Spectropolarimetry of Superluminous Supernova

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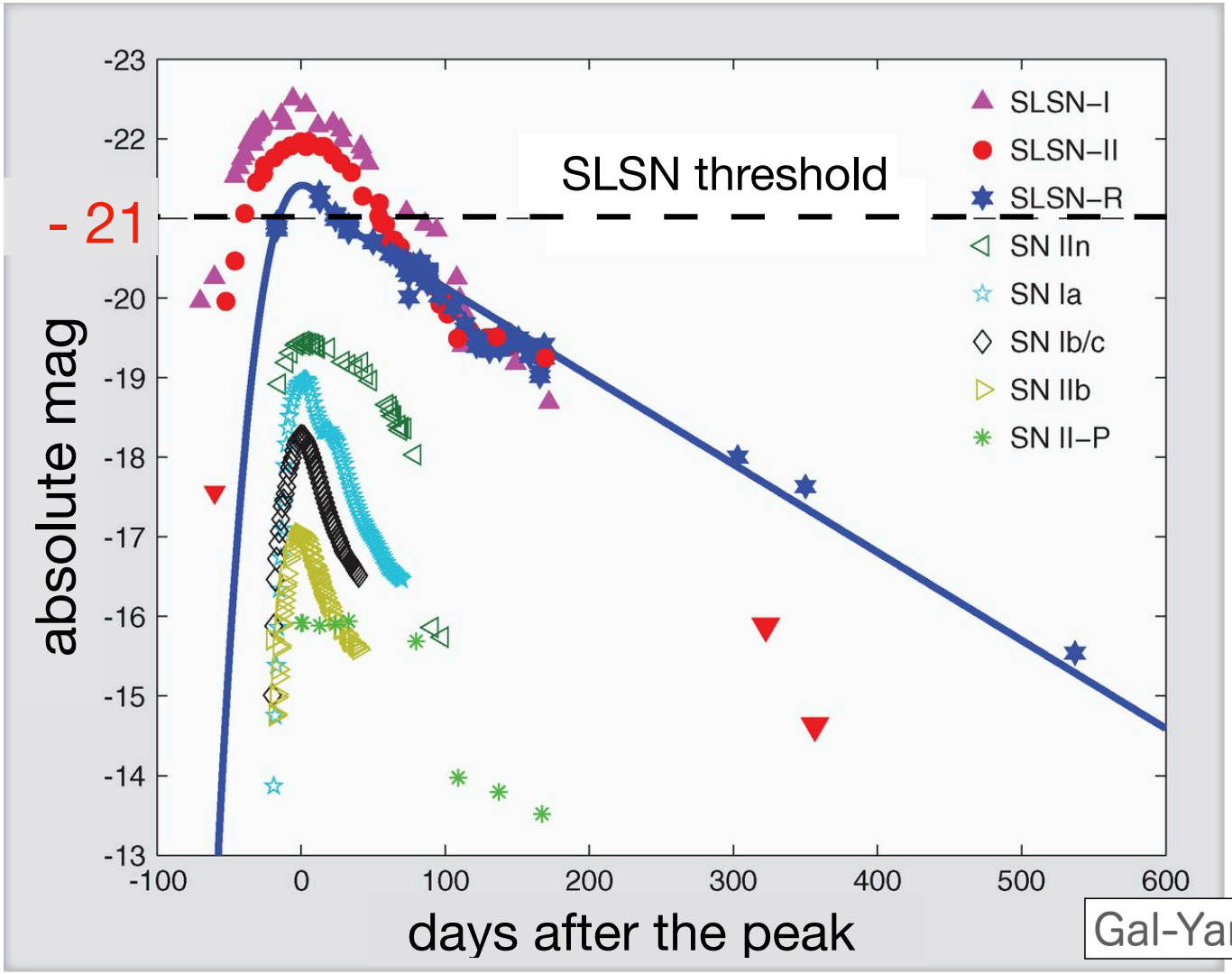
SuperLuminous SuperNovae : SLSNe

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



Gal-Yam et al 2012

Power source of explosion

→ unclear yet

Possible power sources :

- radioactive decay of ^{56}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)

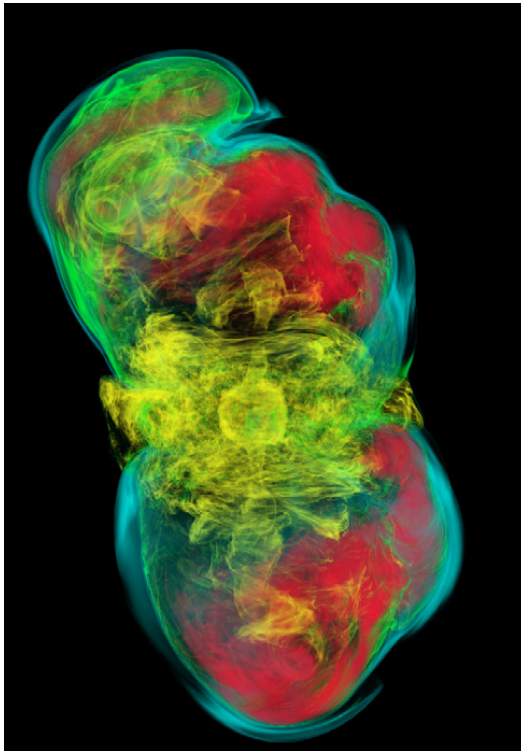
central energy source such as magnetar

→ aspherical explosion ?

