Observational properties of extreme supernovae

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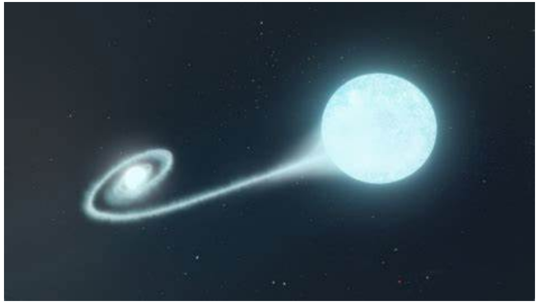
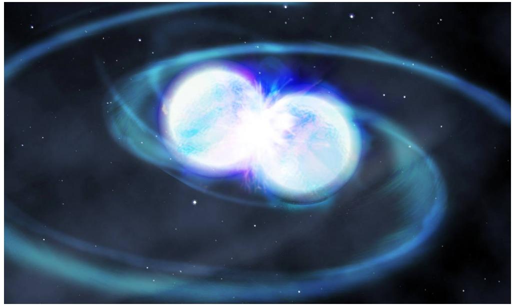
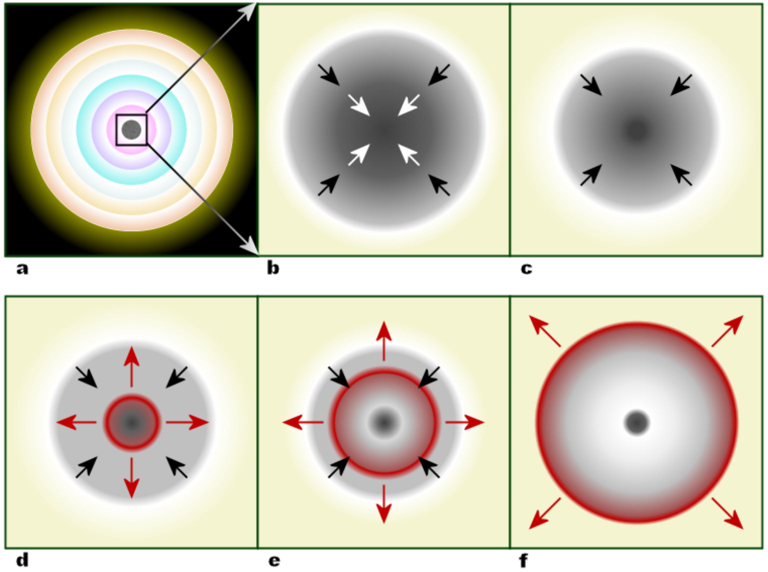
1 : Introduction

A supernova is a powerful and luminous explosion of a star.



