Spectropolarimetry of Superluminous Supernova

Sei Saito (Tohoku University)

Masaomi Tanaka (Tohoku University),
Takashi J. Moriya (NAOJ), Cosimo Inserra (U. of Southampton),
Stuart Sim (Queen’s University Belfast), Mattia Bulla (Stockholm U.),
Giorgos Leloudas (U. of Copenhagen), Chien-Hsiu Lee (NOAO)
SuperLuminous SuperNovae: SLSNe

- 10-100 times more luminous than normal SNe at peak
- absolute magnitude $\leq -21$ mag

![Graph showing SLSN threshold and days after the peak.](image)
Power source of explosion

→ unclear yet

Possible power sources:

• radioactive decay of $^{56}\text{Ni}$
  (e.g., Woosley et al. 2007; Umeda & Nomoto 2008)

• interaction with CSM (SLSNe-II)
  (e.g., Chevalier & Irwin 2011; Moriya et al. 2013)

• central energy source (SLSNe-I)
  (e.g., Kasen & Bildsten 2010; Dexter & Kasen 2013)

Central energy source such as magnetar
→ aspherical explosion?

to study geometry
→ polarimetry (not imaging)
Polarization and geometry

Stokes parameter

\[ Q = \uparrow - \leftrightarrow \]
\[ U = \text{arcsin} - \text{arcsin} \]

Polarization degree

\[ P = \sqrt{Q^2 + U^2} \]

Position angle

\[ \theta = \frac{1}{2} \tan^{-1} \frac{U}{Q} \]

<table>
<thead>
<tr>
<th>Polarization (%)</th>
<th>Axial Ratio (a/b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>~ 0.5</td>
<td>~ 1.1</td>
</tr>
<tr>
<td>~ 1.0</td>
<td>~ 1.2</td>
</tr>
<tr>
<td>~ 2.0</td>
<td>~ 1.5</td>
</tr>
</tbody>
</table>

Hoflich 1991
**Problems in previous studies**

- Only 4 SLSNe-I with polarimetry
  (Leloudas et al. 2015, 2017; Inserra et al. 2016; Lee 2019; Bose et al. 2018; Maund et al. 2019)

- not accurate Interstellar polarization

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**SN 2017egm (SLSN-I)**

-1 ~ +9 days
(around peak)
Interstellar polarization (ISP)

- Supernova
  - intrinsic SN polarization: electron scattering on photosphere
- Interstellar dust
  - ISP: absorption by dust
- Observer
  - observed polarization = intrinsic SN polarization + ISP
Problems in previous studies

- Only 4 SLSNe-I with polarimetry
  (Leloudas et al. 2015, 2017; Inserra et al. 2016; Lee 2018; Bose et al. 2018; Maund et al. 2019)

- not accurate ISP
  \[\text{intrinsic SN polarization? ISP?}\]

SN 2017egm (SLSN-I)
-1 \sim +9 days
(around peak)
Purpose of this study

- to reveal power source of SLSNe
  - to study geometry
  - to estimate ISP $\rightarrow$ intrinsic SN polarization
Data

- Object: SN 2017egm, nearby SLSN-I
  (at $z = 0.0307$, $d_L \sim 140$ Mpc)
- Observation: Spectropolarimetry
- Date: 2017.12.29
  (+185 days after peak: the latest observation)
- Telescope: SUBARU TELESCOPE

Happy 20th Anniversary
National Astronomical Observatory of Japan

Gal-Yam et al 2012

Faint Object Camera and Spectrograph (FOCAS)
Results

polarization at the LATE phase: +185 days after peak

Ca II emission line, unpolarized
Results

polarization at the LATE phase: +185 days after peak

SN 2017egm

Ca II emission line, unpolarized

ISP

Rest wavelength (Å)
Results

polarization at EARLY phase: -1, +5, +9 days after peak (around peak)

at the EARLY phase

intrinsic polarization $P \sim 0.2\%$

$\rightarrow$ axial ratio $(a/b) \sim 1.05$ (spherical)
Results

polarization at the LATE phase: +185 days after peak

SN 2017egm
(Our data)

ISP subtracted

flux ($10^{-16} \text{erg/cm}^2/\text{s}/\text{Å}$)

$P'$ (%)

Rest wavelength (Å)

at the LATE phase

intrinsic polarization $P \sim 1.3\%$

$\rightarrow$ axial ratio $(a/b) \sim 1.3$ (aspherical)
**Discussion**

<table>
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<th>phase (after peak)</th>
<th>Polarization</th>
<th>axial ratio (≡ a/b)</th>
</tr>
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<tr>
<td>EARLY (-1, 5, 9 days)</td>
<td>~ 0.2 %</td>
<td>~ 1.05</td>
</tr>
<tr>
<td>LATE (185 days)</td>
<td>~ 1.3 %</td>
<td>~ 1.3</td>
</tr>
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</table>

**NOTE:**
P of SN 2015bn also increases (Early → Late; Inserra et al. 2016)
※ different epochs from SN 2017egm

→ Inner ejecta of SLSNe-I is more aspherical.

**Clue of Central Energy Source**
Summary

- spectropolarimetric observations at LATE phase (+185 days)
  → accurate ISP, estimated from Ca line

- Increase of intrinsic polarization at LATE phase
  → more aspherical inner ejecta
  → Clue of Central Energy Source
Mahalo for listening !!

photo by Sei Saito on 2019/11/17 at 18:07
(Hawaii Standard Time; MJD = 58806.1)