to study geometry

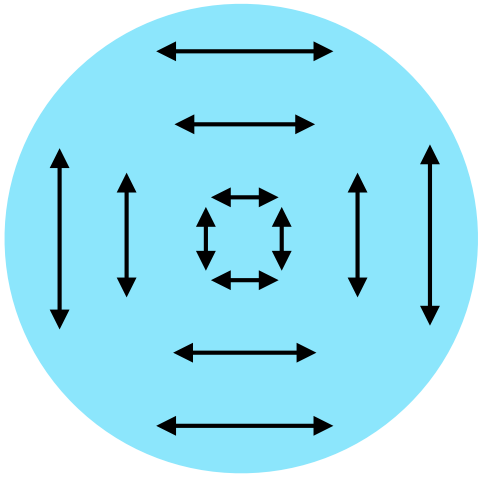
→ polarimetry (not imaging)

magnetar model



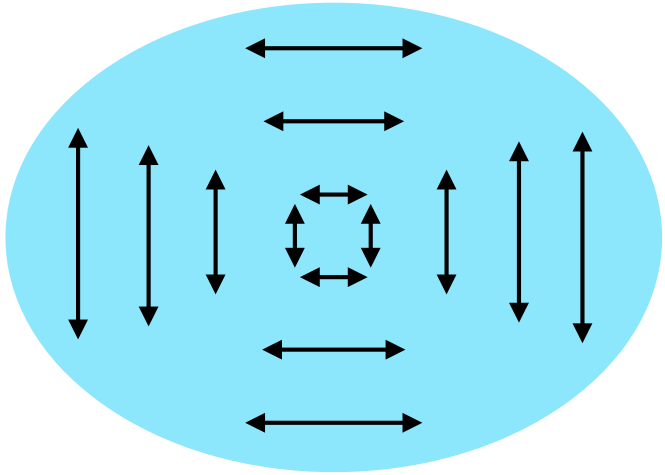
Mosta et al 2014

Polarization and geometry



no polarization

electron scattering



polarized

asphericity → polarization

Stokes parameter

$$Q = \updownarrow - \leftrightarrow$$

$$U = \searrow\!\swarrow - \nearrow\!\swarrow$$

Polarization degree

$$P = \sqrt{Q^2 + U^2}$$

Position angle

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

Polarization (%)	axial ratio (a/b)