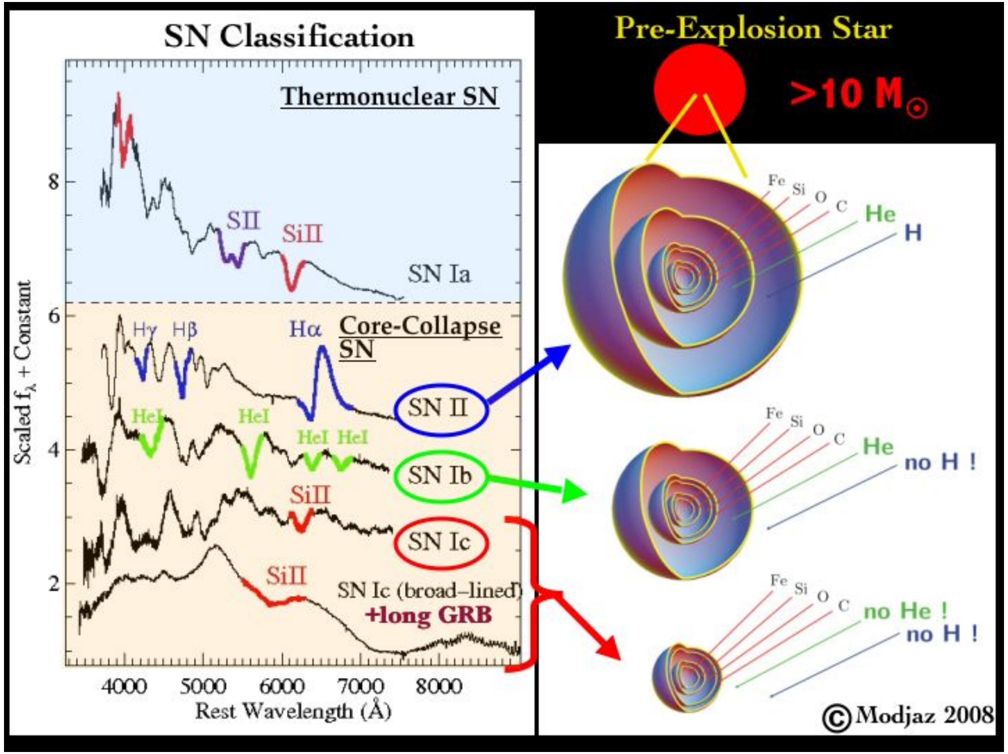


Thermonuclear SN



Core collapse SN

1：Introduction



All major SN classes can be defined based on the peak spectral properties.

