Cosmology with type Ia supernovae: the ultraviolet 'catastrophe' ?

Evolution with redshift of type Ia supernovae in the ultraviolet domain

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Why should we care?

The significant evolution of their UV colors with redshift shows that type Ia supernovae are not as homogeneous as previously thought, resulting in potential bias of their cosmological results.

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Type Ia supernovae as standard candles

To be used as cosmological tools, type Ia supernovae (SNe Ia) have to be **standardized** thanks to their light-curve, color and host galaxy properties [Betoule *et al.*, 2014]. Unfortunately, these empirical corrections are not sufficient. Hence, complementary or, even better, **more elementary laws** have to be found to improve our cosmological use of SNe Ia.

Dataset & methodology

Previous studies
[Milne *et al.*, 2013; 2015]

80 SNe Ia

Very low redshift : direct **UV observations** (Ultraviolet Optical Telescope on Swift mission)
Higher redshift **: spectrophotometry** on SNe Ia spectra (space- and ground-based telescopes)

Our work

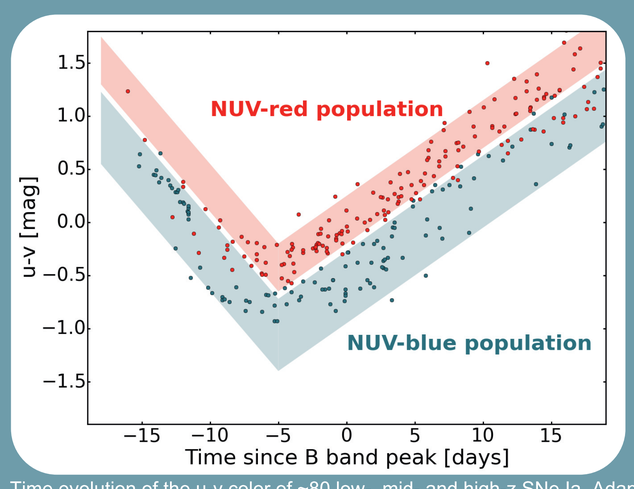
700 SNe Ia

Spectrophotometry on a SNe Ia **template** spectra [Hsiao *et al.*, 2007 - Barbary *et al.*, 2016] calibrated on **optical light-curves** from the Joint Light-curve Analysis (JLA) compilation [Betoule *et al.*, 2014]

Ultraviolet studies

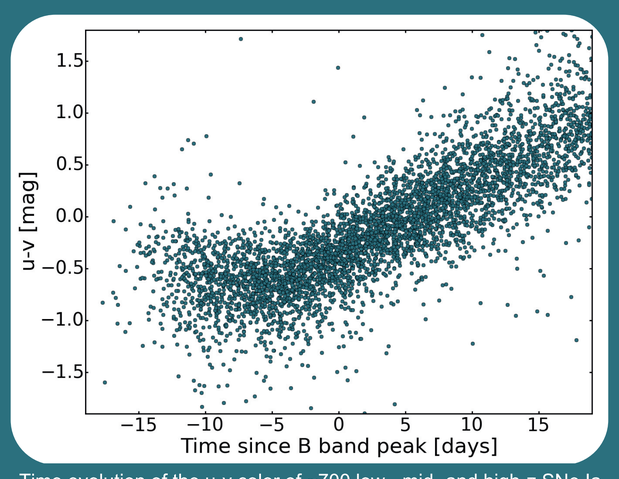
Recently, the SNe Ia rest-frame UV spectra have been extensively studied as they are affected by SNe Ia **explosion physics** as well as by their **progenitor metallicity**. Hence, the ultimate standardizing law could be hiding in the UV domain.

Existence of **two subpopulations** of SNe Ia, separated by their **Near-UV (NUV) color**



Time evolution of the u-v color of ~80 low-, mid- and high-z SNe Ia. Adapted from [Milne *et al.*, 2015] with information from The Open Supernova Catalog [Guillochon *et al.*, 2017].

Continuous distribution of SNe Ia u-v colors

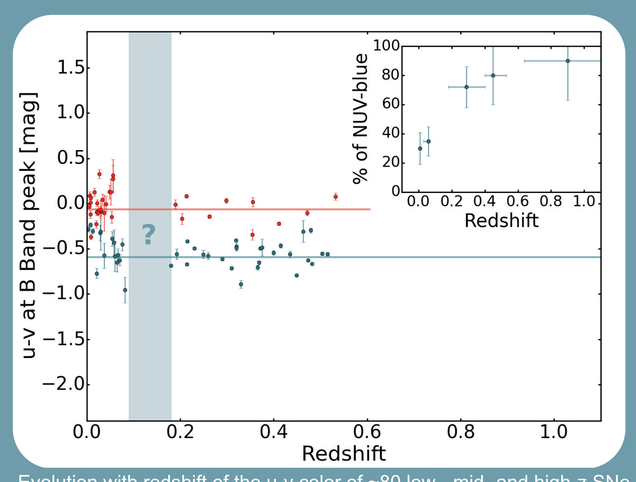


Time evolution of the u-v color of ~700 low-, mid- and high-z SNe Ia from the JLA compilation [Betoule et al., 2014].

Evolution with redshift

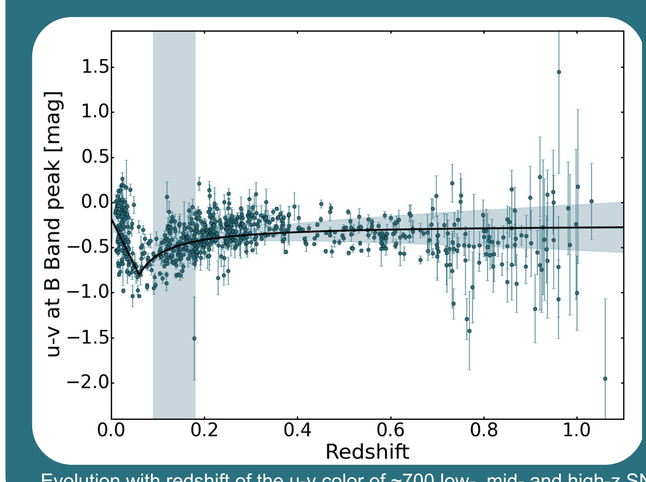
When using standardizing laws, SNe Ia are assumed to not intrinsically **change with redshift** at the risk of **biasing** the subsequent **cosmological results**. But this assumption may not hold in UV when talking about the SNe Ia progenitor metallicity.

Evolution of **distribution in subpopulations**
(No evolution within each subpopulation)



Evolution with redshift of the u-v color of ~80 low-, mid- and high-z SNe Ia from [Milne *et al.*, 2013; 2015]. Insert adapted from [Milne *et al.*, 2015].

Significant evolution of SNe Ia u-v colors at **low redshift** ($z \leq 0.2$)



Evolution with redshift of the u-v color of ~700 low-, mid- and high-z SNe Ia from the JLA compilation [Betoule *et al.*, 2014].

References

Betoule, M., *et al.*, 2014, A&A, 568, A22 • Milne, P.A., *et al.*, 2013, ApJ, 715, 743 • Milne, P.A., *et al.*, 2015, ApJ, 803, 20 • Hsiao, E.Y., *et al.*, 2007, ApJ, 663, 1187 • Barbary, K., *et al.*, 2016, *SNCosmo: Python librairy for supernova cosmology*, Astrophysics Source Code Librairy • Guillochon, J., *et al.*, ApJ, 835, 64 (The Open Supernova Catalog)

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