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BVRI PHOTOMETRY OF THE TYPE Ic HYPERNOVA SN 2002ap

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Supernova (SN) 2002ap in M74 was discovered by Y. Hirose and confirmed by Kushida and Li on January 29 and 30, 2002 (Nakano et al., 2002). The SN was immediately recognized as a "hypernova" from its broad spectral features (see Mazzali et al. 2002 for references). SN 2002ap was discovered very soon after it exploded, as the SN was not detected in a January 25 observation (Nakano et al., 2002). In this note we present the $BVRI$ photometric observations of SN Ic 2002ap at maximum and during the fast-decline phase after maximum brightness. Also, we briefly discuss our main results.

At the Center for Backyard Astrophysics-Concord (CBA) with 44 cm reflector and at Pulkovo Observatory (PO) with 10 cm refractor we monitored SN 2002ap in VRI and BVR passbands, respectively. Both telescopes were equipped with CCD-cameras. All CCD observations were reduced in the standard fashion, with dark current subtraction and flat-field correction using MIDAS package for PO data and AIP4WIN for CBA data. As the SN is isolated and contamination of the photometry by the background galaxy light is negligible we used aperture photometry on the SN nearby bright stars. The photometric data of nine bright stars in the field of M74 provided by Henden (2002) were used for absolute calibration. The final $BVRI$ magnitudes for SN are given in Table 1. We estimate the accuracy of our photometry at $0\overset{\mathrm{m}}{.}03$ for CBA data and at $0\overset{\mathrm{m}}{.}1$ for PO data. The errors in the absolute zero point determination are smaller than 3%.

To check the data, we have compared our photometry with the measurements of Gal–Yam et al. (2002), Riffeser et al. (2002), Yohii et al. (2002) and find excellent agreement. On the other hand, we have found some discrepancy with observations of Borisov et al. (2002). A comparison of $BVRI$ data given by Borisov et al. (2002) with Gal–Yam et al. (2002) and our measurements shows that the B magnitudes obtained with the Schmidt telescope tends to fall below the data of Gal–Yam et al. (2002). The V magnitude obtained with the 60-cm Cassegrain telescope is brighter by $0\overset{\mathrm{m}}{.}1$ mag. Also, the I magnitudes given by Borisov et al. (2002) are systematically brighter than Gal–Yam et al.'s (2002) and our results with the maximum discrepancy of $0\overset{\mathrm{m}}{.}35$ magnitude. In the following we do not take into account these discrepant data. The R magnitudes are in the good agreement with our results. Unfortunately, Borisov et al. (2002) used only one comparison star for differential photometry and, probably, they did not correct the $BVRI$ data for the color terms for different telescopes.

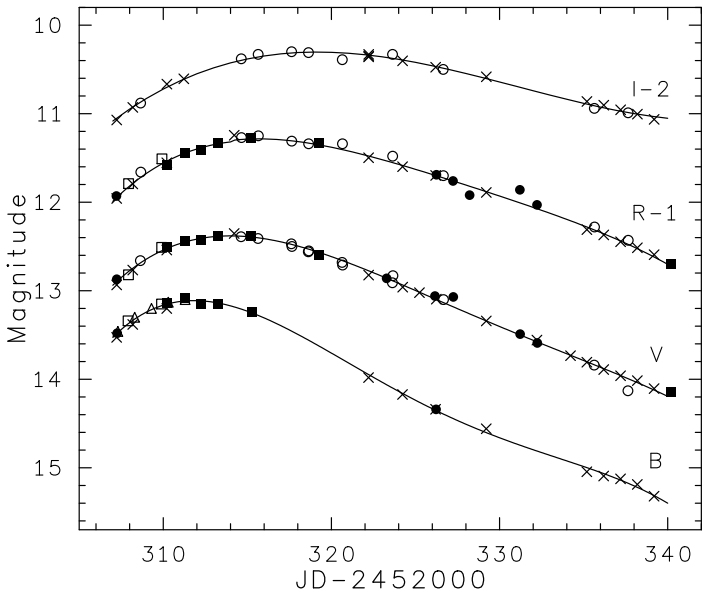

Figure 1. B, V, R and I light curves of SN 2002ap. The open and filled circles indicate the measurements obtained at CBA and PO, respectively. Note the excellent agreement with the data of Gal–Yam et al. (2002; crosses), Riffeser et al. (2002; open squares), Borisov et al. (2002; filled squares) and Yohii et al. (2002; triangles). The solid lines are the least square fits. For clarity, the R and I light curves have been shifted by the amounts noted on the plot.