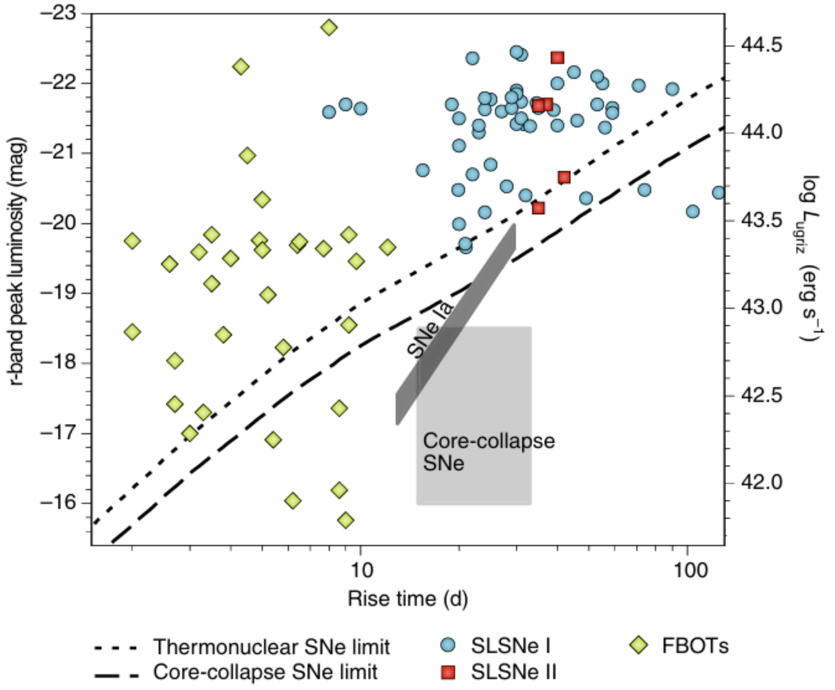
SN Ia: S II, Si II

SN II: Hα, Hβ, Hγ

SN Ib: He I

SN Ic/ SN Ic-BL : Si II

1：Introduction



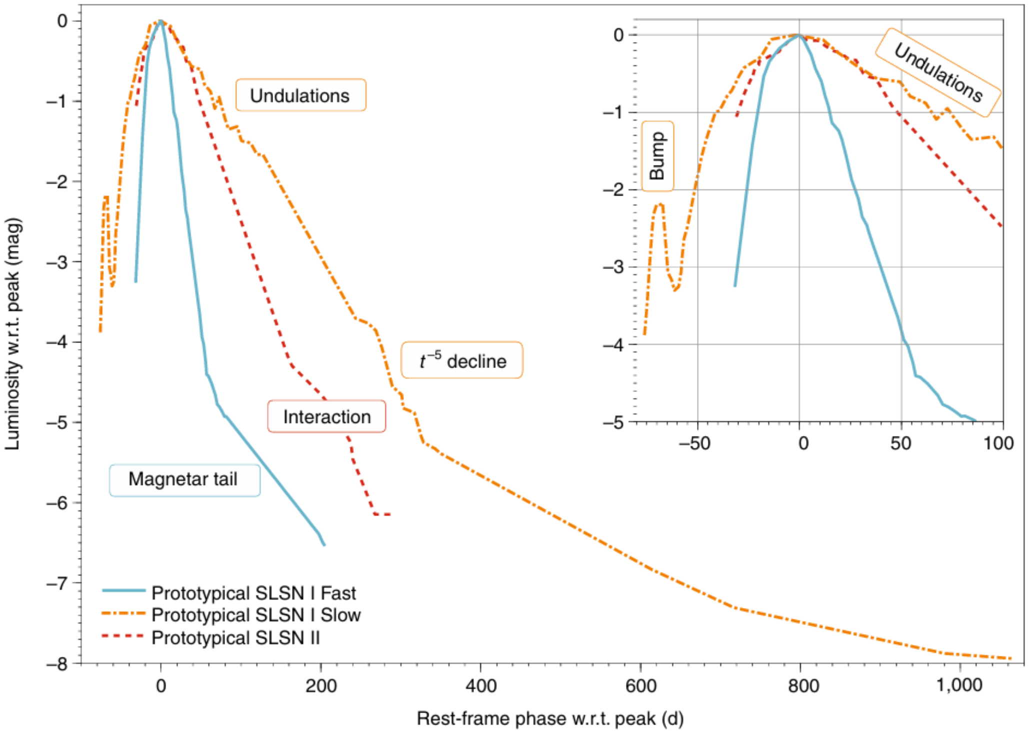
Almost a decade ago astronomers discovered transients defying the standard paradigm of stellar explosion. Their luminosity and evolution cannot be explained by the two classical mechanisms of core-collapse and thermonuclear explosions.

2：SLSNe

Currently, SNSLe can be divided into two categories, four subcategories

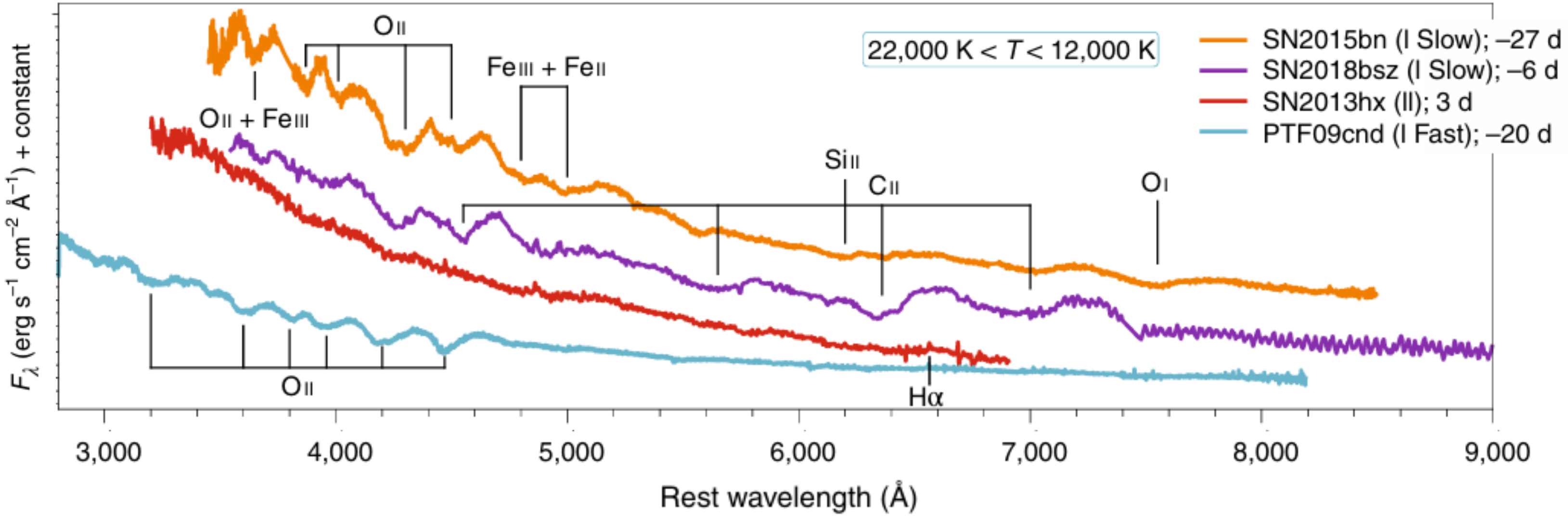
- SLSN I Fast (or F) for which SN2011ke could be considered the prototype, it decline rapidly;
- SLSN I Slow (or S) for which SN2015bn is the best observed example, and it decline slowly ;
- SLSN II with SN2013hx as the archetype
- SLSN IIn dominated by interaction as exemplified by SN2006gy