~ 0.5	~ 1.1
~ 1.0	~ 1.2
~ 2.0	~ 1.5

Hoflich 1991

Problems in previous studies

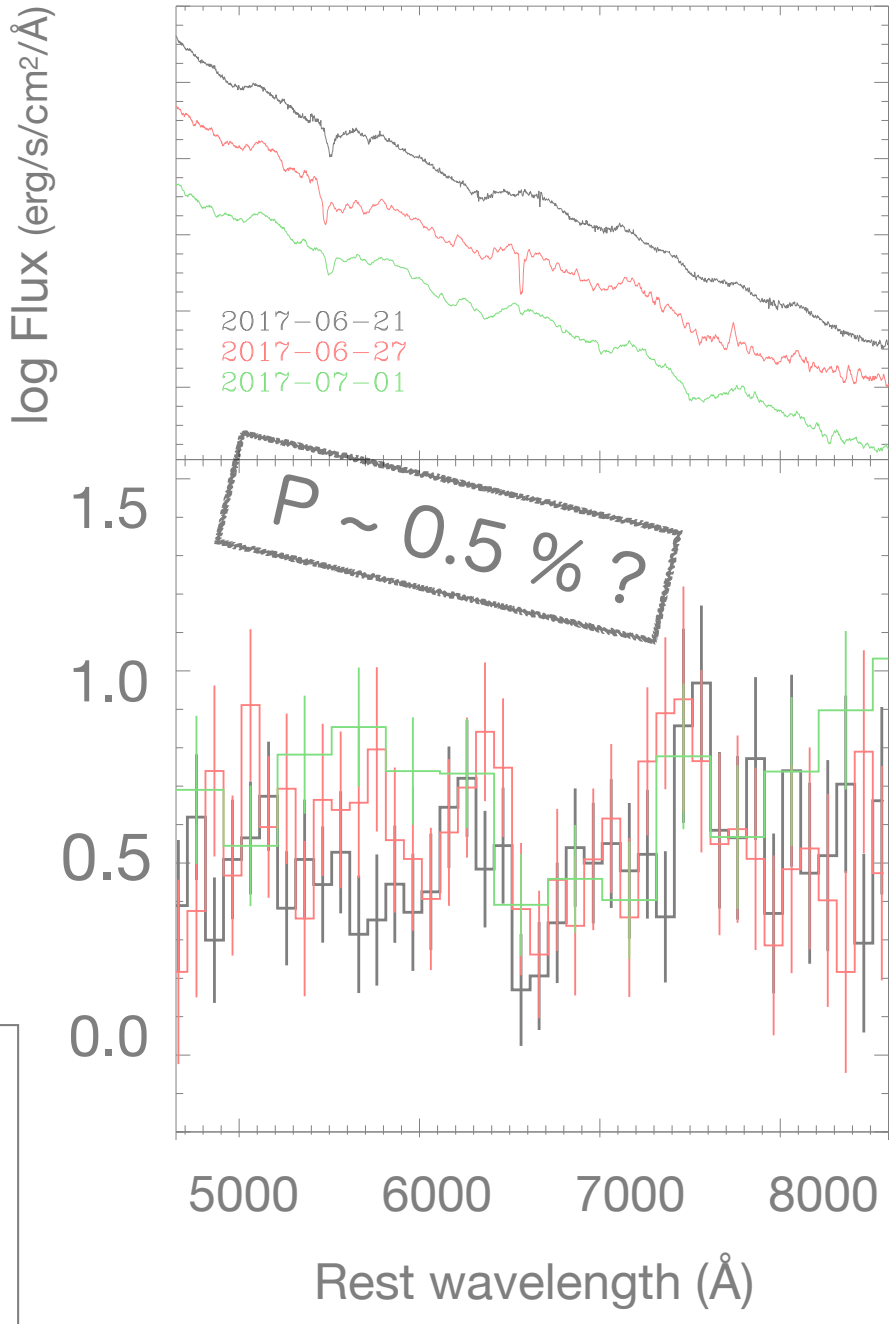
- Only 4 SLSNe-I with polarimetry

  (Leloudas et al. 2015, 2017;

  Inserra et al. 2016; Lee 2019;

  Bose et al. 2018; Maund et al. 2019)

- not accurate Interstellar polarization



Bose et al. 2018

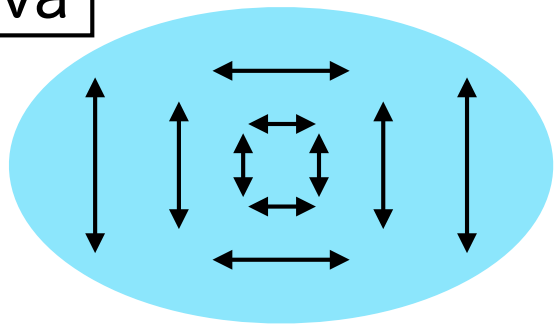
SN 2017egm (SLSN-I)

-1 ～ +9 days

(around peak)

Interstellar polarization (ISP)

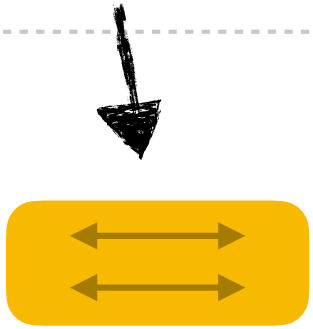
Supernova



intrinsic SN polarization :

