$ Interaction of the SN with a non-degenerate companion $\rightarrow$ Single Degenerate Scenario smoking gun

Simple Picture !!!
Actual Progenitor Problem much more complicated than that !!!
SN 2018oh

- Discovered on UT 2018 Feb. 4.41 by ASAS-SN (Survey name: ASASSN-18bt)

- Host galaxy UGC 04780  \((z = 0.0109, d = 52.7 \text{ Mpc})\)

- Host galaxy in K2 C16 Field

- Dense photometric and spectroscopic coverage from the ground

- SN 2018oh is a normal to overluminous SN Ia

- Considerable amount of unburnt carbon in the ejecta
Early “bumps” and nebular spectra

Theoretical Prediction

Blue flux excess

Companion

Collision

WD explodes

Kasen 2010

Theoretical Prediction
Early “bumps” and nebular spectra

Observations

Hosseinzadeh 2017

Marion 2016

Dimitriadis 2019a

De 2019
Early “bumps” and nebular spectra

Table I

<table>
<thead>
<tr>
<th>Model Name</th>
<th>$M_{st}$ ($M_\odot$)</th>
<th>$L_{4658}$ ($10^{40}$ erg s$^{-1}$)</th>
<th>$L_{4658}/L_{4655}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS38</td>
<td>0.25</td>
<td>6.8</td>
<td>0.98</td>
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<td>MS7</td>
<td>0.37</td>
<td>9.3</td>
<td>1.43</td>
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<td>MS54</td>
<td>0.32</td>
<td>15.7</td>
<td>1.04</td>
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<td>MS63</td>
<td>0.24</td>
<td>7.0</td>
<td>1.23</td>
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<td>SG</td>
<td>0.17</td>
<td>5.6</td>
<td>0.82</td>
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<td>RG319</td>
<td>0.28</td>
<td>4.5</td>
<td>0.84</td>
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<tr>
<td>RG428</td>
<td>0.33</td>
<td>8.7</td>
<td>1.08</td>
</tr>
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</table>

Note. $M_{st}$ refers to mass of material stripped from the companion (taken from Boehner et al. 2017). $L_{4658}/L_{4655}$ is the ratio of peak flux of H$\alpha$ to that of [Fe II] $\lambda$4658, not necessarily at line center. All luminosities reported are calculated at 200 days past explosion.

Theoretical Prediction

Theoretical Spectrum

Reduced Mass Models

Total Deposition

B17 models

$M_{st}$ ($M_\odot$)

Optical Spectrum

Hydrogen

Helium
Early “bumps” and **nebular spectra**

No $\text{H}\alpha$ in the nebular spectra

$M_{H, \text{stripped}} \lesssim 10^{-3} - 10^{-4} M_\odot$
Results from SN 2018oh

Magnitude + Offset

Phase from B-band maximum (rest-frame days)

ASAS-SN discovery

Explosion

Nebular spectra

Dimitriadis 2019b
Results from SN 2018oh

- Right Ascension: 16-06-01 UT 00:20:00.2
- Declination: 20" 16 - 06 - 01 UT 08:20:00
- DEIMOS: H $\lambda$ 5875, He $\lambda$ 6678
- LRIS: H $\alpha$, He $\lambda$ 6678

SN 2018oh +236d smoothed
SN 2011fe +230d norm.

DEIMOS

LRIS

Dimitriadis 2019b
Results from SN 2018oh

$M_H < 5.4 \times 10^{-4} M_\odot$  
$M_{He} < 4.7 \times 10^{-4} M_\odot$

Similar results in Tucker 2019

Dimitriadis 2019b
Conclusions

**Nebular spectroscopy -** $M_H < 5.4 \times 10^{-4} \, M_\odot - M_{He} < 4.7 \times 10^{-4} \, M_\odot$

1. SN 2018oh did not have a Roche-lobe filling companion
   - Some SNe Ia show signs of material originating from a non-degenerate companion
2. The theoretical models over-predict the H$\alpha$ luminosity
   - Unlikely that the amount of stripped material is off by two orders of magnitude
3. SN 2018oh had a more distant non-degenerate companion
   - Very unlike orientation to produce the early flux excess
4. SN 2018oh had a significant amount of $^{56}$Ni on its surface and radiative transfer calculations incorrectly predict a red early flux
   - Line-blanketing difficult to overcome
   - Red flux excesses have been seen in other SNe Ia
   - Asymmetric distribution of Nickel + particular viewing angles?
5. Other models?