2 ：SLSNe - light curve evolution



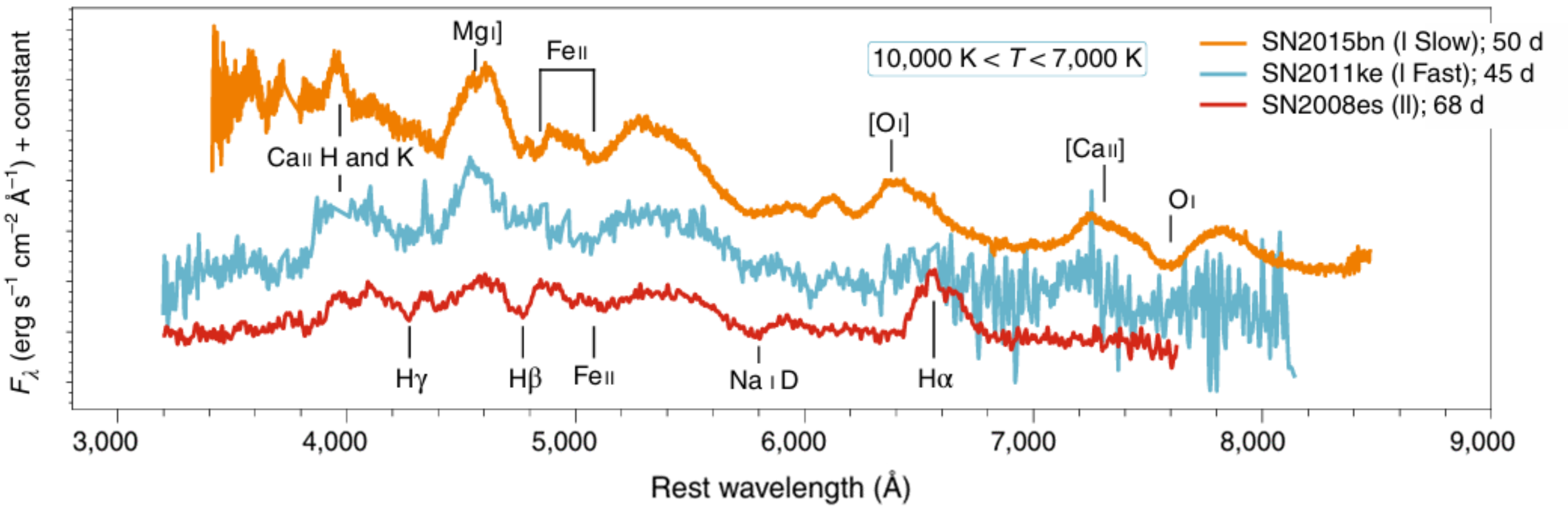
- SLSN light curves have long timescales with an average rise time of 28 and 52 days for SLSNe I Fast and Slow, respectively.
- SLSNe II show an average rise time of 34 days.

