SN 2020ank: a bright and fast-evolving H-deficient Superluminous Supernova

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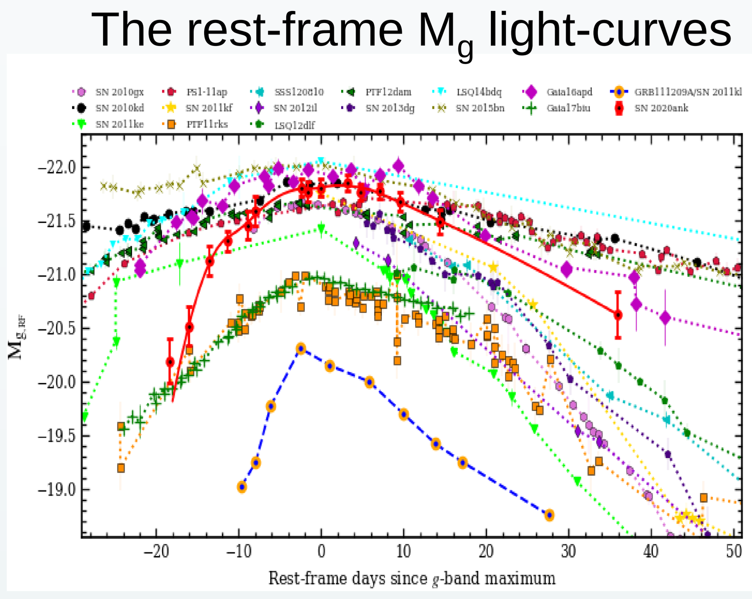
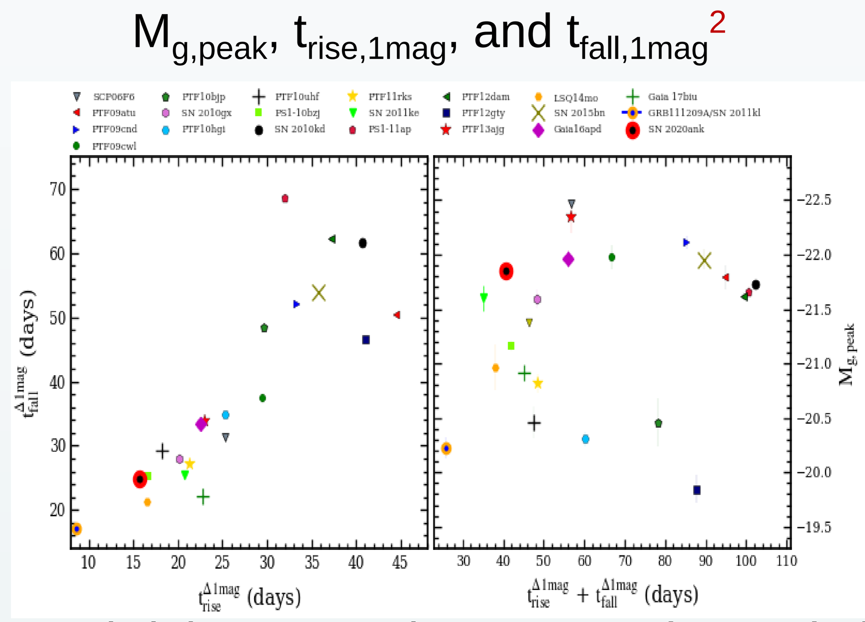
Introduction: Superluminous supernovae (SLSNe) are a new class of SNe (2–3 magnitudes brighter than classical SNe) that were recognized about a decade ago (Quimby et al. 2011). SLSNe comprising ~0.01 per cent of normal core-collapse SNe (CCSNe), and nearly 150 objects have been spectroscopically confirmed so far. Like classical CCSNe, SLSNe are spectroscopically divided into two categories: hydrogen-poor (SLSNe I) and hydrogen-rich (SLSNe II; Branch & Wheeler 2017). Based on the post-peak decay rates, SLSNe I are broadly classified into fast- and slow-decaying categories. Photometrically slow-evolving (rise time t_r ~33–100 days) SLSNe I also exhibit slower spectroscopic evolution in comparison to the fast-evolving (t_r ~13–35 days) SLSNe I (Inserra et al. 2018). SLSNe I are so bright (total energy ~10^{51} erg) that they require a power source beyond that of traditional SNe. The widely accepted physical mechanism of radioactive decay (RD) of ^{56}Ni for normal class of H-deficient CCSNe has been found to be inefficient in explaining the observed high peak-luminosity in most of the SLSNe I. So, various other plausible models are proposed to explain the relatively wider and luminous bolometric light curves of SLSNe I, including Circumstellar Matter Interaction (CSMI), spin-down Millisecond Magnetar (MAG), and their possible combinations, termed as 'HYBRID' models, e.g. CSMI+RD, CSMI+MAG, CSMI+RD+MAG (Chatzopoulos et al. 2013). At early times, SLSNe I have a blue continuum, peaking in the ultraviolet, have temperatures above ~14,000 K, and exhibit characteristic W-shaped OII features towards blue (Quimby et al. 2018). SLSNe I are thought to be a subtype of SNe Ic, because after a few weeks, they exhibit spectral features similar to those of SNe Ic (Pastorello et al. 2010). In this poster, some of the photometric and spectroscopic properties of fast-decaying SLSN 2020ank (t_r ~29 days) have been discussed. The analysis was performed based on the data obtained from the Sampurnanand Telescope, Himalayan Chandra Telescope, and the recently commissioned Devasthal Optical Telescope along with some publically available data[1]. See **Kumar et al. 2021, MNRAS, 502, 1678** for details.

