Photometric study of Nova Cas 1995

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Received: December 31, 1996

Abstract. We present the results of UBVR photometry of Nova Cassiopeiae 1995 obtained in the first 16 months following its outburst. We have classified the nova as slow with $t_{3,V}$ = 173 d, $t_{3,B}$ = 189 d. The corresponding absolute magnitudes of the nova at maximum are MV_{max} = -6.70±0.23, MB_{max} = -6.49±0.32. The latter value yields a mass of 0.66±0.05 $M_\odot$ for the white dwarf component. We have determined the colour excess E(B-V) = 0.57±0.01 and the distance to the nova d = 2.39±0.38 kpc.

Key words: novae - photometry

1. Introduction

Nova Cassiopeiae 1995 was discovered by Yamamoto (1995) on August 24, 1995 at the coordinates $\alpha_{2000} = 01^h05^m05^s.4$, $\delta_{2000} = +54^o00'41"$. It reached its brightness maximum V_{max} = 7.09 and B_{max} = 7.59 on December 17, 1995 (JD 2450069). An identification with a B = 19.0 (±0.2) precursor has been suggested by Munari et al. (1996), which sets the outburst amplitude at 11.4 mag.

In order to illustrate the general photometric appearance of Nova Cas 1995, the visual magnitude estimates from the VSNET archive and two-day averages are presented. The light curve (Fig. 1) shows large brightness variations which exceed 2^m. After a slow rise to maximum, a fast decline with t_2 = 19 days occurred, which could lead to the misleading classification of the nova as fast. This classification is in disagreement with its slow spectral evolution. Munari (1995) drew attention to the unusual photometric and spectroscopic features and linked the object to the class of symbiotic novae. On the other hand, Duerbeck (1995) classified Nova Cas 1995 as a slow nova of the HR Del type.

The optical spectra of Nova Cas 1995 taken by Iijima and Rosino (1995) on Aug. 26.96 UT (JD 2449956.46) showed a blue continuum and narrow emission lines of H I and Fe II. The lines had P-Cyg type absorptions with blueshifts in the range from -280 to -400 km/s. On Oct. 17.1 UT (JD 2450007.6) these blueshifts were -360(±30) km/s (Iijima and Rosino, 1996). FWHM of prominent emission lines were 270 (±20) km/s. The spectra taken by Munari et al. (1995) on Nov. 4.88 UT (JD 2450026.38) showed a very strong F type continuum with moderate to weak emission lines superimposed. Absorption and emission