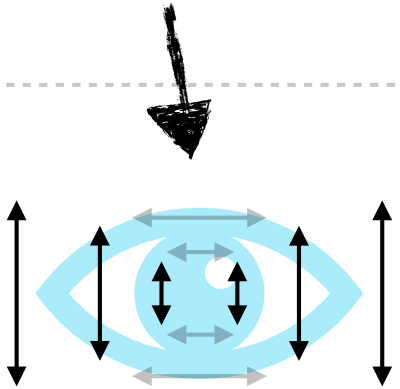
electron scattering on photosphere

interstellar dust



ISP : absorption by dust

observer



observed polarization

= intrinsic SN polarization + ISP

Problems in previous studies

- Only 4 SLSNe-I with polarimetry

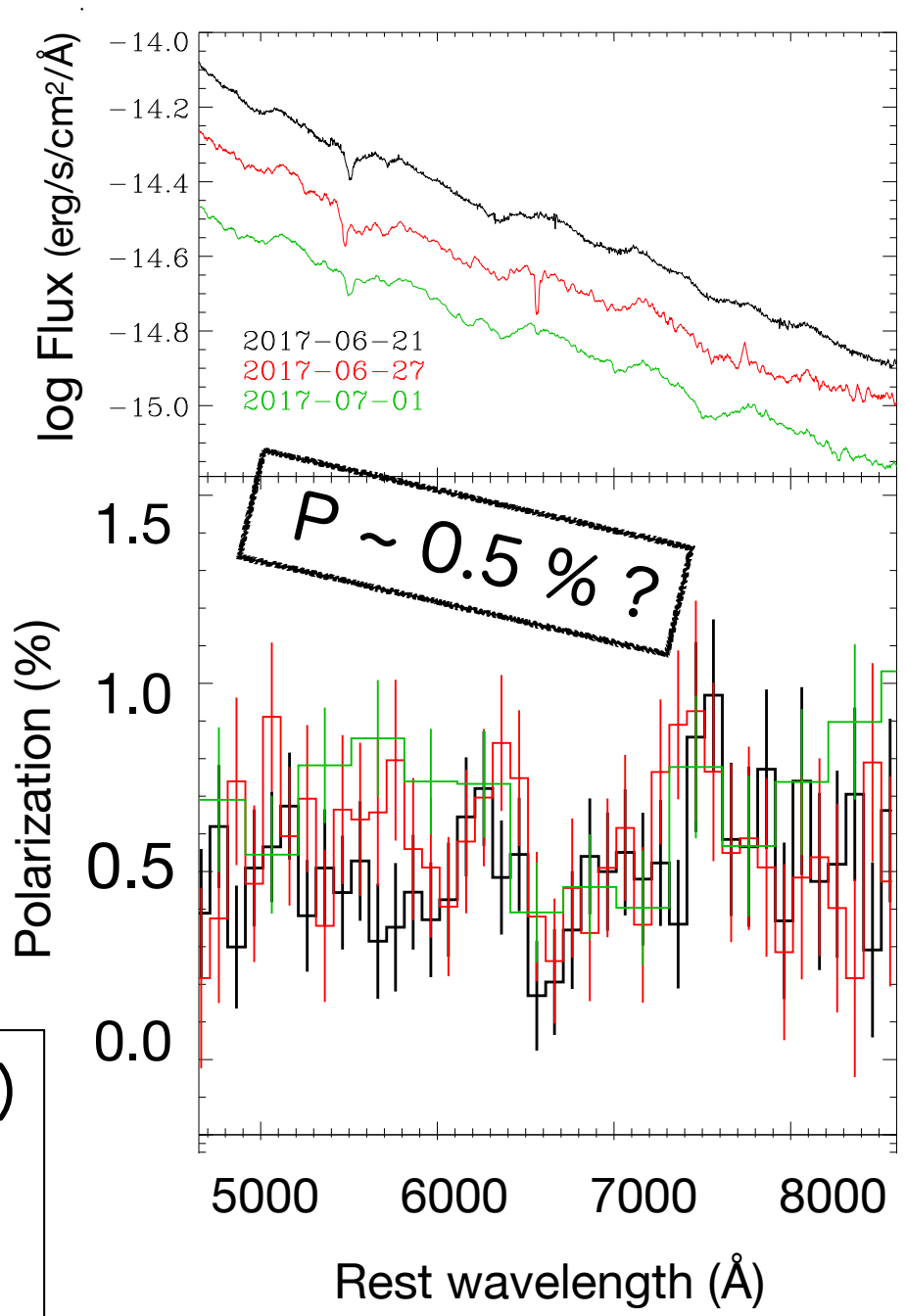
  (Leloudas et al. 2015, 2017;

  Inserra et al. 2016; Lee 2018;

  Bose et al. 2018; Maund et al. 2019)

- not accurate ISP

  → intrinsic SN polarization ? ISP ?



Bose et al. 2018

SN 2017egm (SLSN-I)

-1 ～ +9 days

(around peak)

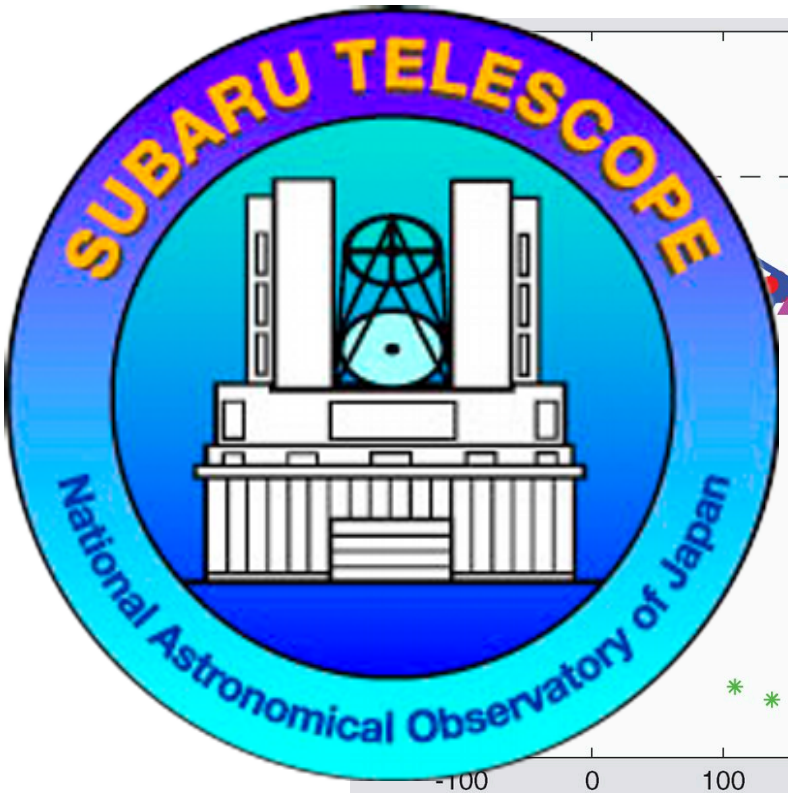
Purpose of this study

- to reveal power source of SLSNe
  - to study geometry
  - to estimate ISP → intrinsic SN polarization

