



Stepping into the New Era for Early-phase Type Ia Supernova Survey

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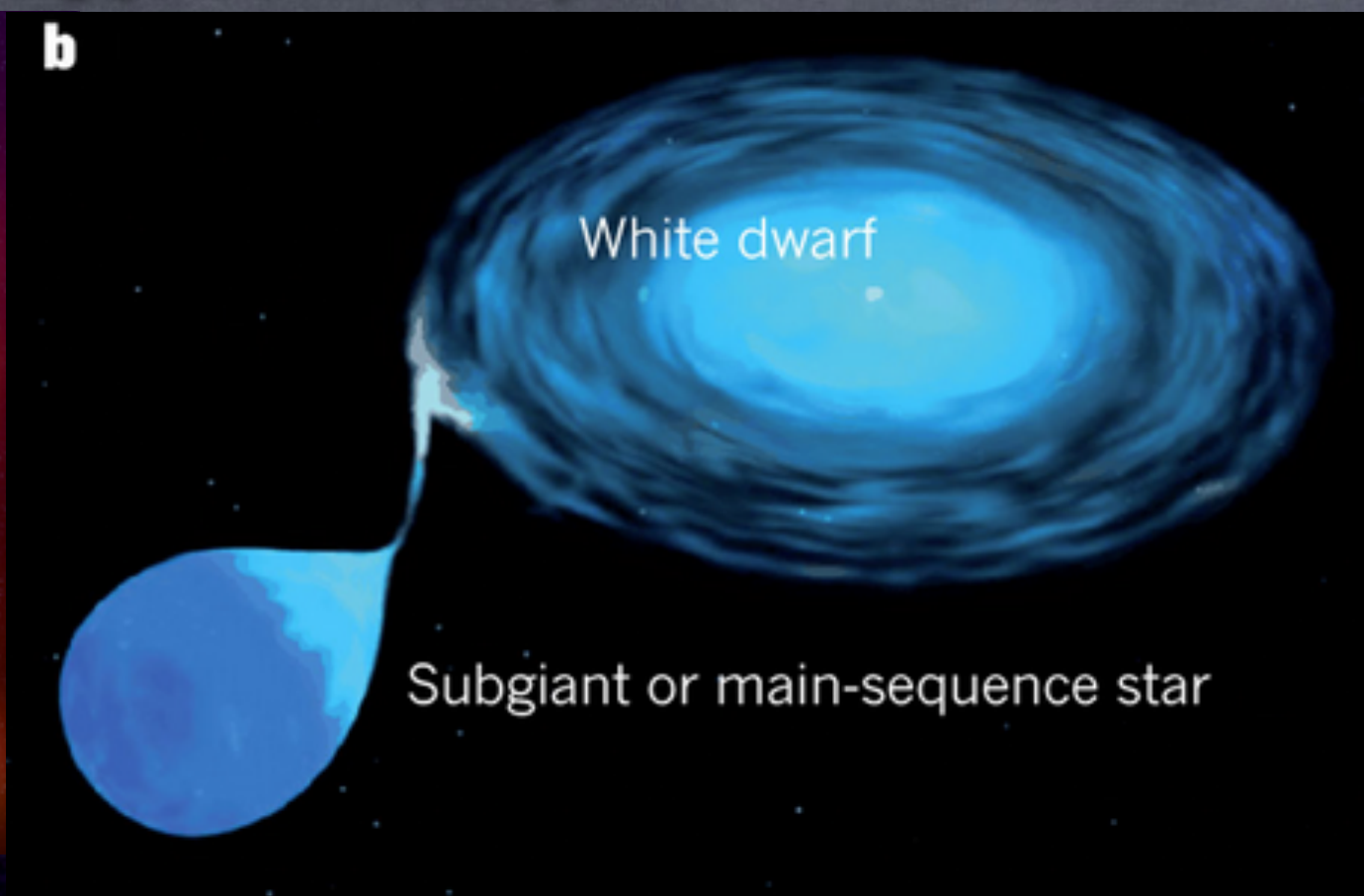
