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On the Statistical Characterization of SN IIn Light Curves

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Abstract. The objetive of this work is to characterize the photometric properties of type IIn SNe. In order to do that, we are carrying out a tight monitoring campaign. We present seven differential photometry light curves in R-band and preliminary results on decline rates of different portions of the light curves and detections of modulations in time scales smaller than a month. This is a report of work in progress.

1. Introduction

Type IIn SNe are a relatively new class of type II SNe (Filippenko 1989, Schlegel 1990), characterized by the following properties:

- The optical spectra is dominated by strong narrow emission lines, most notably H_α. Balmer lines are often observed with a composite profile: a narrow component (FWHM$\sim$ 200 km s^{-1}) superposed on a base of intermediate width (FWHM$\sim$ 1000-2000 km s^{-1}) and sometimes a very broad component (FWHM$\sim$ 5000-10000 km s^{-1}).
- They do not show the characteristic broad P-Cygni signature, although narrow P-Cygni profiles are detected in some cases at high spectral resolution (SN 1997ab, Salamanca et al. 1998; SN 1997eg, Tenorio-Tagle G., priv. communication; SN 1999E, Aretxaga et al. in prep.).
- Some of them are unusually luminous at maximum brightness and have a very slow decay of luminosity after maximun light. SN 1998Z, one of the most extensively observed SN IIn, was 5 mag brighter in V-band than standard SN II-P or SN II-L at day 600 (Stathakis et al. 1991). Some of them are also luminous in radio and X-rays, showing an outcome of energy of several times 10^{51} erg (Aretxaga et al. 1999).

These peculiar radiative properties have been interpreted as a result of the quick re-processing of the mechanical energy of SN explosions by a dense circumstellar medium (Chugai 1991, Terlevich et al. 1992, Plewa 1995). In this model, radiative cooling becomes important before the thermalization of the ejecta is complete. The shocked material undergoes a rapid condensation behind both, the leading and the reverse shocks. These high density thin shells, the freely expanding ejecta and the unperturbed interstellar gas are all ionized by the shocks and are responsible for the complex emission lines of these objects.

These kinds of SNe are also called Seyfert 1 impostors because of the striking similarity between their spectra and those of type 1 Seyfert nuclei (Filippenko 1989).

2. The data

The photometric data were acquired from 1999 January 15 until 2000 May 25 at two telescopes:

- 2.12m in Cananea (Sonora, Mexico). We used the LFOSC spectrophotometer which has imaging facilities. This has a $10' \times 6'$ field, with a sampling of 1 arcsec/pix (Zickgraf et al. 1997).
- 1m Tonantzintla (Puebla, Mexico). The field is $4.2' \times 4.2'$ and a sampling of 1arcsec/pix.

We performed differential photometry using for comparison two field stars for all frames. The instrumental magnitudes of these stars were obtained with the IRAF DAOPHOT package.

Tipically, the photometric errors in 2.12m telescope are between 0.01 and 0.03 mag, and in 1m telescope between 0.02 and 0.04 mag.

We used a purpose-built IRAF package (SNOOPY) based on DAOPHOT to get the instrumental magnitude of the SN. This calculates a mean PSF whith field stars and fits the galaxy background with a Legendre polynomial. SNOOPY fits and subtracts the PSF and removes the fitted background in the SN position, getting the instrumental magnitude of the SN and the residuals.

We performed simulations to estimate the error of the measurement of the SN magnitudes which are sensitive to the galaxy background removal. We created artificial stars and placed them in nearby regions to the original SN position, and estimated the magnitudes with SNOOPY. The total error is a combination of the photometric error, the PSF-fitting error and the error given by the simulations. Typically, this is between 0.03 and 0.05 mag.