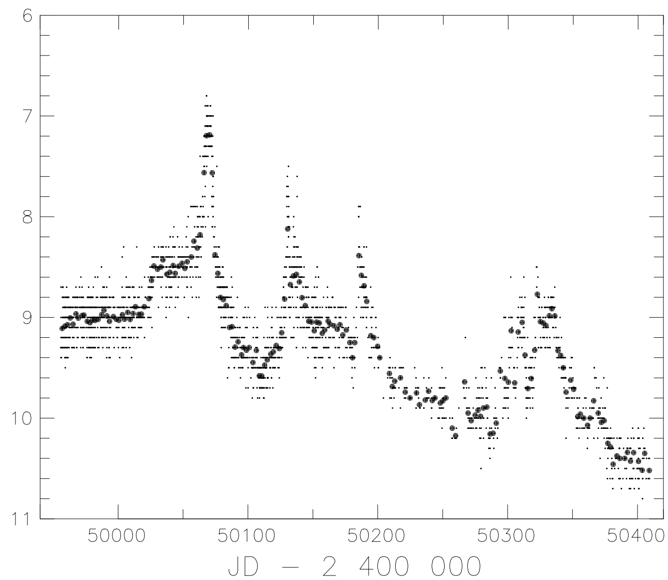

Figure 1. VSNET visual estimates. Black circles are two-day averages

lines were very narrow and sharp. The H_α - H_γ, Ca II infrared triplet and many Fe II lines appeared in moderate emission, while higher Balmer lines were present in absorption. The profiles consisted of sharp absorptions (FWHM 55 km/s) superimposed onto the blue wing of narrow emission (FWHM 95 km/s) components, shifted by about -85 km/s from the latter. According to Iijima and Rosino (1996) a pure absorption spectrum of an F-type supergiant appeared at maximum brightness (e.g. 1995, Dec. 19.8 UT i.e. JD 2450071.3). The spectra taken by Munari (1996) on Jan. 3.8 UT (JD 2450086.3) showed a marked increase in intensity and FWHM of the emission lines (FWHM 650 km/s). According to Iijima and Rosino (1996) the blueshift of the P-Cyg type absorptions and FWHM of the prominent emission lines increased to -1060 ($\pm$30) km/s and 640 ($\pm$30) km/s in the post-maximum stage (e.g. 1996, Mar. 1.8 i.e. JD 2450144.3). In the middle of March 1996 the nova was still in the pre-nebular phase. Munari et al. (1996) found a reddening E(B-V) $\sim 0.45^m$ from the equivalent widths of the interstellar D1 and D2 sodium lines.

High resolution IUE spectra (Gonzales-Riestra et al., 1996) obtained on Jan. 6, 1996 (JD 2450089) showed a weak P-Cyg emission feature at Mg II 280 nm with broad absorption extending to - 500 km/s. The line profile was not consistent with the presence of a wind and rather resembled the profiles seen in the optically thick stages of other novae. The N III] 175-nm and C III] 191-nm appeared in the spectrum characteristic of the pre-nebular phase. The reddening estimated from the strength of the 220 nm absorption feature was E(B-V) = 0.6^m.

2. Observations, light and colour variations

Our photoelectric UBVR observations were obtained at the Skalnaté Pleso (SP) and Stará Lesná (SL) Observatories of the Astronomical Institute of the Slovak Academy of Sciences. In both cases a single-channel pulse-counting photoelectric photometer installed in the Cassegrain focus of the 0.6m reflector was used. The integration time of one measurement depended on observational conditions and was taken to be between 6 and 10 seconds. The positions and magnitudes of the comparison stars are given in Table 1. Data reduction, atmospheric extinction correction and transformation to the UBVR standard system were carried out. Our photometric observations taken on 76 nights between Aug. 31, 1995 and Dec. 29, 1996 are in Table 3. The U,B,V,R magnitudes are normal points (mean averages of individual observations). The number of individual observations n included in the normal point differs and depends on the photometric quality of the night during the observing run. On excellent nights 6-10 observations were averaged into one normal point. Mean error of one normal point is 0.006^m in U band, 0.005^m in B band, 0.004^m in V band and 0.003^m in R band. The net time of our observations was 148 hours and 9 minutes.

Table 1. Comparison stars

Star	Name	α_{2000}	δ_{2000}	R	V	B	U
cmp1	SAO 21952 HD 232357	$1^h3^m13.6^s$	53° 54' 48"	8.92	9.08	9.21	8.96
cmp2	SAO 21994 HD 232374	$1^h5^m36.3^s$	54° 7' 52"	9.34	9.57	9.70	9.44

The U,B,V and R light curves of Nova Cas 1995 constructed from our data, as well as from the data published by Ohsima et al. (1996) and from VSNET are depicted in Fig. 2. The corresponding colour indices are shown in Fig. 3.

The most interesting feature of the nova light curve are three stages of stronger activity. Each stage consists of two sharp brightness maxima - flares. The second flare in each pair is brighter. Basic characteristics of pairs of flares are given in Table 2. Maxima of the two flares in the second and the third stage of activity were detected only by visual observers (Fig. 1). The activity stages lasted 86 days, 102 days and 123 days. The time interval between the maxima of activity was 117 and 137 days.

Due to the appearance of a pure absorption F-type supergiant spectrum at JD 2450071.3 (Iijima and Rosino, 1996), the brightness maximum at JD 50068.4 was identified as the principal maximum of the nova. Large brightness variations, which exceed 2^m prevented us to find reliable t_2 time. The $t_{3,V}$ and $t_{3,B}$ times were found by linear fitting of the V and B light curves between JD 2450210 and 2450260 as $t_{3,V} = 173\pm5$ days and $t_{3,B} = 189\pm5$ days, respectively. Thereafter another flare has occurred. The brightness of the nova 15 days after maximum was $V_{15} = 8.91^m$ and $B_{15} = 9.48^m$.