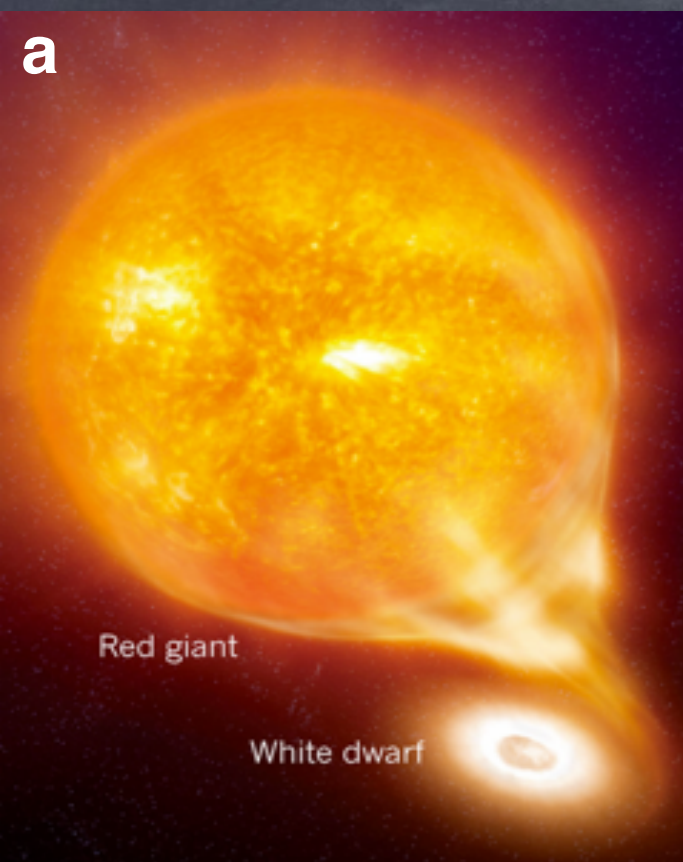
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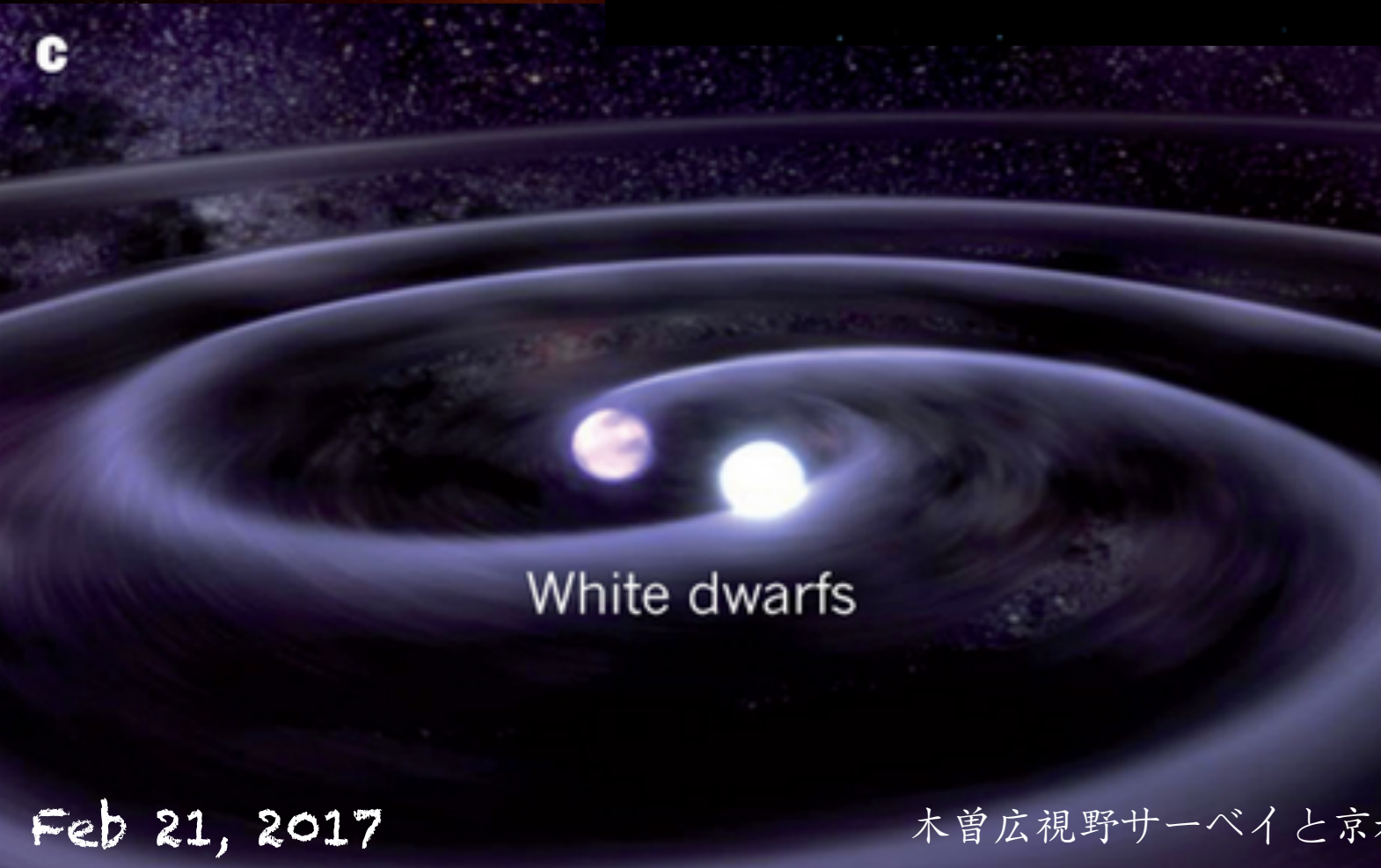
Feb 21, 2017