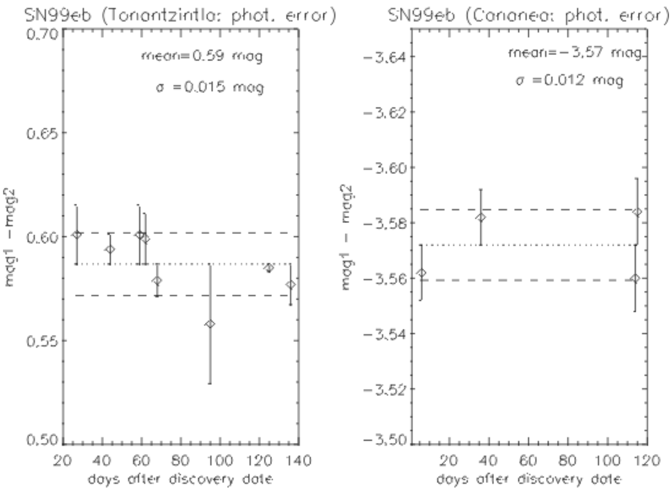

Fig. 1. Individual photometric errors and the standard deviation of the difference between magnitude of comparison stars in the field of SN 1999eb.

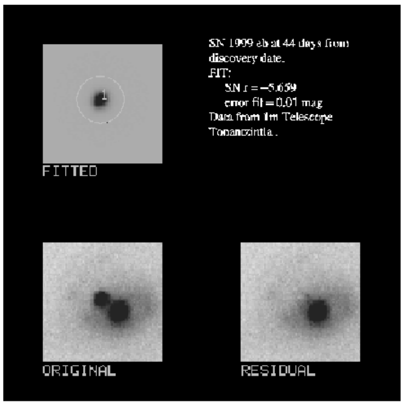

Fig. 2. Example of fitting method with SNOOPY for SN 1999eb

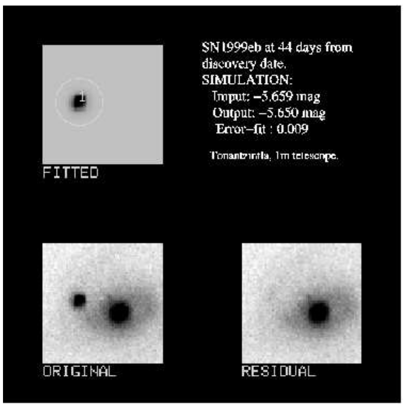

Fig. 3. Example of simulation. Note the different position of the mock SN.

3. The light curves: Some results ...

In figure 4 we present seven light curves in R-band, and in figures 5,and 6 some preliminary results on decline rates and detections of modulations in time scales smaller than a month.

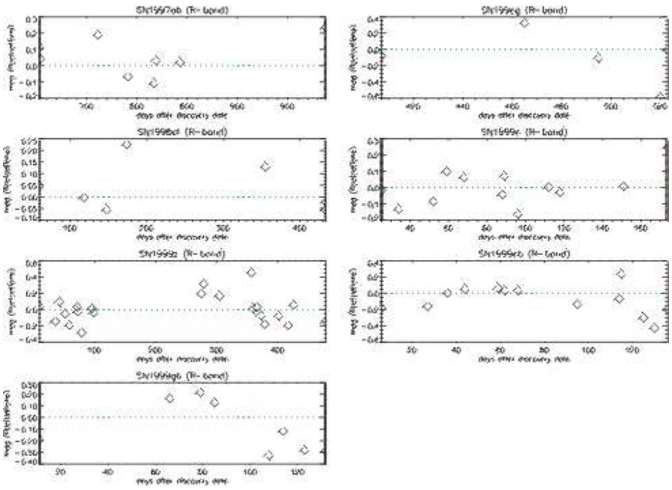

Fig. 6. Residuals from the lineal fitting of the light curves of the SNe.