Data

- Object : SN 2017egm, nearby SLSN-I
  (at z = 0.0307, d_L ~ 140 Mpc)
- Observation : Spectropolarimetry
- Date : 2017.12.29

  (+185 days after peak : the latest observation)
- Telescope :

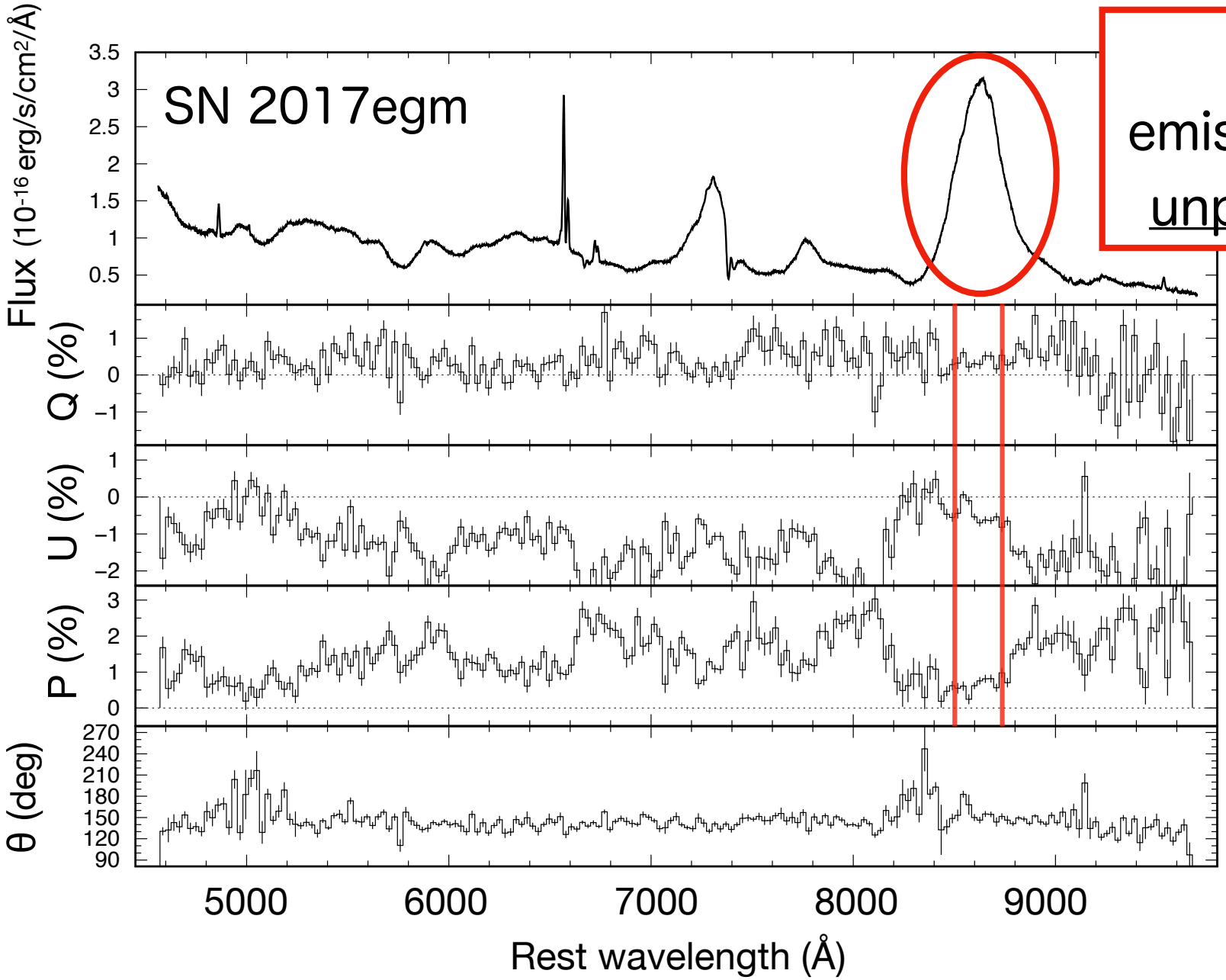


Gal-Yam et al 2012

Faint Object Camera and Spectrograph (FOCAS)