木曾広視野サーベイと京都3.8m即時分光によるタイムドメイン天文学の推進

➤ Basics of Type Ia supernovae

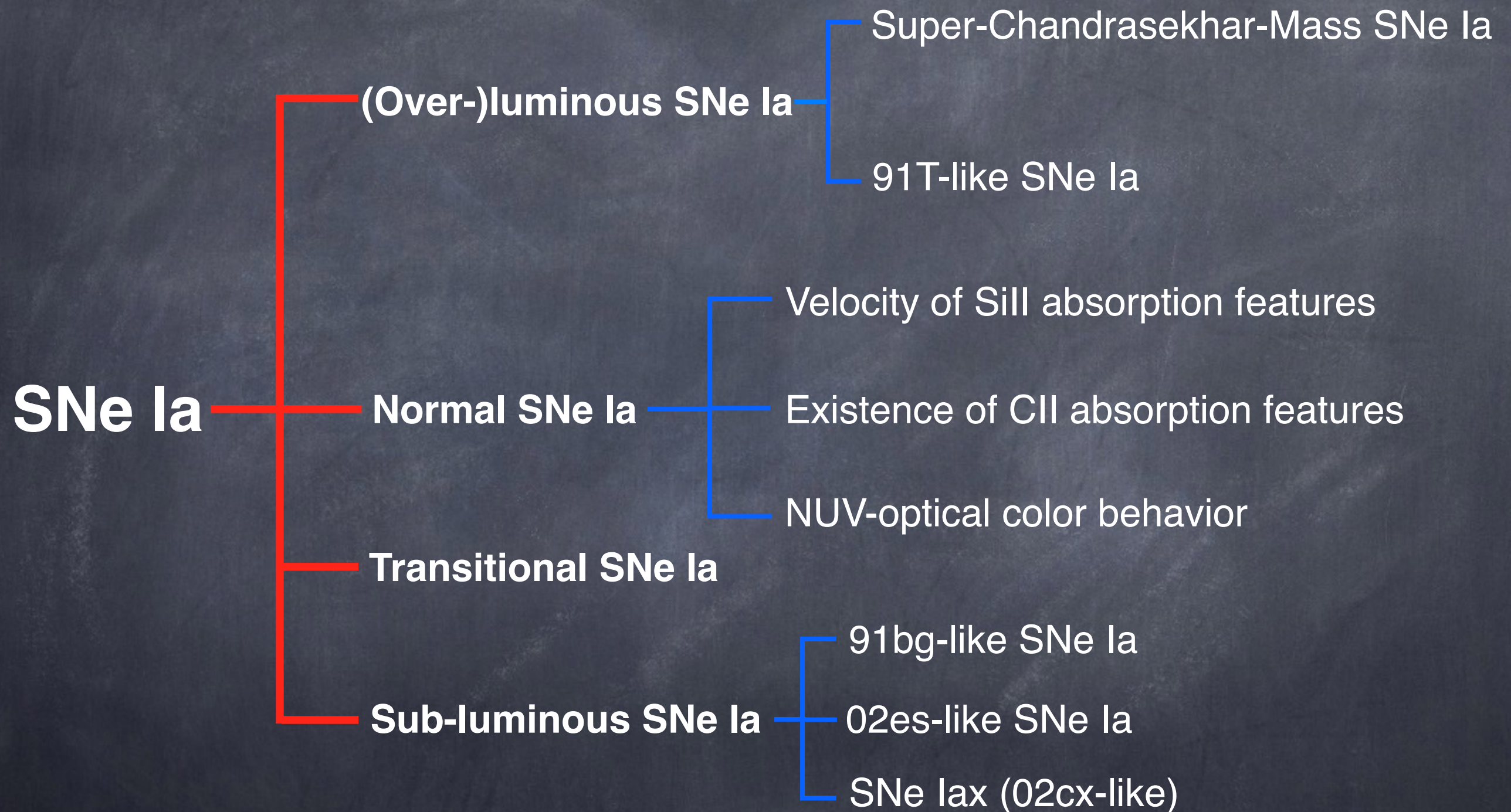


Single Degenerate
Progenitor Model
(SD Model)