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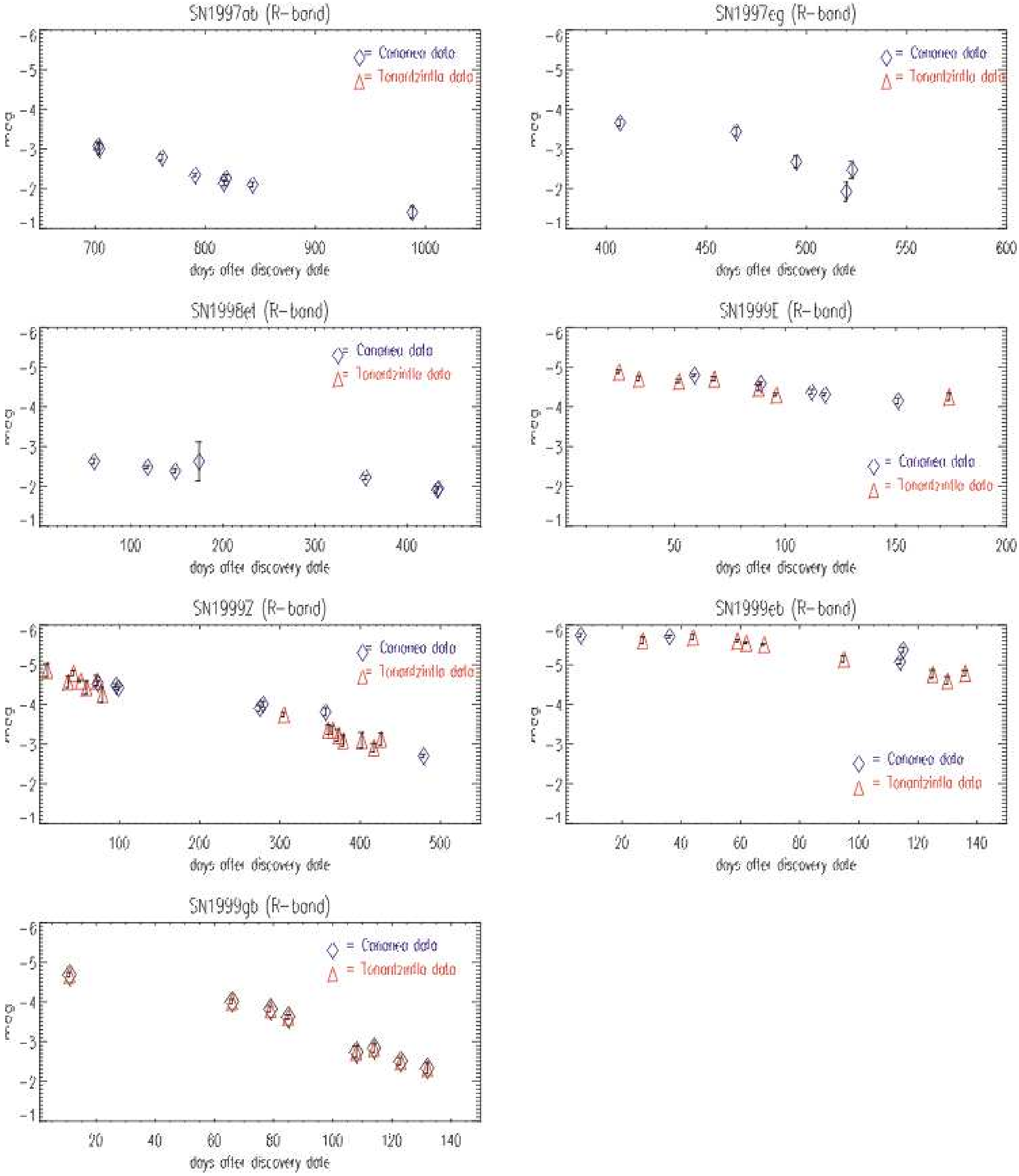

Fig. 4. The light curves. Note the different shapes of the light curves. This might mean that type IIn SNe is a very heterogenous group.