Photometric properties of SN 2020ank

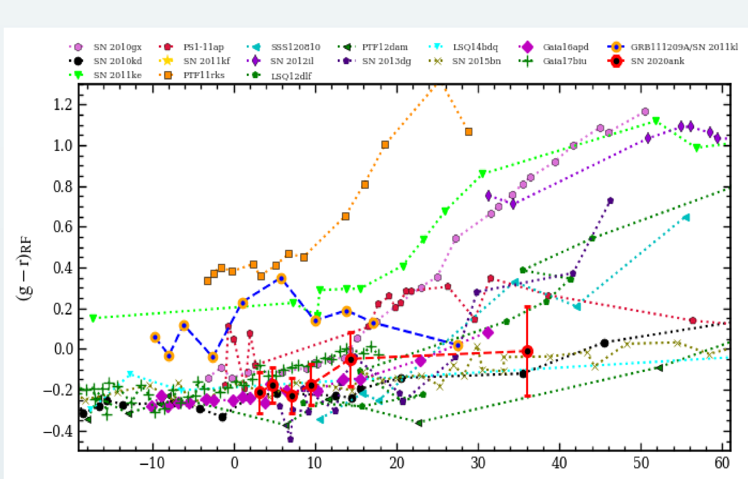
The rest-frame M_g light-curves



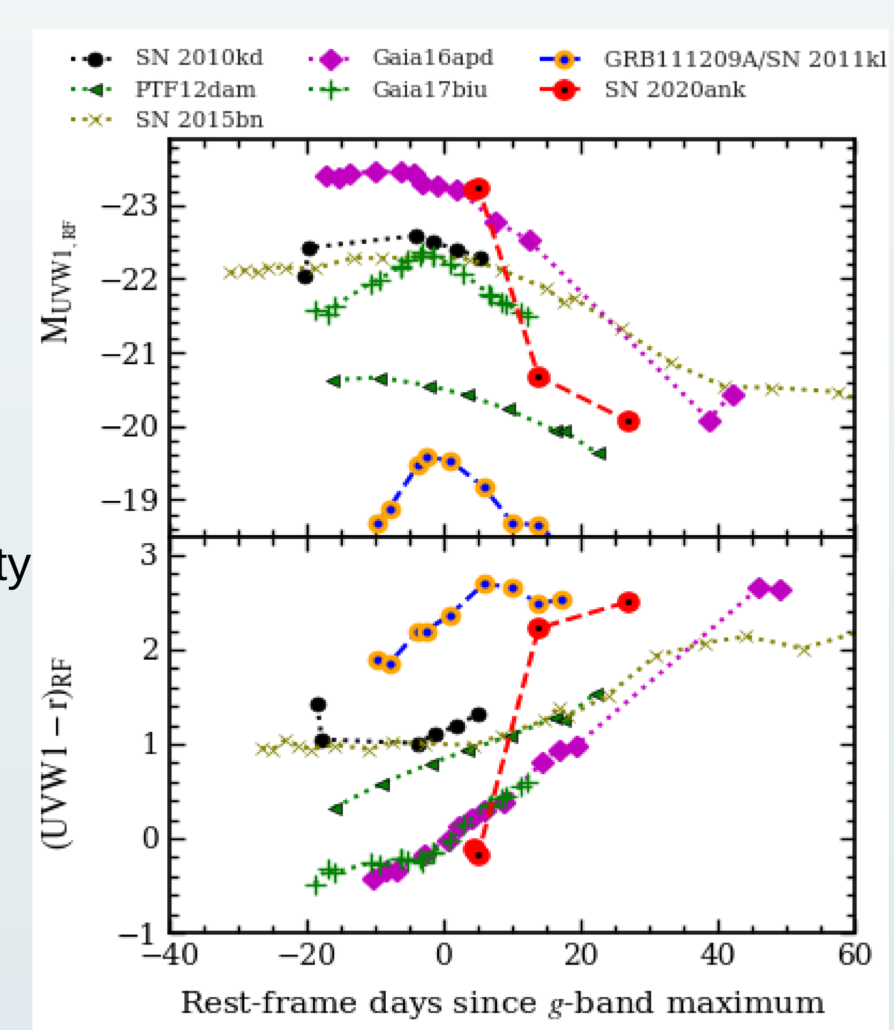
$M_{g,peak}$, $t_{rise,1mag}$, and $t_{fall,1mag}$[2]