The behaviour of U-B and B-V colour indices in the premaximum stage shows a slow shift from A to F supergiant. The V-R index did not change in the premaximum stage. Sharp reddening pulse in both B-V and U-B was detected at the principal maximum. An increase of R colour till JD 2450207 was caused by the strenghtening of H_α emission line intensity as it is well visible in spectra taken by Munari et al. (1996). Rapid increase of V-R index from 0.53 (JD 2450070) to 1.61 (JD 2450105), from 1.48 (JD 2450198) to 2.72 (JD 2450207) and from 1.1 (JD 2450364) to 1.7 (JD 2450381), which has always occured after the bright flare, was caused by the increase of brightness in R colour and simultaneously by the decrease of brightness in V colour.

Table 2. Activity stages of Nova Cas 1995.

Activity stage	Filter	Beginning JD*	Max_1 JD*	Δm_1	Max_2 JD*	Δm_2	End JD*
		50014.4	50026.4		50068.4		50100.4
	U	9.29	8.81	0.47	7.60	1.66	9.24
1	B	9.38	8.91	0.56	7.59	2.20	10.04
	V	8.89	8.40	0.58	7.09	2.18	9.50
		50105.2	50135.3		50185**		50207.4
	U	9.45	8.19	1.25			9.4:
2	B	10.11	8.70	1.41			10.11
	V	9.60	8.25	1.43			9.86
		50260.5	50311**		50322.4		50383.4
	U	9.29			8.11	1.63	10.19
3	B	9.38			8.63	1.53	10.93
	V	8.89			8.27	1.51	10.65

* JD - 2 400 000, ** from visual observations

3. Basic parameters of Nova Cas 1995

Using the classification scheme of nova light curves (Duerbeck, 1981), we can classify Nova Cas 1995 as D type with slow evolution, extended premaximum, delayed maximum with several brightness peaks. The nova belongs to the same group as HR Del and RR Pic.

The rates of decline in the V and B light curves were used to estimate the absolute V and B magnitudes at maximum using the following relations:

a) absolutely calibrated MV_{max} - t_2 relation (Della Valle and Livio, 1995)