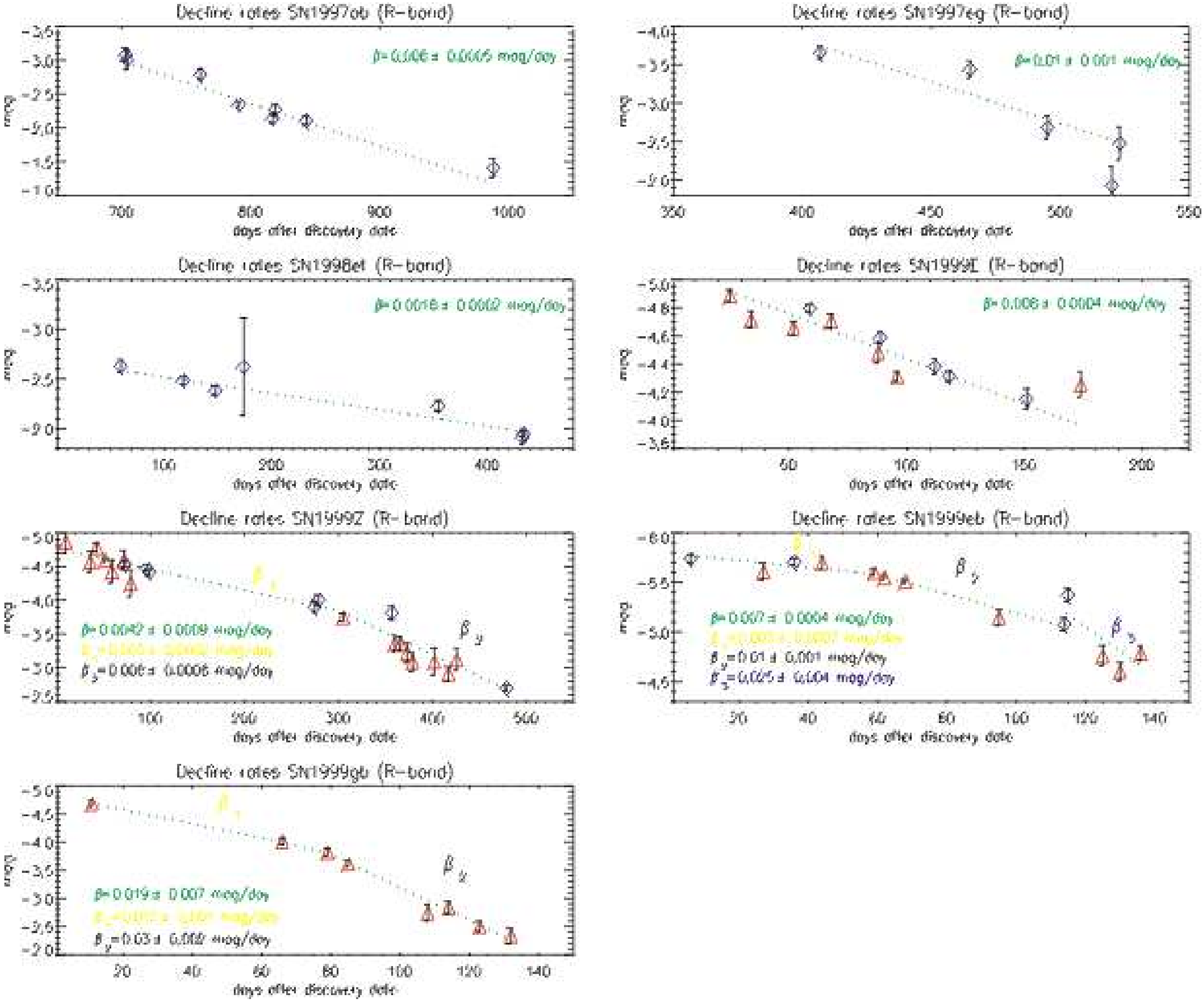

Fig. 5. Decline rates of SNe. Green color indicates the total lineal decline rate of the curves, and other colors indicate partial decline rate in different parts of the curves. Note that older SNe present a lineal decline rate and younger SNe have more complicated shapes.