Results

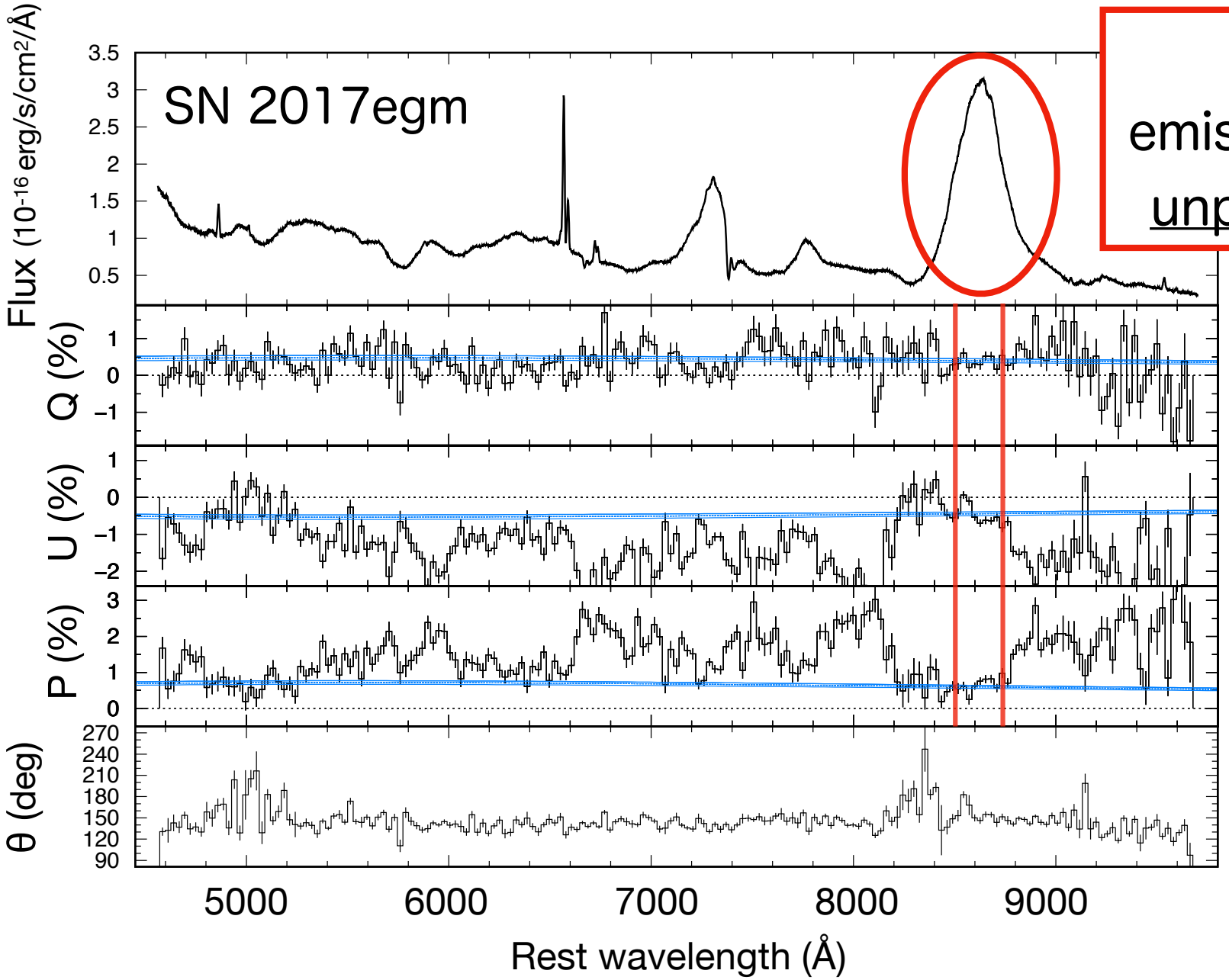
polarization at the LATE phase: +185 days after peak