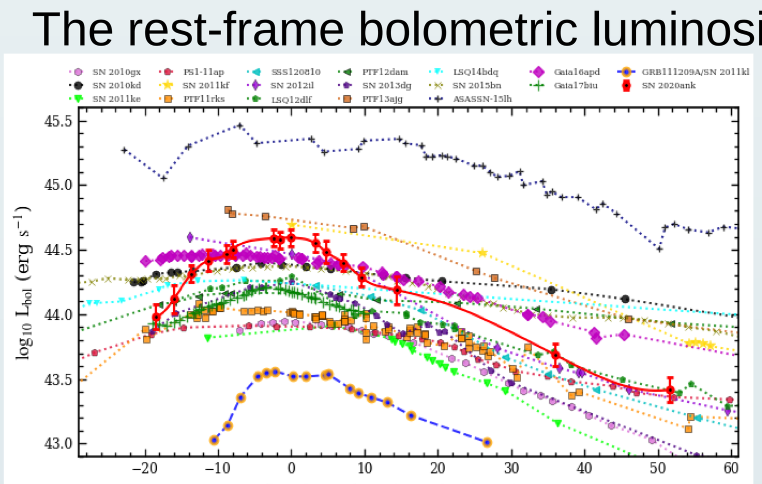
The rest-frame g-r color evolution



UV-brightness and UVW1-r color evolution



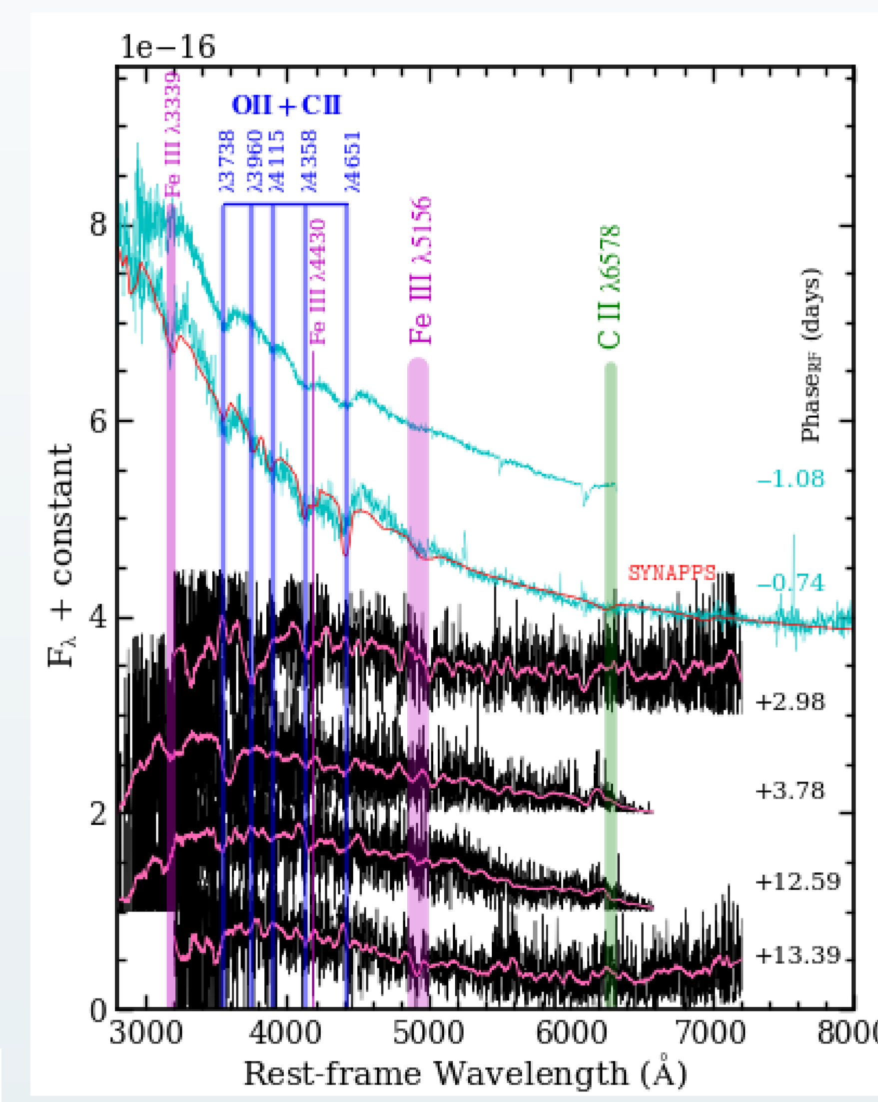
The rest-frame bolometric luminosity

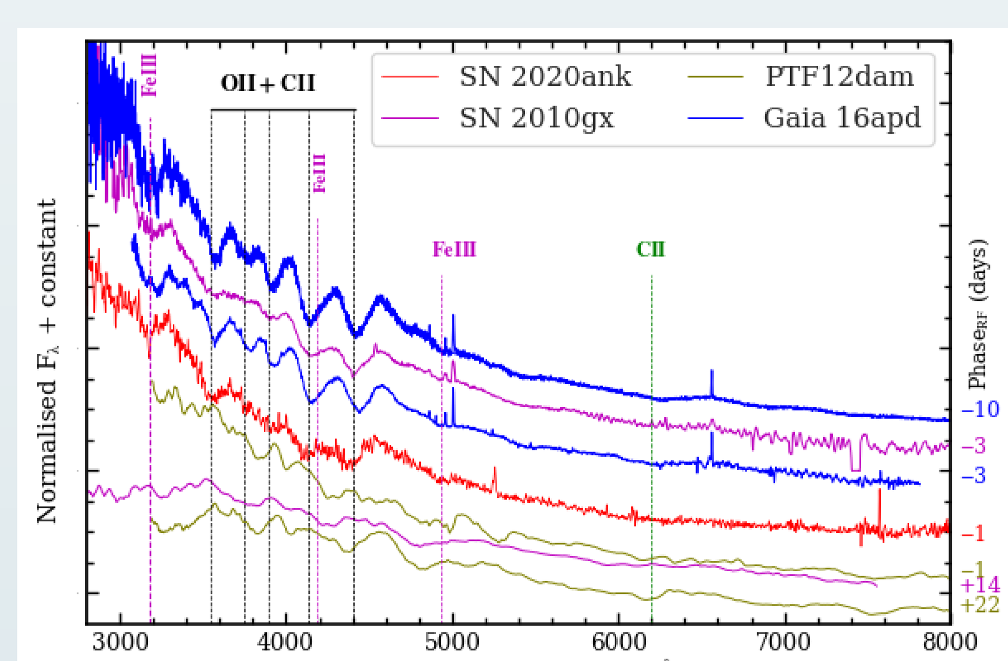


Spectroscopic properties of SN 2020ank

❑Spectra of SN 2020ank, starting from -1 to +13 days are presented. The near-peak spectrum (at -0.74 day; with a black-body temperature of ~14,800 ± 300 K and V_{ph} ~ 12,050 km s^{-1}) of SN 2020ank is also reproduced using the SYNAPPS code. The spectrum is found to be dominated by the W-shaped O II features with weak signatures of C II and Fe III ions, however exhibiting a clear absence of H and He lines.

❑The absorption minima of lines interpreted as C II and O II were fitted by larger velocities (16,500 and 17,750 km s^{-1}, respectively) than for Fe III (13,100 km s^{-1}).