Double Degenerate
Progenitor Model
(DD Model)

➤ Basics of Type Ia supernovae



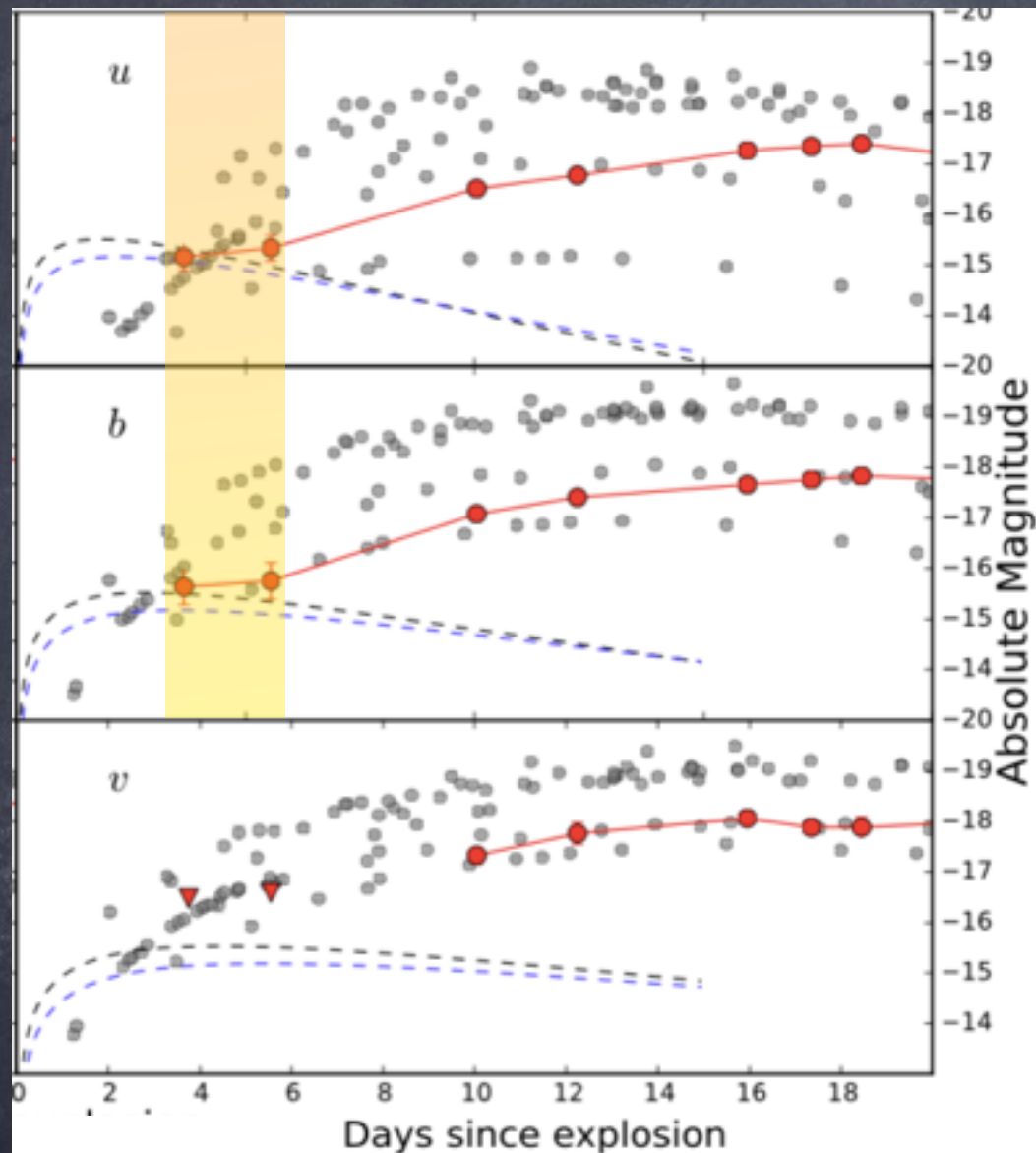
➤ Understandings of Early-phase Type Ia supernovae