Ca II emission line, unpolarized

Results

polarization at the LATE phase: +185 days after peak

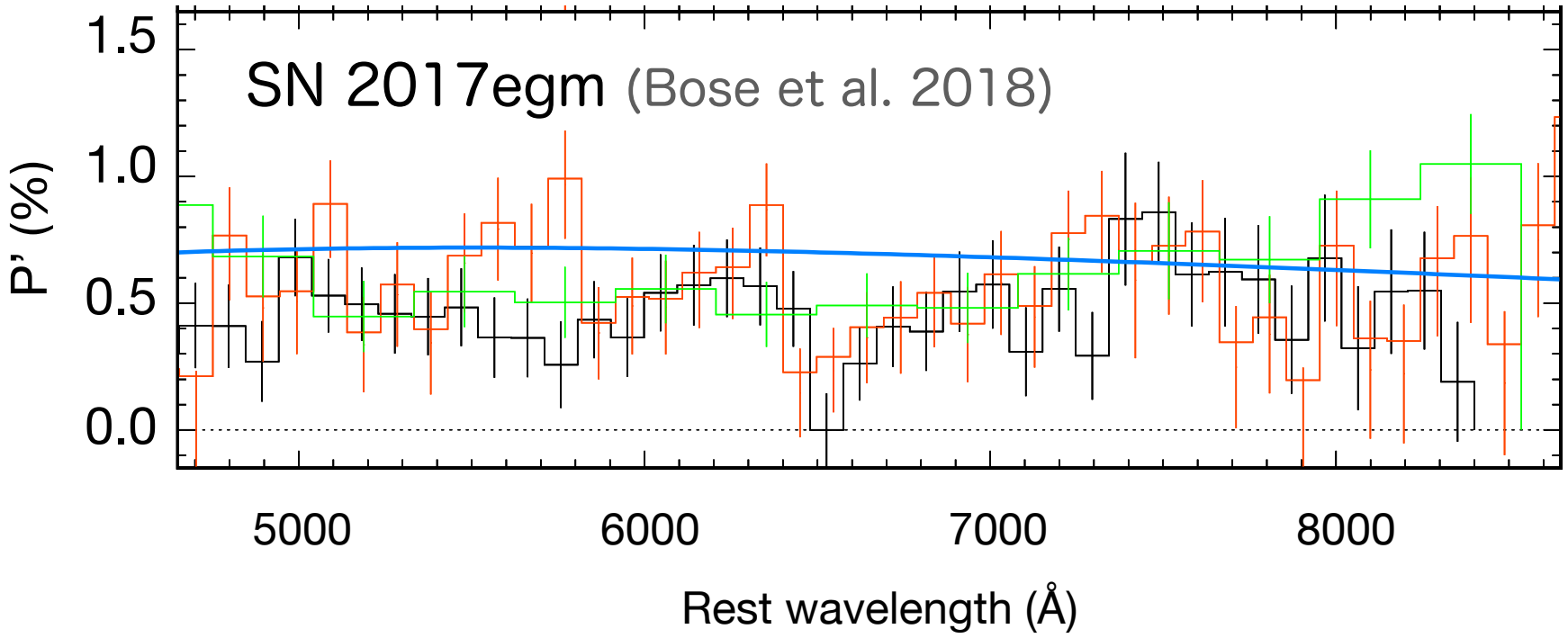


Ca II emission line, unpolarized

ISP

Results

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



ISP

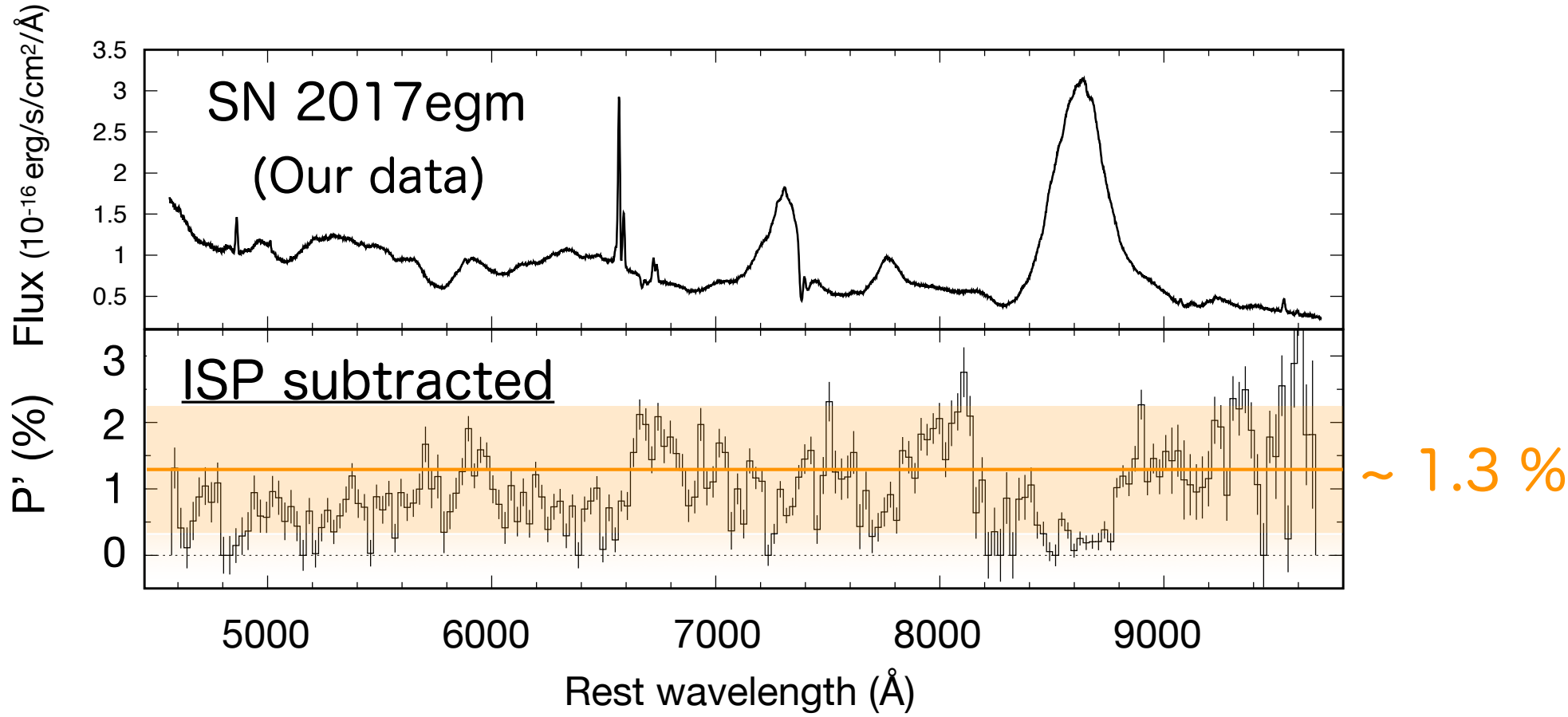
at the EARLY phase

intrinsic polarization P ~ 0.2 %

→ axial ratio (a/b) ~ 1.05 (spherical)

