Photometric Classification using physical properties of Type Ia supernovae

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Current and future transient surveys (e.g. SDSS, DES, LSST) are designed to find thousands of Type Ia supernovae (SNe Ia) to constrain the properties of dark energy. Since spectroscopy of all SNe is unfeasible, they need to be classified based on multi-band photometry. A photometric SN Ia hubble diagram has the advantages of extending to higher redshifts and having a larger sample size than a Hubble diagram with spectroscopically classified SN Ia (e.g. Campbell et al., 2013). The aim of this project is to use physical properties of SN Ia to improve the classification of SNe.

Near infrared light curves of SN Ia have a different morphology from optical light curves in that they rebrighten ~ 2 weeks after the first maximum, showing a characteristic 'double -peaked" behaviour in the $izyJHK$ filters (e.g. Dhawan et al., 2015). This feature is unique to SN Ia and is not seen in SNe of other subtypes. In our investigation, the aim is to improve the representativeness of the training sets by detecting whether a given SN has a second maximum.

The initial step we analysed a sample of low-redshift SN Ia from the Carnegie Supernova Project (CSP; Contreras et al., 2010; Stritzinger et al., 2011) to test how well can we detect a second maximum for a given (known) SN Ia. Light curves in the i band were fitted using a gaussian process (GP) regression. The sample was divided into a 'training' and 'test' set to determine the optimal hyperparameters for the GP fit. For the optimal parameters, $\sim 85\%$ of the SNe were correctly classified as having a second maximum. A example of the light curve fit along with the first and second derivatives of the GP is shown in Figure 1.

Following the fits for the low-z data, we applied the routine for fitting the light curves to a set of simulations from the Supernova Photometric Challenge (SPCC; Kessler et al., 2010a,b). We restricted the sample known SN Ia's at $z < 0.2$ to test the routine on the best sampled lightcurves and find that 90% of the SNe are correctly classified as having a second maximum.

The next steps for this project would include

1. Extend the redshift distribution of the simulated lightcurves fitted to $z = 0.4$.

2. Implement the second maximum routine into the classification framework `snmachine`

3. Improve the second maximum detection criteria

4. Investigate impact of our classifier as a pre-processing step on photometric classification performance

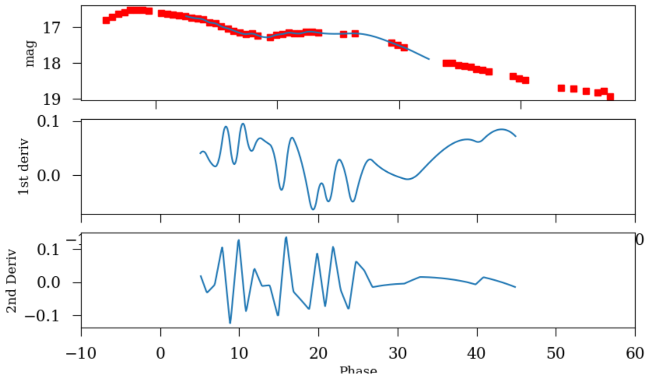

Figure 1: A gaussian process fit to the lightcurve of SN 2005M along with the first and second derivative. For the analyses, the derivatives are calculated in the phase range +10 - +40 days since this range captures the entire distribution of possible epochs at which the second maximum can occur.

References

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