2 ：SLSNe - Spectroscopic evolution



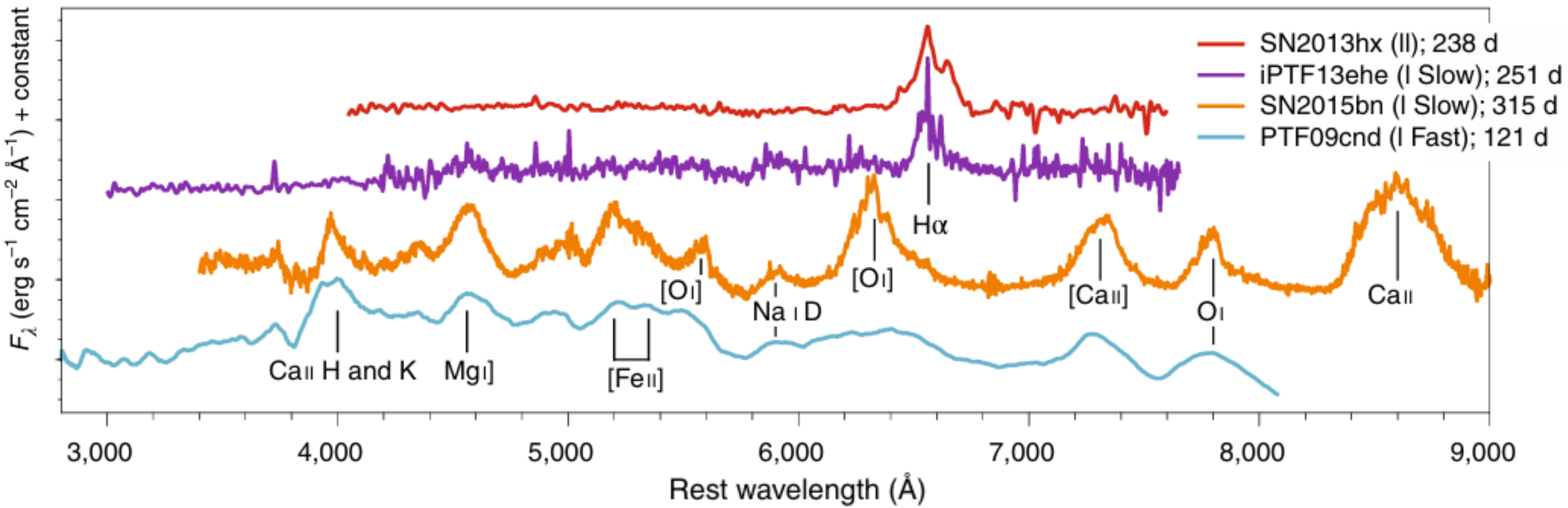
- SLSNe I Fast are mainly dominated by the typical [O II] lines,
- SLSNe I Slow show [Si II]and [Fe III] features, as well as [Fe II] and [O I] as soon as the ejecta temperature approaches 12,000 K.
- SLSNe II are instead featureless around the peak epoch with a broad, very shallow Hα profile.

2 ：SLSNe - Spectroscopic evolution



- At this epoch(30d) the strongest features are [Ca II] H and K lines, several [Fe II] multiplets around 5,000 Å and [Mg I].
- SLSNe I Slow shows a broad emission feature that is likely a blend of [Mg I], [Fe II] and [O I]. Forbidden lines such as [O I] and [Ca II] become visible at this phase in SLSNe I Slow, whereas they never appear in SLSNe I Fast.
- SLSNe II show the [Fe II] multiplet, [Na I] D and Balmer lines, as well as a high-velocity Hα feature.

