

# Photometric Observations of Recent Supernovae

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**Summary.** Regular photometric observations of sufficiently bright northern supernovae are carried out at Sternberg Astronomical Institute's observatories. Since 1998 the observations of more than 60 supernovae were obtained on about 150 nights with different telescopes and detectors. We present the data of the observation program, the parameters of light curves for 18 SNe and the light curves for SNe 1999aa, 2001B, 2002bo.

## 1 Introduction

The light curves are among the major sources of information about the nature of supernovae. They are the main tool for the use of SNe as distance indicators, and can also be used for SN classification and for constraining theoretical models. The observational data have been substantially increased during last years. The modern observational programs contributed high-quality multi-color CCD photometry with good temporal sampling for many SNe. But the rate of SN discovery is so high, that for some sufficiently bright SNe only few photometric data points have been obtained. Often only the low-quality results of amateur groups are available. So, regular photometry of bright SNe remains an urgent observational task.

SN photometry has been carried out at Sternberg Astronomical Institute since the 1960s, and the most prominent results were obtained for SNe 1981B, 1984E, 1984L, and 1985F [7, 11, 12, 13]. Their light curves were derived from photographic and photoelectric observations. During the 1990s we had serious difficulties in accomplishing observations. Only since 1998 it was possible to revive the program, using CCD detectors.

## 2 Observations and Reductions

The observations were carried out with 125-, 60-, 50-, and 38-cm telescopes of Sternberg Institute Crimean observatory and also at 70- and 30-cm telescopes in Moscow. We used CCD cameras AP-7p, ST-8, ST-7 and ST-6 with different sets of filters, and occasionally obtained also photographic and photoelectric observations. The reductions were done in the usual manner. The

**Table 1.** Basic data for observation program

SN	T <sub>1</sub>	T <sub>n</sub>	N	SN	T <sub>1</sub>	T <sub>n</sub>	N	SN	T <sub>1</sub>	T <sub>n</sub>	N
1997cx	19	214	11	1999em	5	379	24	2001dn	2	82	17
1997dn	7	117	8	1999gi	4	354	21	2001dp	4	93	6
1997do	3	118	12	1999gn	103	29	5	2001ed	16	53	6
1997dq	5	116	10	1999gq	93	15	3	2001ef	11	52	4
1997ef	3	122	8	2000C	45	32	9	2001en	41	47	6
1997eg	79	8	5	2000E	13	79	13	2001fa	19	47	6
1997ei	62	6	4	2000cx	21	103	19	2001gd	94	41	6
1998D	21	11	7	2000db	19	100	5	2002an	52	51	8
1998S	29	366	15	2000dk	3	73	17	2002ap	3	307	23
1998aq	127	97	6	2000dx	13	67	12	2002bo	6	72	17
1998dh	31	95	5	2000ev	2	80	6	2002bu	3	57	10
1998ef	29	30	4	2000ew	1	156	7	2002cr	6	19	4
1998es	2	94	8	2001B	19	104	14	2002cs	2	19	4
1999D	4	96	10	2001C	18	98	8	2002es	11	76	5
1999X	20	49	13	2001G	16	71	5	2002hh	13	241	19
1999aa	2	72	17	2001V	9	84	14	2002ho	14	16	6
1999ac	16	43	6	2001X	17	76	11	2002hw	9	17	11
1999an	7	24	4	2001ai	6	33	3	2002ji	4	112	8
1999dk	7	82	4	2001ay	8	38	6	2003Z	29	57	4
1999dh	15	95	4	2001bf	3	133	10	2003as	9	72	8
1999ej	19	41	5	2001bg	2	13	3	2003cg	2	53	8
1999el	12	52	10								

magnitude differences between SNe and 1-2 comparison stars were derived by aperture photometry. When the galaxy background near SN was bright and non-uniform, we subtracted the image of the galaxy obtained after fading of SN from the image with SN. On photometric nights we calibrated the comparison stars and determined the transformation equations from instrumental system to the standard one by observing Landolt's [3] and Mermilliod's [6] standard stars, and also clusters M67 [1] and NGC7790 [9].

The brief review of the program is presented in Table 1, where for all SNe with more than 2 observations we report the following data: T<sub>1</sub> is the time in days from discovery until first observation; T<sub>n</sub> is the time from first observation until last observation; N is the number of nights on which observations were obtained.

### 3 Results of Observations

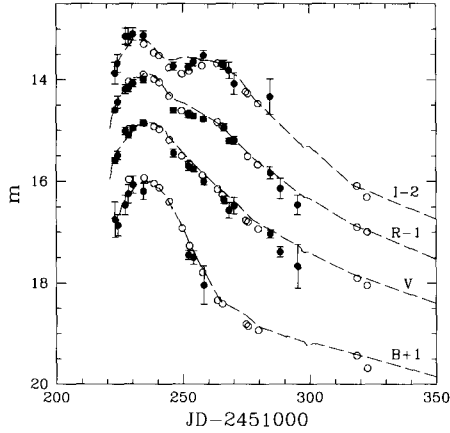
Observations of 23 SNe have been already reduced. For 5 SNe the data were insufficient to determine the shape of the light curves. The main light curve parameters for 18 SNe are reported in Table 2, where *m* is magnitude at