"early-phase": within ~ 3 days after the "first light".

What we want to know...

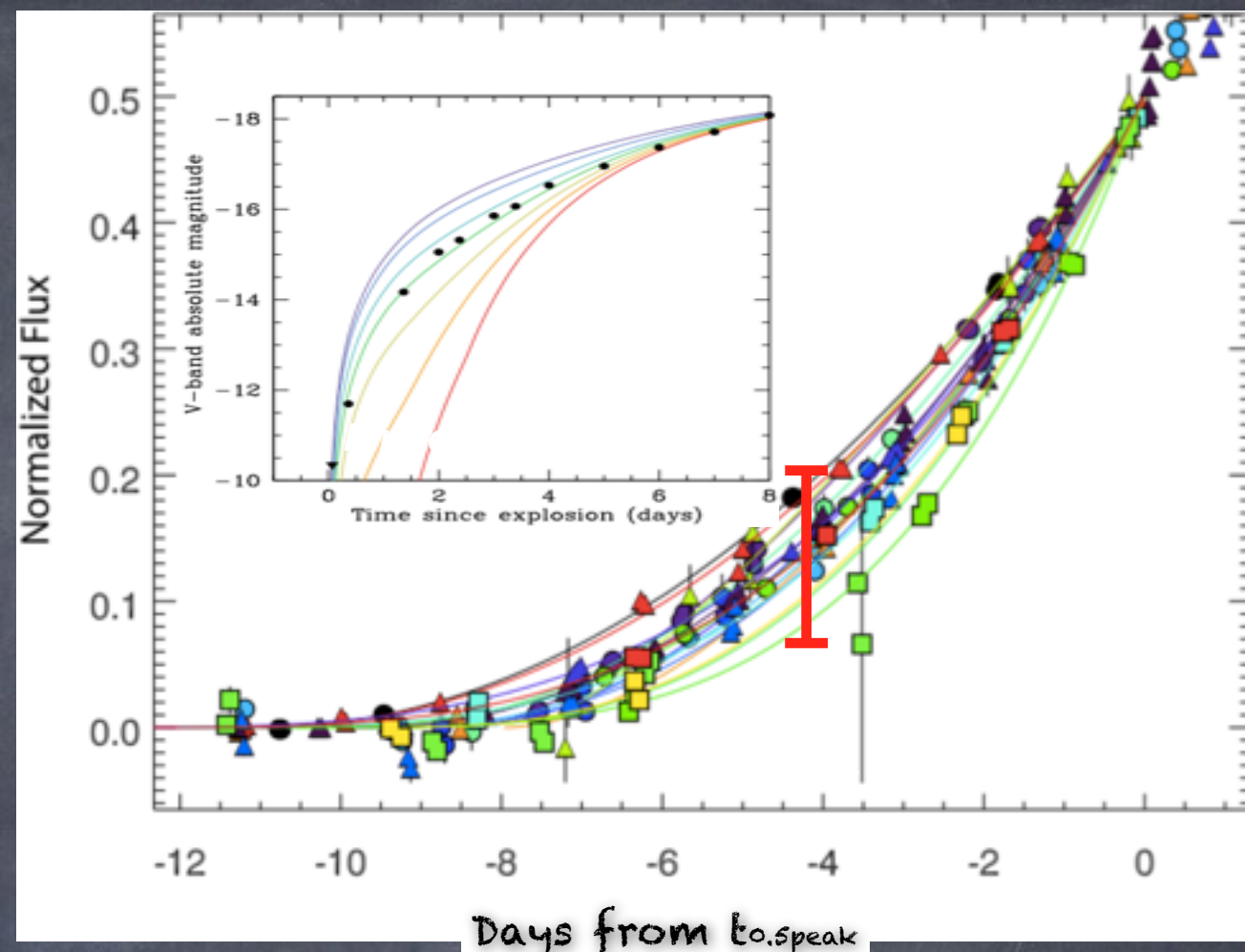
- ✧ SNe Ia with peculiar early photometric feature;
- ✧ The early-phase light curve/color diversity;
- ✧ The origin of "dark phase";
- ✧ The carbon footprint in early SN Ia spectra;
- ✧ Velocity evolution for specific absorption lines;
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-
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► Current understandings of Early-phase Type Ia supernovae