Results

polarization at the LATE phase: +185 days after peak



at the LATE phase

intrinsic polarization P ~ 1.3 %

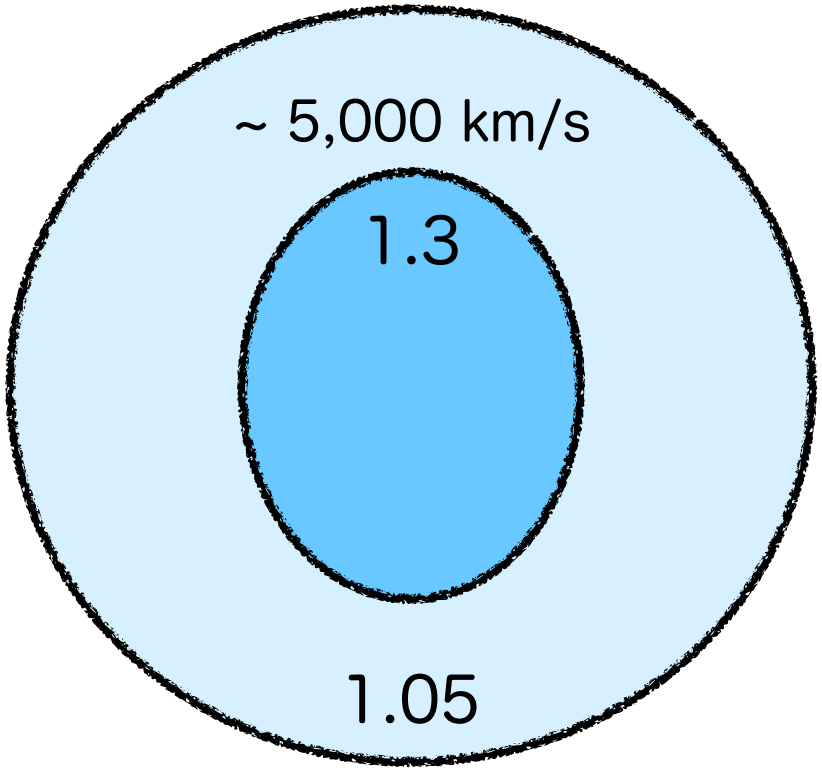
→ axial ratio (a/b) ~ 1.3 (aspherical)

Discussion

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

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

SN 2017egm



EARLY → Outer ejecta
LATE → Inner ejecta

→ Inner ejecta of SLSNe-I is more aspherical.

Clue of Central Energy Source

Summary

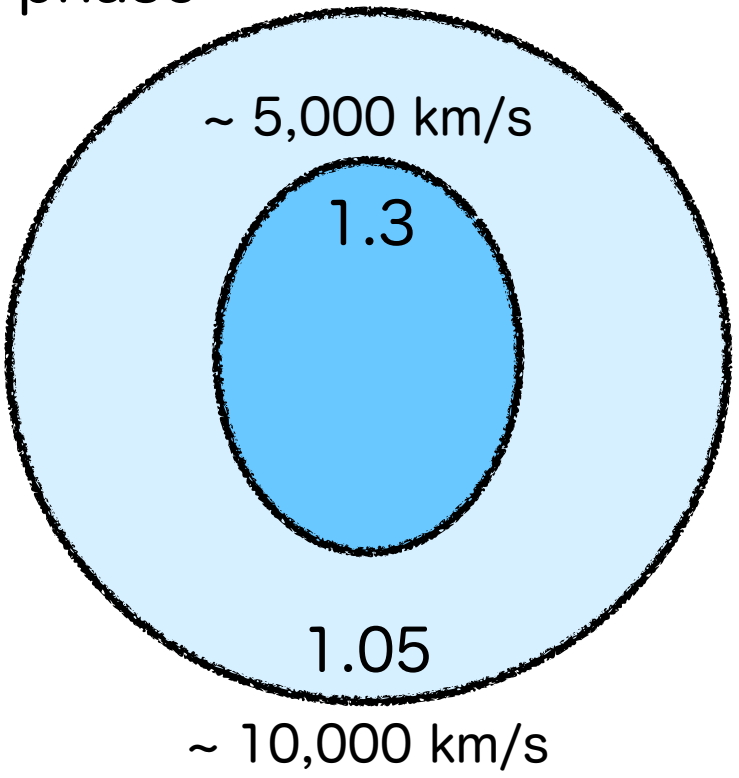
- spectropolarimetric observations at LATE phase (+185 days)

  → 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)