Table 1: Observations of SN 2002ap

Julian Day	B	V	R	I	Telescope
2452307.26	13.48	12.87	12.93		PO
2452308.65		12.66	12.66	12.88	CBA
2452310.66		12.47	12.45	12.63	CBA
2452314.64		12.38	12.27	12.38	CBA
2452315.65		12.40	12.25	12.33	CBA
2452317.63		12.48	12.31	12.30	CBA
2452318.64		12.56	12.34	12.31	CBA
2452320.65		12.70	12.43	12.39	CBA
2452323.28		12.86			PO
2452323.64		12.87	12.48	12.36	CBA
2452326.22	14.34	13.06	12.69		PO
2452326.66		13.10	12.70	12.50	CBA
2452327.25		13.07	12.76		PO
2452328.22			12.82		PO
2452331.22		13.49	12.86		PO
2452332.24		13.59	13.03		PO
2452335.63		13.84	13.28	12.94	CBA
2452337.64		14.13	13.43	12.99	CBA

Table 2: SN 2002ap light curve properties

Filter	t_0 (J.D.)	m_{max} (mags)	$m(t_0^B)$ (mags)	$\triangle m_{15}$ (mags)	M_{abs} (mags)
B	2452311.8(.5)	13.11(.04)	13.11(.04)	1.31(.06)	–16.7
V	2452314.0(.5)	12.38(.04)	12.43(.04)	0.94(.06)	–17.4
R	2452315.7(.5)	12.28(.04)	12.41(.04)	0.71(.06)	–17.4
I	2452318.6(.5)	12.31(.04)	12.54(.04)	0.63(.06)	–17.3

Figure 1 shows the $BVRI$ photometry of SN 2002ap from Table 1 and published data as a function of the Julian date. Using all available photometric data, except some data of Borisov et al. (2002) (see above), we determined the time and the magnitude of maximum light for SN 2002ap in the B, V, R and I filters by fitting a fourth-order polynomial to the photometry obtained over 30 days of observation. The results are listed in Table 2, where column (1) gives the time of maximum light, column (2) the magnitude at the time of maximum light, column (3) the magnitude at the time of B maximum, column (4) the total magnitude which the light curve decline from maximum to 15 days past maximum, and column (5) the absolute magnitude at maximum brightness. The errors given in this table represent the range of acceptable fits to the data.

The absolute magnitudes of SN 2002ap were computed assuming the distance 8 Mpc (μ=29$^{\rm m}\!\!.$5) to M74 from Sharina et al. (1996). Additionally, we correct the absolute magnitudes for Galactic and host galaxy extinctions according to Schlegel et al. (1998) and Klose et al. (2002), respectively. The absolute magnitude at maximum brightness of this object (M_V = –17.4) is comparable to the "hypernova" of type-Ic SN 1997ef (Mazzali et al., 2000), but fainter than SN 1998bw (Galama et al., 1998) by about 2 mag. On the other hand, the shapes of the light curves are similar to those of SN 1998bw. As one can see from Fig. 1 and Table 2, SN 2002ap peaks earlier in the bluer passbands and the peaks of the light curves are wider in the redder passbands. The decline rates of SN 2002ap are also similar to SN 1998bw. Finally, except for the lower peak magnitude, the characteristics of the light curves are similar to those of SN 1998bw. Observations of SN 2002ap at very late stage are needed to reveal the nature of this unique object.

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