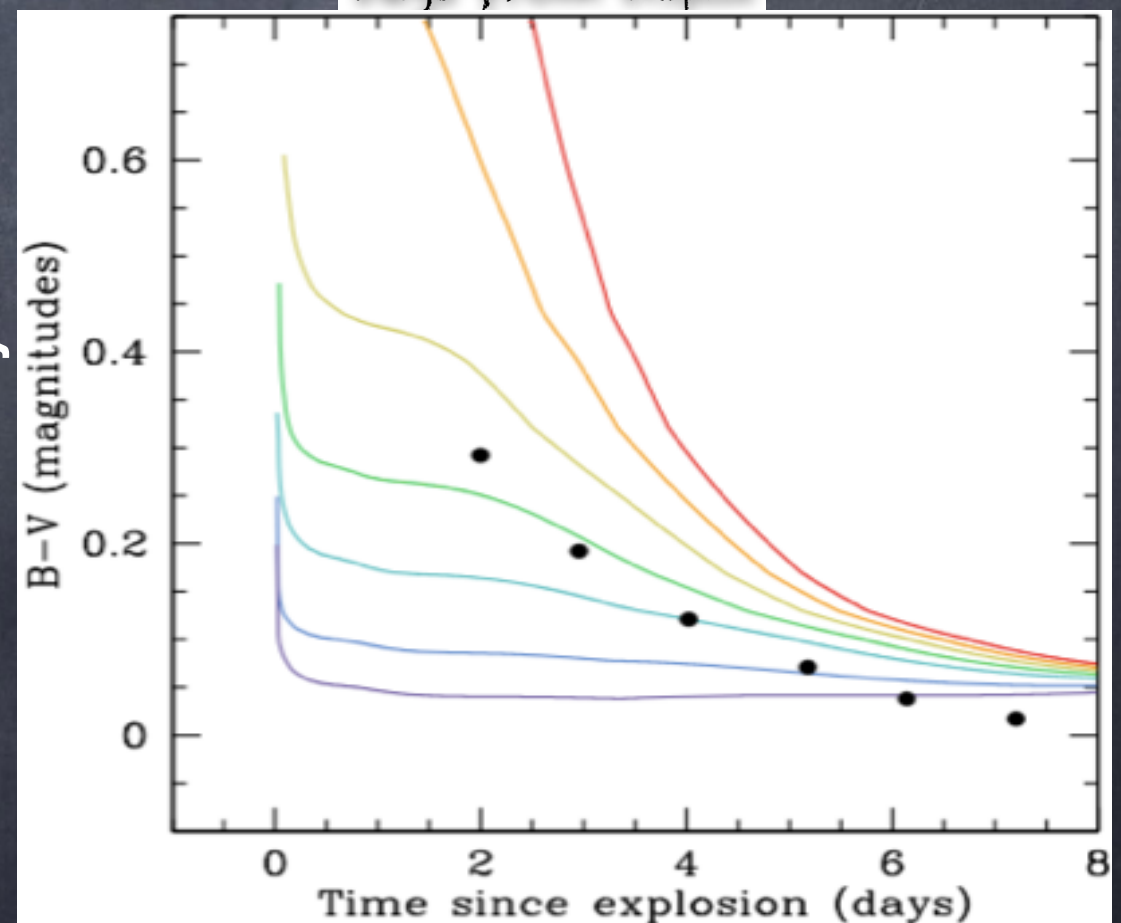


Cao+2015, Nature

Peculiar early-phase light curve caused by the ejecta-companion interaction?