2 : SLSNe - Spectroscopic evolution

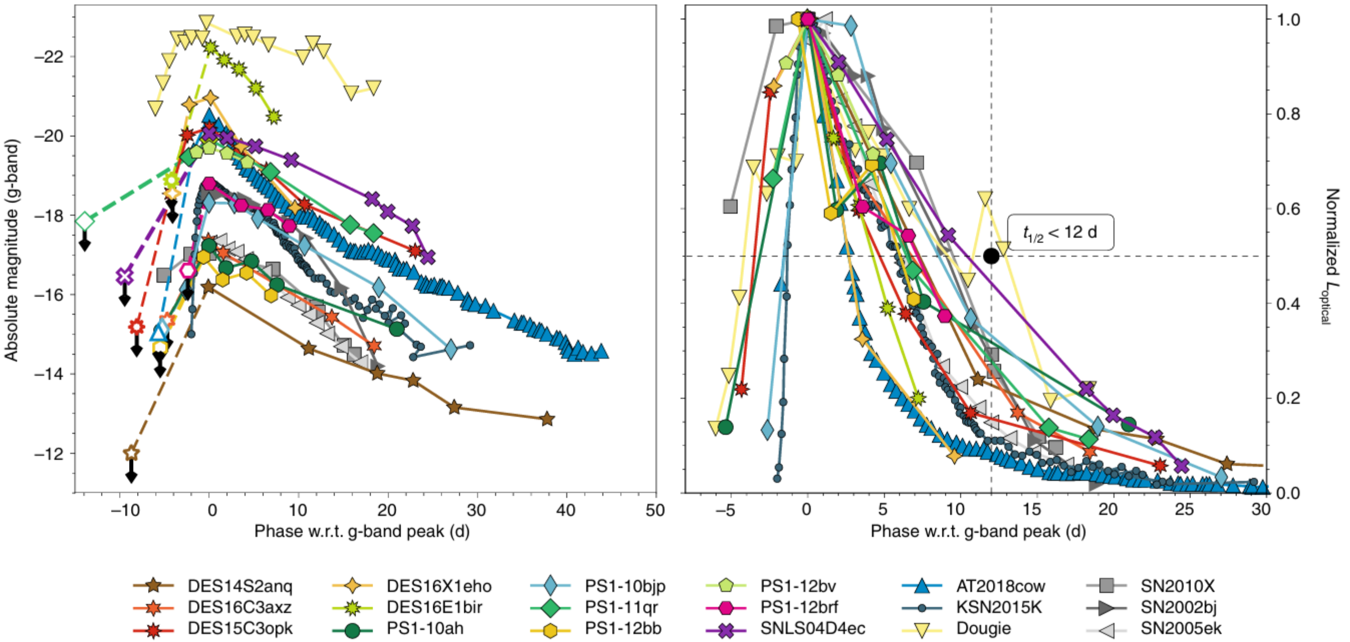


- SLSNe I Slow also show the same features they developed at 30–50 days but forbidden lines such as [O I] and [Ca II] are stronger. A strong [Ca II] triplet, [O I] and [Mg I] are also visible.
- SLSNe I that showed a strong [C II] signature around the peak epoch systematically display a Hα profile
- A similar profile is also displayed in SLSNe II where the ejecta collides with a ring-shaped, or clumpy, CSM

3：Fast blue optical transients

- The field of rapidly evolving transients has flourished during the past few years thanks to the advent of wide-field surveys, the majority of them can (and have been) explained as the final outcome of a massive stripped star or a thermonuclear explosion.
- The overall evolution of some of these transients is not as fast as the events presented in the PanSTARRS (or PS1), Subaru Hyper Suprime-Cam Transient Survey and DES samples , which in the literature are more often being referred to as fast blue optical transients (FBOTs).
- Moreover, the transients of such samples, as well as the nearby event AT2018cow at 60 Mpc, show timescales and spectroscopic evolution inconsistent with any standard scenario or model able to reproduce the observables (or some of them) of the objects mentioned above.