$$MV_{max} = -7.92 - 0.81 \arctan \frac{1.32 - \log t_2}{0.23}. \quad (1)$$

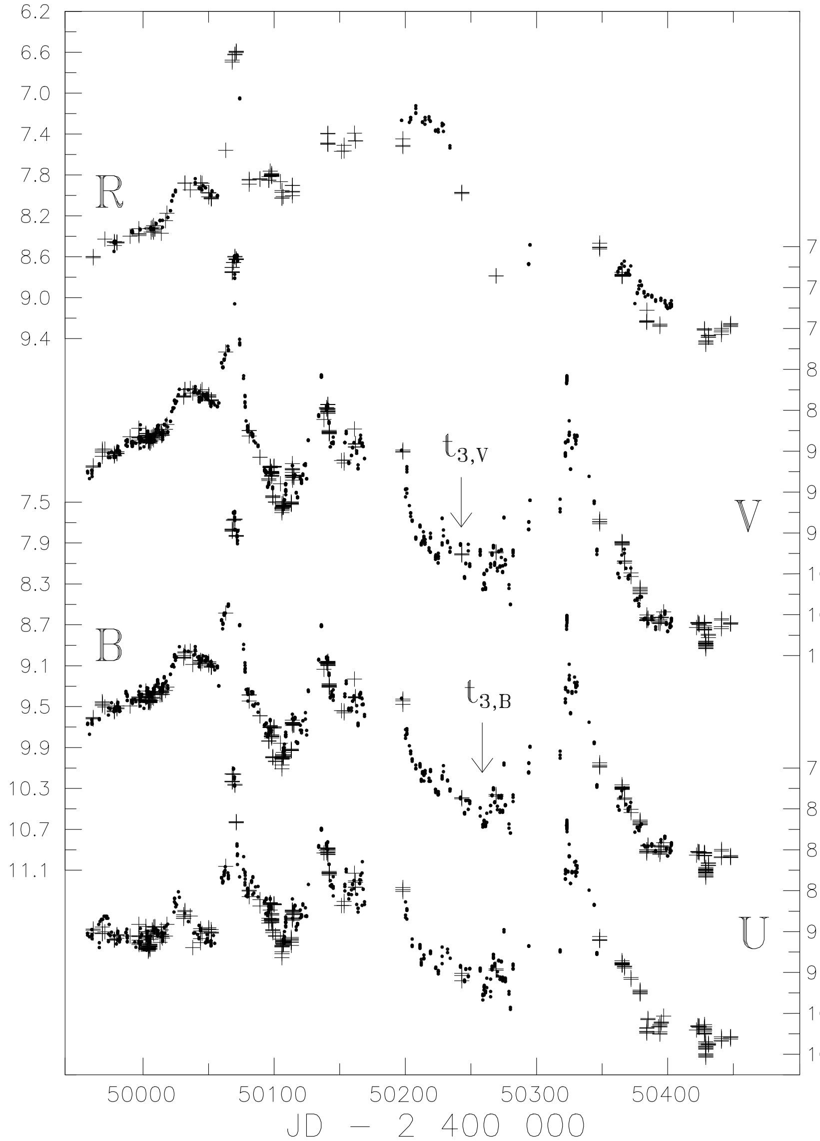

Figure 2. Photoelectric UBVR magnitudes of Nova Cas 1995. Our observations are designated by crosses

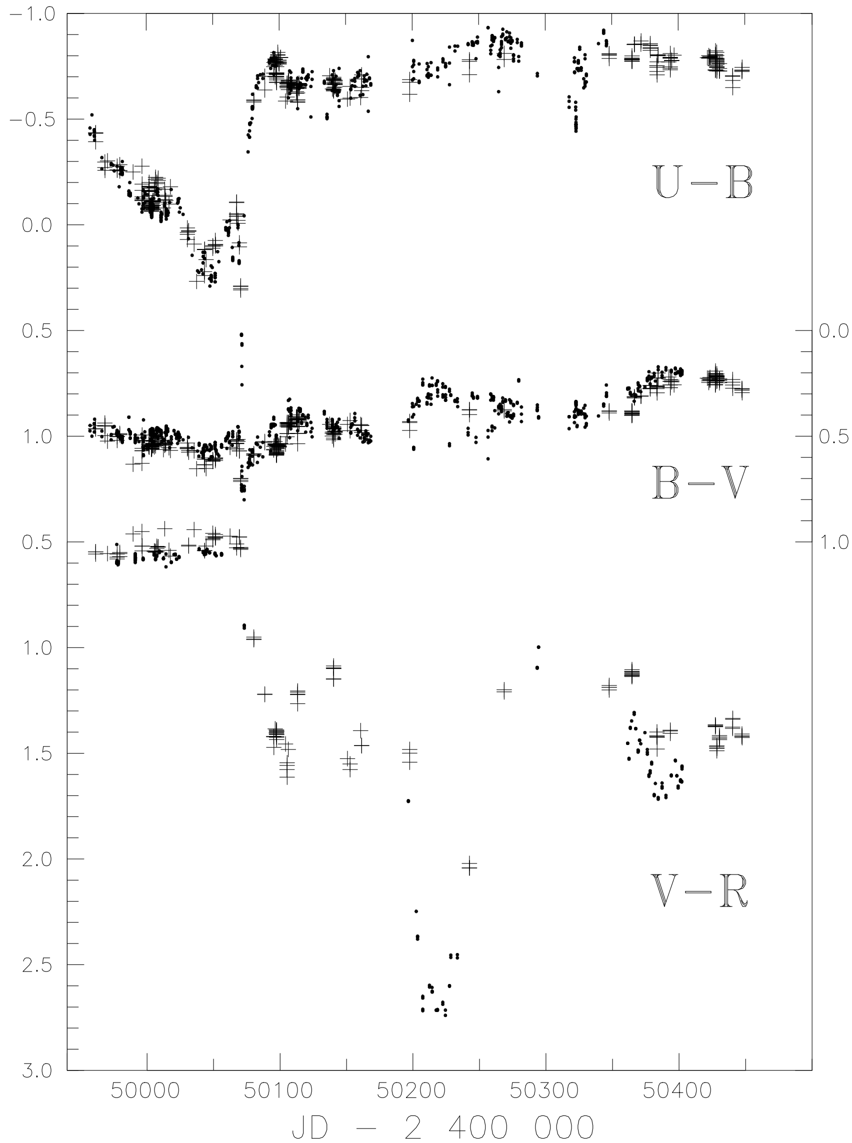

Figure 3. Photoelectric U-B,B-V and V-R colours of Nova Cas 1995

If we wish to employ t_3 time (instead of t_2 time) in relation (1), we have to transform t_3 to t_2 time. Capacciolli et al. (1990) published the following transformation formula. If t_3>80 days, then

$$t_3 = (1.68\pm0.04)\, t_2 + 2.3(\pm1.6)\, days. \quad (2)$$

By applying this formula and $t_{3,V}$ = 173 days we easily find that $t_{2,Vtransf.}$ = 101.6±3.4 days.