Color curve diversity of ESNe Ia



Current/Upcoming Transient Survey



DECam

DES, HiTS, open-use obs

Subaru/HSC

SSP transient survey,
open-use obs

LSST

?



0.5~2-m telescope/
4~10 deg² CCD array

KISS, SKYS

ASAS-SN

iPTF

ZTF

Tomo-e Survey

✧ Review for recent SN surveys

Project	All-Sky Automated Survey for Supernovae (ASAS-SN)
Telescope	Eight 0.14-m robotic telescopes (two Units)
Survey Area	~20,000 sq. deg per night
Observing Depth	~17 mag in V-band
ESNe Ia*	ASASSN-14lp in ~3.5 yrs

Project	intermediate Paloma Transient Factory (iPTF)
Telescope	1.2-m Samuel Oschin Telescope
Camera	7.2 deg ² FoV Camera (11 2k x 4k CCDs)
Observing Depth	≲ 20.5 mag in R-band
ESNe Ia*	ptf11kly , iptf13asv, iptf13ebh, iptf14atg , iptf14bdn, etc.

Project	Zwicky Transient Facility (ZTF)
Telescope	1.2-m Samuel Oschin Telescope
Camera	47 deg² FoV Camera
Observing Depth	20.5 ~ 21.0 mag in R-band
ESNe Ia*	?

*The statistics is based on published papers.

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➤ ESNe Ia survey with Tomo-e Gozen Camera

- Total survey area per night: 10,000 deg²
- Cadence: 2 hours
- Depth: 18 mag for 2-hour cadence, 19 mag for 1-day cadence
- Filter: white-band
- Number of runs in each night: 3-4 visits per night for a given field

Expected number of ESNe Ia: $EN \sim 4/\text{yr}$

✧ ESNe Ia survey with Tomo-e Gozen Camera

- ✧ Advantages: extremely wide observations;
high cadence monitoring;
follow-up observations can be easily conducted;
- ✧ Drawbacks: current strategy is not efficient for ESNe Ia search;
large amount of follow-up observations;
a big challenge for the candidates inspection;

Any telescopes and anybody are welcome to join. Contact us if you would like to devote either your telescope time or yourself (or both!) for such an exciting project!!

➤ "Modified" ESNe Ia survey with Tomo-e

- Total survey area per night: 10,000 deg²
5,000 deg²
- Cadence: 2 hours
- Depth: 18 mag for 2-hour cadence, 19 mag for 1-day cadence
18.7 mag 19.7 mag
- Filter: white-band
- Number of runs per night: 3-4 visits/night for a given field
- 3 days for each Observing run

Expected number of ESNe Ia?

Expected number of ESNe Ia?

	Original	New
Survey area per day	10,000 deg ²	5,000 deg ²
ESNe Ia detection rate	$\sim 0.33a/\text{day}/\text{deg}^2$	$2.5a/\text{day}/\text{deg}^2$

Expected number: $EN_{\text{new}} \sim 3.8 * EN = 15.2/\text{yr} !!$

Note: The depth for real observation could be deeper because of the compressed slewing time.

Follow-up network

	Original	New
Follow-up ESNe Ia	< 18.2 (r)	< 18.9 (r)
Expect ESNe Ia Number	4/yr	15.2/yr
	Photometric	Spectroscopic
Domestic	OISTER	Kyoto 3.8-m
International	0.6~2.5-m telescope, SWIFT	2~3m telescopes

➤ Summary

- ✧ Early-phase SNe Ia play an irreplaceable role in addressing the progenitor and explosion mechanism issue of SNe Ia.
- ✧ A number of ESNe Ia can be expected with the Tomo-e transient survey, though the current strategy is not optimized for ESNe Ia search. The total ESNe Ia number can be doubled by applying the modified strategy.
- ✧ Lots of transient candidates will be discovered in Tomo-e era, which requires tremendous amount of follow-up observations with small/medium-aperture telescopes.