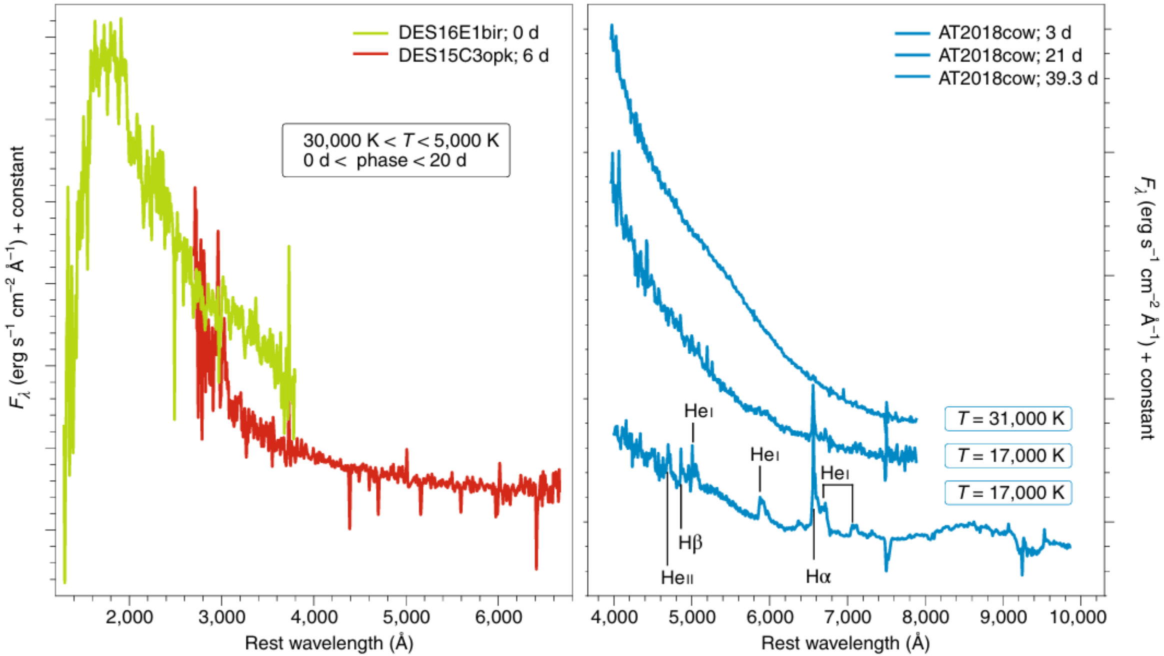
3 : Fast blue optical transients



The peak magnitudes of FBOTs span from the fainter end of core-collapse SNe up to luminosities comparable to SLSNe.

FBOTs are usually characterized by a rapid lightcurve rise to the peak and an exponential decline within 30 days after peak, or a time above half-maximum luminosity of less than 12 days.

3 ：Fast blue optical transients



Weak, redshifted emission of hydrogen and helium, both ionized and neutral, appears after ~10 days in the spectrum of AT2018cow. These become more prominent, centred and with a red shoulder after 35 days up to at least 85 days.

From a spectroscopic point of view, these transients are hot, featureless blackbodies at peak, with a lack of narrow permitted lines in emission typical of interacting SNe

4：Summary

- In order to obtain a phenomenological definition similar to SNe, the luminosity and spectral evolution characteristics of SNSLe are discussed. The magnetar scenario seems able to reproduce all the main observables, and some hybrid models (that is, magnetar plus interaction) might be equally or more effective.
- The luminosity and spectral properties of FBOTS are also discussed. Several suggested scenarios to explain the object are linked to a central X-ray engine model, for example, a failed explosion of a blue supergiant with the formation of a black hole or an electron-capture SN with a millisecond magnetar. Other explanations point toward a tidal disruption event from an intermediate mass black hole; formation of a magnetar in a binary neutron star merger or interaction with a CSM.

THANK YOU FOR LISTENING