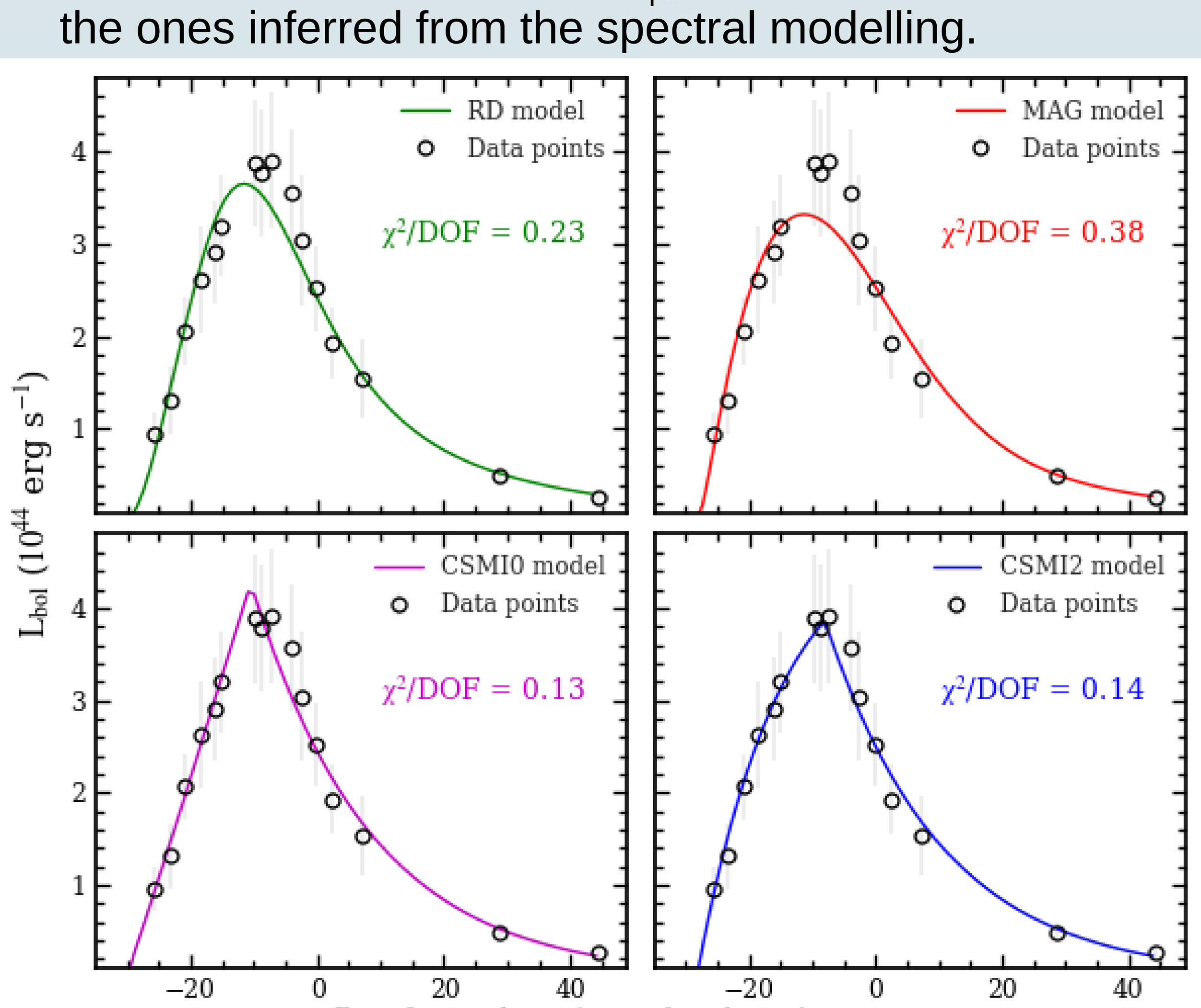


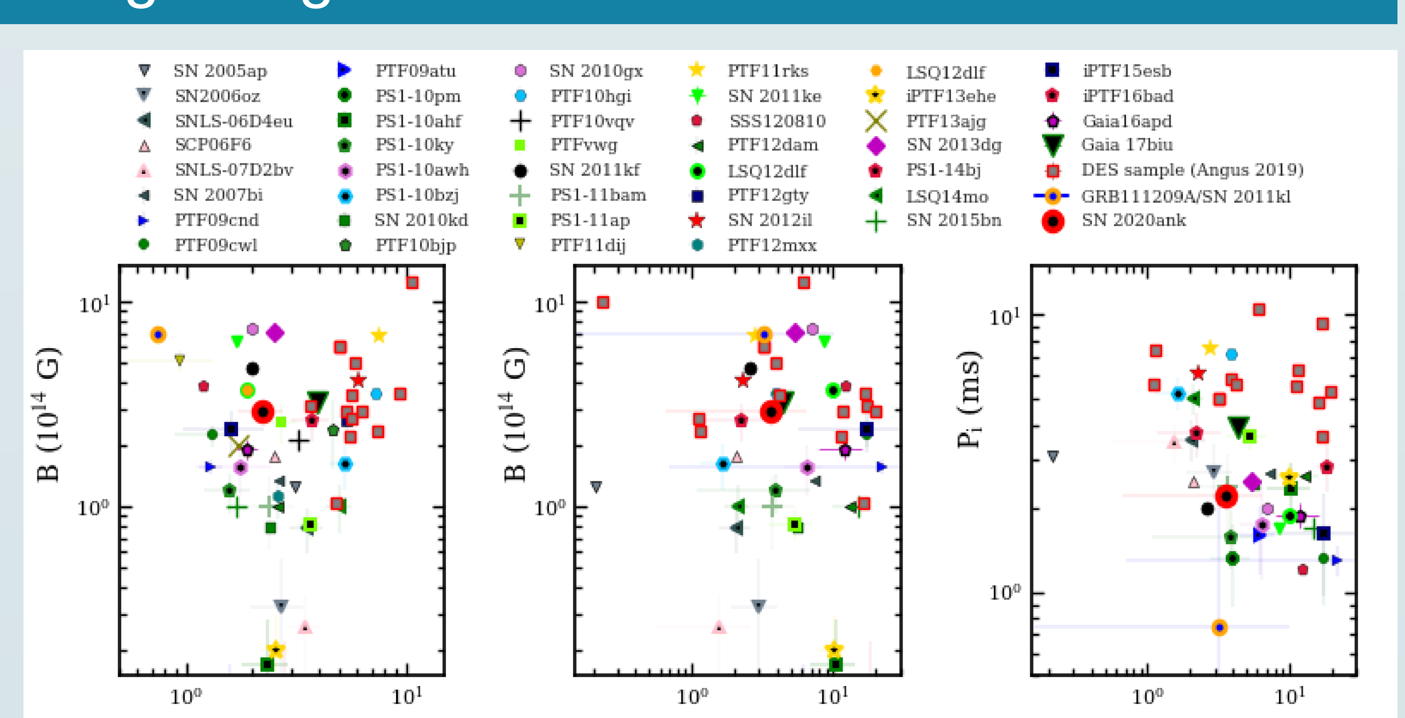


❑The near-peak spectral similarity of SN 2020ank with SN 2010gx (fast-evolving; Pastorello et al. 2010) and apparent similarity with the spectrum of the PTF12dam (slow-evolving; Nicholl et al. 2013) at +22 days confirms comparatively faster spectral evolution of SN 2020ank.

Light-curve modelling using MINIM

❑We attempt to reproduce the bolometric light curve of SN 2020ank with the RD, MAG, constant density CSMI (CSMI0), and wind like CSMI (CSMI2) semi-analytical light curve models using the MINIM code (Chatzopoulos et al. 2013). In summary, based on our fitting we consider the MAG model as the most probable one because 1) it fits the data well, and 2) its parameters (e.g., ejecta mass (M_{ej}) and photospheric velocity (V_{ph})) are realistic and closer to the ones inferred from the spectral modelling.





❑Comparison of the initial period (P_i), magnetic field (B), and ejecta mass of the new-born magnetar (M_{ej}) of SN 2020ank with those found in case of other well-studied SLSNe I from