Photometric Classification of Supernovae

A Study of Supernovae Contamination

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Photometric Typing

The photometric identification of Type Ia supernovae (SNIa) in samples including significant numbers of core collapse supernovae (SNcc) must be robust in order to improve the SN cosmology constraints. Cosmology measurements are potentially very sensitive to the purity of the SNIa sample. Unfortunately, our knowledge and simulation tools for SNcc are limited, partially due to the emphasis on SNIa studies in the last two decades.[1]

SNANA

We simulated a sample of SNcc using the SNANA analysis package.[2] These SNcc were then fit to a Type Ia lightcurve model. For each supernova, SNANA gives back a fit probability that indicates how well it was able to fit that lightcurve to a Type Ia model. When simulating supernovae, SNANA uses both SNcc and SNIa templates representing real data.

Studying Contamination

For the first part of our project we solely used SNANA to both simulate and fit SNcc lightcurves. Our goal was to learn about SNcc contamination in a mixed sample of SNIa and SNcc supernovae. We simulated a pure sample of SNcc and then fit that sample to a Type Ia model. However after fitting, some were recognized as SNIa. After applying a series of cuts, we were left with 179 SNcc still recognized as SNIa. To the right is a table showing the templates that were used to simulate the SNcc that were still recognized as SNIa after the cuts were made.

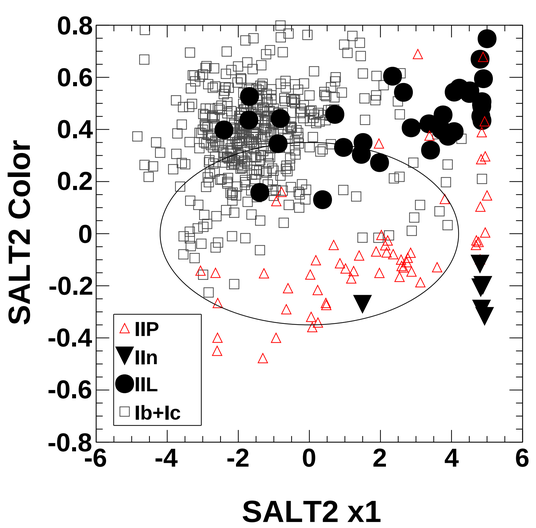

Figure 1: SALT2 Color (c) vs. SALT2 Stretch (x_1). SNcc inside the ellipse are kept. This selection cut is particularly useful in eliminating Type IIn and Type IIL SNcc.

SNcc Type	IAU name	Exp. Name	# Passing SNIa Cuts
Ib	**2006ep**	**CSP-2006ep**	**112**
Ib	2004gv	CSP-2004gv	1
Ib	2006jo	SDSS-014492	1
Ib	2007nc	SDSS-019323	1
Ibc	NA	SNLS-04D11a	1
Ic	**2007ms**	**SDSS-017548**	**12**
Ic	2004fe	CSP-2004fe	3
Ic	NA	SDSS-004012	3
Ic	NA	SDSS-014475	1
IIP	**2004hx**	**SDSS-000018**	**28**
IIP	2006kv	SDSS-015320	1
IIP	2006ns	SDSS-015339	2
IIP	2007kw	SDSS-018109	1
IIP	2007ll	SDSS-018457	1
IIP	2007pg	SDSS-020038	4
IIL	composite	composite	6
IIn	2006ez	SDSS-012842	1

Table 1: The templates of SNcc identified as SNIa, as a function of type, IAU name, experiment name and frequency of events.

As stated above, the goal of the first half of this project, was to better understand SNcc in order to pick out SNIa from mixed samples of supernovae.[3] As one can see, the methods used were unable to properly recognize all the SNcc as core-collapse supernovae, as seen in Table 1. However the study did provide some further insight on understanding SNcc identified as SNIa. If we better understand the 2006ep, 2007ms and 2004hx templates we could better understand why SNcc are recognized as SNIa.