**Table 2.** Parameters of light curves for SNe

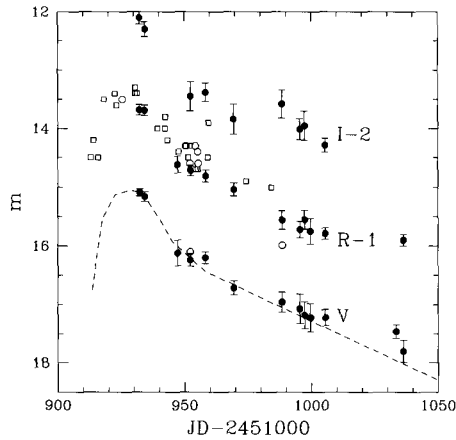
SN	SN Type	$m$	$\Delta m_{15}$	$\mu$	$A_B$	$E(B - V)$	$M$
1997cx	IIL	14.2 <i>R</i>		32.0	0.10		-17.9 <i>R</i>
1997do	Ia	14.2 <i>B</i>	1.3	33.3	0.27		-19.4 <i>B</i>
1997cf	IcPec	16.5		33.3	0.18		-17.1
1998D	Ia	15.5 <i>R</i>	1.3	33.7	0.06	0.15	-18.6 <i>R</i>
1998dh	Ia	13.9	1.0	32.6	0.29	0.1	-19.0
1998ef	Ia	15.0 <i>R</i>	1.1	34.4	0.32	0.15	-19.7 <i>R</i>
1998es	IaPec	13.8	0.9	33.1	0.14	0.16	-19.8
1999D	IIP	17.4		33.4	0.07		-16.1
1999X	Ia	16.3	1.0	35.0	0.14		-18.8
1999aa	IaPec	14.8	1.0	33.9	0.17		-19.2
1999gi	IIP	14.9		30.3	0.07	0.21	-16.1
1999el	IIL	14.9		31.9	1.58		-18.2
2000E	Ia	13.7	1.3	31.9	1.58	0.36	-19.3
2001B	Ib	15.0		32.0	0.54		-17.5
2001V	Ia	14.5	0.9	34.1	0.08		-19.5
2001X	IIP	15.3		32.0	0.17		-16.8
2002ap	IcPec	12.4		29.5	0.31	0.09	-17.4
2002bo	Ia	13.6	1.1	31.8	0.11	0.35	-19.2

plateau for SNe IIP and at maximum light for SNe of other types, in the  $V$  band unless followed by symbol denoting other band;  $\Delta m_{15}$  is only a rough estimate, based on comparison with template SN Ia light curves; distance modulus  $\mu$  is taken from [14] or estimated from radial velocity, corrected for Virgocentric infall, with  $H_0 = 75 \text{ km s}^{-1} \text{ Mpc}^{-1}$ ; galactic absorption  $A_B$  is from [8], and  $E(B - V)$  is estimated by comparing the color curves of SNe under study with those for which extinction is known to be negligible, for SNe 1999gi and 2002ap it is taken from [4, 5]; the absolute magnitude  $M$ , also in the  $V$  band unless another band is noted, is derived using the reported apparent magnitude, distance and extinction, for SNe with no data on  $E(B - V)$  we assumed negligible reddening in parent galaxies and accounted only for galactic extinction.

The main conclusion is that all studied SNe are quite similar to the typical objects of their classes, as regarding shape of the light curves and absolute magnitudes. Among two peculiar SNe Ia (similar to SN 1991T) SN 1998es was slightly overluminous, while absolute magnitude of SN 1999aa was quite close to the average value for SNe Ia. The light curves for SNe 1999aa, 2001B and 2002bo are presented in Figs. 1-3.



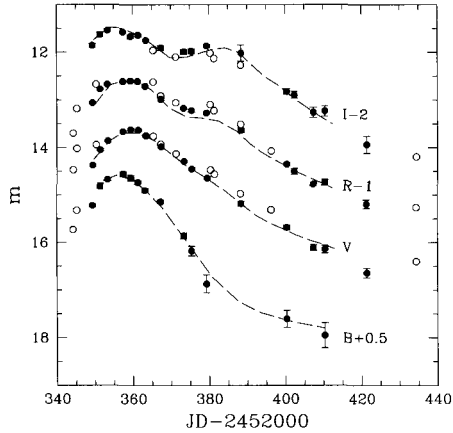
**Fig. 1.** Light curves of SN 1999aa in the *B, V, R, I* bands. Filled symbols show our results, open symbols are the data of [2]. The dashed lines are the light curves of SN IaPec 1991T.



**Fig. 2.** Light curves of SN 2001B in the *V, R, I* bands. Filled symbols show our data, open symbols are the data from IAU Circulars and VSNET. The dashed line is *V* light curve of SN Ib 1984N.

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**Fig. 3.** Light curves of SN 2002bo in the  $B$ ,  $V$ ,  $R$ ,  $I$  bands. Filled symbols represent our data, open symbols show the data of [10]. The dashed lines are the light curves of SN Ia 1998bu.

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