the literature. Overall, most of the slow-evolving SLSNe I (e.g., SN 2010kd; Kumar et al. 2020) appear to have larger M_{ej} values in comparison to those exhibited by the fast-evolving SLSNe I (e.g., SN 2020ank; Kumar et al. 2021).

❑SLSN 2011kl (Greiner et al. 2015), the only known case so far associated with the ultra-long Gamma-Ray Burst (Ul-GRB), e.g. GRB 111209A shows the highest value of B and lowest value of P_i among all the SLSNe I of the sample (except for SN 2010gx and SN 2013dg).

Summary

- ➢ SN 2020ank is one of the brighter fast-evolving SLSNe I with the peak g-band absolute magnitude of −21.84 ± 0.10 mag. The pre-peak rising and post-peak decaying rates of the light curves are similar to other well studied fast-evolving SLSNe I. However, the rest-frame g−r colour evolution of SN 2020ank is not consistent with the fast-evolving SLSNe I and is closer to the slow-evolving ones.
- ➢ The bolometric light curve of SN 2020ank is symmetric around the peak with $L_{rise,max/e}$ ≈ $L_{fall,max/e}$ ≈ 15 days. The MINIM light-curve modelling and high UV flux near the peak indicating towards a central engine based powering source for SN 2020ank.
- ➢ Using the values of v_{ph} obtained from the SYNAPPS spectral fitting and t_r, we constrain the photospheric radius (2.4 x 10^{15} cm), total optical depth (74.6), M_{ej} (7.2 M_{sun}), and kinteic energy (6.3 x 10^{51} erg) of SN 2020ank.
- ➢ The spectral similarity with SN 2010gx confirms the faster spectral evolution of SN 2020ank.

References: Pastorello A. et al., 2010, ApJ, 724, L16 • Quimby, R., et al., 2011, Nature, 474, 487 • Chatzopoulos, et al., 2013, ApJ, 773, 76 • Nicholl M. et al., 2013, Nature, 502, 346 • Branch D., Wheeler J. C., 2017, Supernova Explosions. Springer-Verlag, Berlin • Inserra, C., et al., 2018, MNRAS, 475, 1046 • Kumar, Amit, et al., 2020, ApJ, 892, 28 • Kumar, Amit, et al., 2021, MNRAS, 502, 1678

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1: Data is taken from: https://lasair.roe.ac.uk/object/ZTF20aahbfmf/ and https://wis-tns.weizmann.ac.il/

2: $t_{rise,1mag}$, and $t_{fall,1mag}$ are time taken to rise/decay by 1 mag to/from the peak absolute magnitudes