SNcc Template Study

Next we attempted to better understand these 179 supernovae, mostly produced by the 3 templates above, by using a python library called SNCosmo.[4] The library allows us to fit the lightcurves of these supernovae to individual SNcc and SNIa templates, as opposed to fitting it to only a Type Ia and getting a single fit probability. When using SNCosmo we select the best template to be the template with the lowest χ^2/dof.

First we analyzed each of the 179 supernovae with a select 8 templates originally from `psnid`[5]. These templates were used to simulate SNcc in SNANA, however do not contribute to the SNcc that were recognized as SNIa in Table 1. When analyzing a particular supernova for each template, SNCosmo would try to fit the lightcurve and obtain a χ^2/dof. From here we found the template producing the smallest χ^2/dof and identified the supernova to have the SN Type represented by that template. We obtained the following distribution of supernovae when following the procedure described:

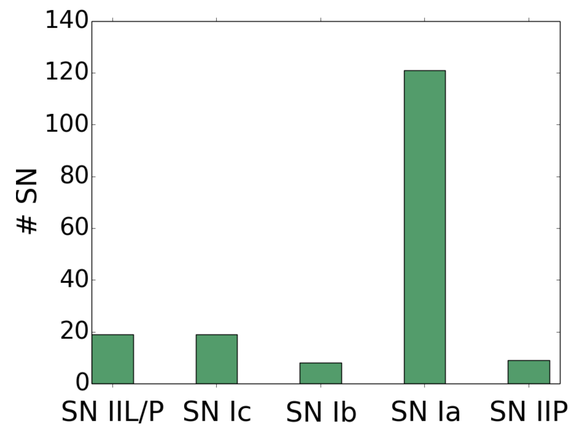

Figure 2: The distribution of SNcc identified by SNCosmo using the select 8 templates.

Many of these supernovae were recognized as Type Ia's by SNCosmo, but there was a noticable reduction as well. Next, we added the three SNcc templates (bolded in Table 1) that most likely produced lightcurves identified as SNIa into SNCosmo's database. After incorporating these templates we obtained the following results:

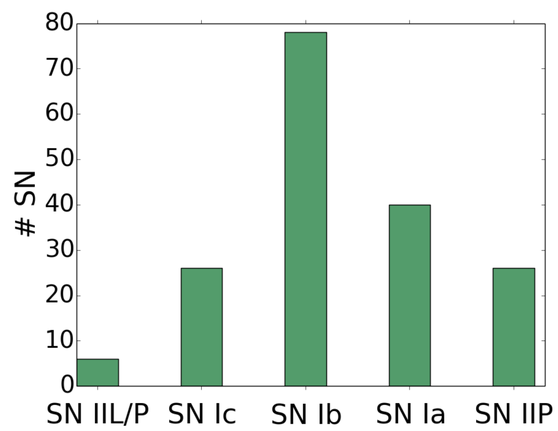

Figure 3: The distribution of SNcc identified by SNCosmo with the three SNcc templates most likely to produce supernovae identified as SNIa.

Conclusion

The simulated set of 179 SNcc that were identified as Type Ia was reduced by about 30% when SNCosmo was used to identify those supernovae. After incorporating the 3 additional SNcc templates that produced lightcurves that were identified as SNIa into SNCosmo, the number of SNcc identified as SNIa was again reduced by another 30%.

[1]Gjergo *et al.* 2013, ``Type Ia supernovae selection and forecast of cosmology constraints for the Dark Energy Survey''
[2]Kessler, R. and others, ``SNANA: A Public Software Package for Supernova Analysis''
[3]Duggan *et al.* ``Uncertainties in Core Collapse Supernova Simulations and the Impact on Cosmology Sample Purities''
[4]https://github.com/sncosmo/sncosmo
[5]Sako, M *et al.* 2011, ``Photometric Type Ia Supernova Candidates from the Three-year SDSS-II SN Survey Data''