Environmental dependence of SN Ia i-band secondary maximum with BayeSN

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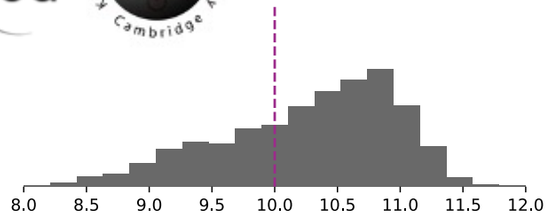


1) History of the 'mass step'

- Type Ia supernovae (SNe Ia) are precise cosmological distance indicators, thanks to their low scatter post-standardisation.
- However, there remains a still-unexplained difference in the properties of SNe Ia in different environments: the 'mass step'.
- **Understanding this is vital for cosmology and will shed light on the nature of SN Ia progenitors.**

Comparable in size to the signal of dark energy!

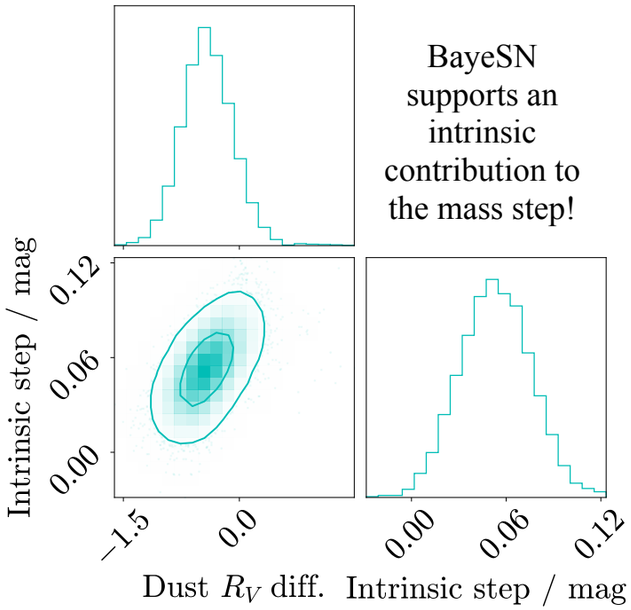
2) BayeSN: A Probabilistic SED Model

- BayeSN (Mandel+22, Grayling+24) is a hierarchical Bayesian SED model for SNe Ia
- SED composed of population mean, variation with stretch, dust extinction and intrinsic colour variation across the population.
- BayeSN can be used to fit SN light curves, but we can also infer population-level properties of SNe Ia in different environments *separately*.
- **This allows the data to inform us what is driving these environmental differences.**

3) Analysis

We apply BayeSN to investigate the cause of the mass step and consider **time and wavelength-dependent differences** between SNe Ia in different environments**.**

We analyse two *independent datasets
Foundation+PS1MD+DES3YR:
(475 SNe, z<0.4)
DES5YR:
(~400 SN, z<0.35)



BayeSN supports an intrinsic contribution to the mass step!

Grayling et al. 2024

4) Differences in i-band

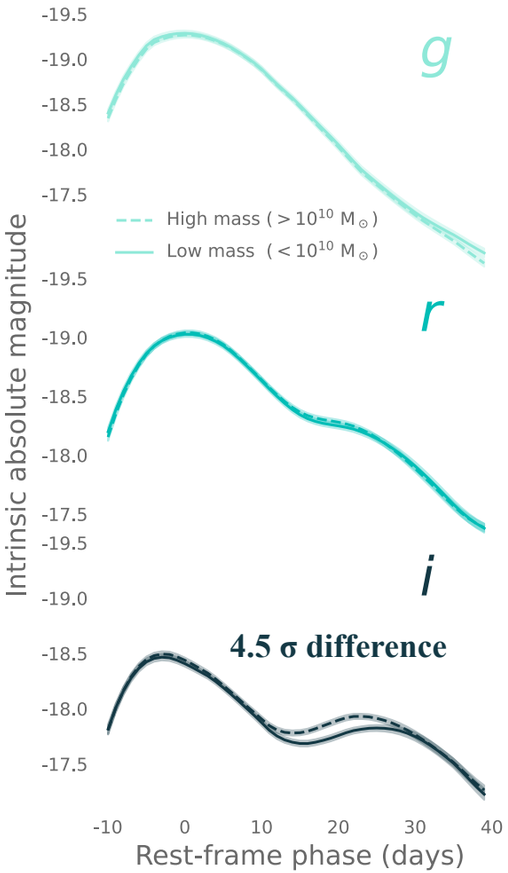
- **Significant differences in i-band secondary maximum** between different environments, independent of dust/stretch.
- Consistent across two analyses; Grayling et al. (2024) finds 4.5σ while Grayling and Popovic (2025) find >3σ.

5) What is driving this difference?

Kasen (2006) and Deckers et al. (2024) suggest i-band secondary maximum is linked to metallicity, maybe this relates to progenitor age/metallicity?

6) Conclusions

- BayeSN is publicly available, GPU-accelerated SN Ia SED model, used for population inference and light curve fitting
- **BayeSN supports intrinsic differences between SNe Ia in different environments**, which are particularly notable in i-band secondary maximum
- The exact cause remains uncertain; **uncovering this is vital for understanding SN Ia astrophysics and cosmological inference.**



References Grayling and Popovic 2025

Mandel+2022, MNRAS, 510, p. 3939-3966
Grayling+2024, MNRAS, 531, p. 953-976
Grayling & Popovic 2025, accepted in MNRAS
Kasen 2006, ApJ, 649, p. 939-953.
Deckers+2024, A&A, 694, A12