Photometric Search for Weirdos in the SDSS-II SN Survey Data

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weirdos: rare / unusual astrophysical transients

SDSS SN Survey
~ 300 deg**2
ugriz with ~ 2-4 day cadence
~ 500 confirmed SNe Ia
~100 confirmed SNe Ib/c, II
~1000 “good” Photometric SNe

Kulkarni & Kasliwal
Transients in the local universe white paper
Gaussian process modelling

generalized light-curve fit

set of observations $y$

$$p(y|K, f_0) = (2\pi)^{N/2} \det(k + \eta)^{-1/2} \exp[-\frac{1}{2}(y - f_0)^T(k + \eta)^{-1}(y - f_0)]$$

predictive distributions on function space

fit parameters

mean function

$$\bar{f}^p - f_0^p = k_{np}^T[k_{nn} + \eta_{nn}]^{-1}(y - f_0^p)$$

covariance

$$k_{pp}^p = k_{pp} - k_{np}^T[k_{nn} + \eta_{nn}]^{-1}k_{np}$$
Squared exponential covariance function

$$C_{ij} = \sigma_a \times e^{(x_i - x_j)^2 / 2\sigma_b^2}$$

For fitting, a Gaussian prior on $\sigma_b$

$12 \pm \text{a few}$
SN Ia @ $z \sim 0.05$
SN Ia @ z ~ 0.05

SN003901

Photometric Identification of Supernovae
91bg-like
Photometric Identification of Supernovae

91bg-like

SN018890

ugriz
SN Ib

SN014492

ugriz
SN 2005hk
(SN 2002cx-like)
SN 2005gj
(SN 2002ic-like, Ia w/ CSM interaction)
Type IIP
length scale is not constant
Photometric Identification of Supernovae

Pathological Fit

SN002409

ugriz
Fast transient
(point Ia candidate)

SN002140
SN 2006gz
Super-luminous H poor SNe (Leloudas et al, 2012)

Photometric Identification of Supernovae
probably super-luminous Hydrogen poor CC (Quimbies)
Photometric Identification of Supernovae

probably super-luminous

Hydrogen poor CC

SN002538
characterize SNe with derived quantities from the GP model

\[ n = 2 \times \text{nfilt} + 3 \times (\text{nfilt}-1) = 22 \text{ for ugriz} \]

**rise time**: number of magnitudes rise from -5 to 0 days

**fall time**: number of magnitudes fall from 0 to +10 days

**colors**: early time (-5 days), at peak (0 days), late time (+10 days)

**mean ± std**

colors

rise time/ decline time
fast transients

confirmed Ias

fast weirdos!
~25 objects
a selection of 2010X-like/ point Ia candidates from SDSS-II

less fast; more point Ia-like

lack of hosts, α,δ distribution, featureless spectra implies probably Milky Way objects
cluster SNe using hierarchical clustering algorithm
dendrogram, using all candidates of type 1 1 1+
(confirmed Ias, Ib/cs, IIs and probable Ias)

the realm of the weirdos!

high S/N
well-sampled
SNe

4524=2005gj