b) MV_{max} - t_3 relation (Schmidt 1957)

$$MV_{max} = -11.75 + 2.5 \log t_3. \quad (3)$$

c) MV_{15}, MB_{15} relation of van den Bergh & Younger (1987). They found empirically that the absolute magnitudes of novae are the same 15 days after the maximum:

$$MV_{15} = MB_{15} = -5.23\pm0.16. \quad (4)$$

d) MB_{max} - t_3 relations (Pfau 1976; Livio 1992)

$$MB_{max} = -10.67(\pm0.30) + 1.80 \log t_3 (\pm0.20) \quad (5)$$

$$t_{3,B} = 51.3 \times 10^{\frac{MB_{max}+9.76}{10}} \times (10^{\frac{2(MB_{max}+9.76)}{30}} - 10^{\frac{-2(MB_{max}+9.76)}{30}})^{\frac{3}{2}} days. \quad (6)$$

We have calculated the following values of MV_{max} and MB_{max} using these relations: MV^1_{max} = -6.91, MV^3_{max} = -6.15, MV^4_{max} = -7.05, MB^4_{max} = -7.12, MB^5_{max} = -6.57, MB^6_{max} = -5.79 (this value was determined numerically solving the equation (6)) with the unweighted means: MV_{max} = -6.70 ±0.23 MB_{max} = -6.49±0.32.

The calculated intrinsic colour index at maximum $(B\text{-}V)^{in}_{max}$ = 0.21 is close to that derived by van den Bergh & Younger (1987) for the intrinsic colours of novae at maximum $(B\text{-}V)^{in}_{max}$ = 0.23 ±0.06.

Interstellar extinction can be found:

1) from the comparison of the observed $(B\text{-}V)_{max}$ index during the reddening pulse at maximum affected by extinction with the intrinsic colour index. For the values $(B\text{-}V)_{max}$ = 0.80 and $(B\text{-}V)^{in}_{max}$ = 0.21 the colour excess E(B-V) = 0.59.

2) from the relation of van den Bergh & Younger (1987) who found that novae two magnitudes below maximum have an unreddened colour index of

$$B - V = -0.02\pm0.04. \quad (7)$$

The observed colour of Nova Cas 1995 two magnitudes below maximum is B-V = 0.52, i.e. E(B-V) = 0.54.

3) from the relation of Miroshnichenko (1988) who developed the photometric method of determining the interstellar extinction towards the novae. He

found that during the "stability stage", which occurs not very long after the maximum, when both U-B and B-V indices do not change systematically, the colour excess is given by

$$E(B-V) = (B-V)_{SS} + 0.11(\pm 0.02), \tag{8}$$

where $(B\text{-}V)_{SS}$ is the mean colour index during the stability stage. In Nova Cas 1995 the stability stage lasted from Jan. 25 to Feb. 29, 1996. For $(B\text{-}V)_{SS}$ = 0.24 corresponding E(B-V) = 0.55.

The mean value of the reddening found from the values 0.60 (Gonzales-Riestra et al. 1996) and data mentioned above is E(B-V) = 0.570±0.013. The corresponding absorptions are: A_V = 3.1 E(B-V) = 1.767±0.040 and A_B = 4.1 E(B-V) = 2.337±0.053.

The distance of the nova determined from the V data is 2.54±0.34 kpc, from the B data 2.23±0.42 kpc, so that the mean value of the distance is 2.39±0.38 kpc.

Using the formula given by Livio (1992)

$$MB_{max} = -8.3 - 10.0 \log(M_{wd}/M_{\odot}) \tag{9}$$

we can estimate the mass of the white dwarf in Nova Cas 1995 as M_{wd} = 0.66±0.05 $M_{\odot}$.

The expansion velocity of the main envelope of Nova Cas 1995 calculated from the empirical relation found by McLaughlin (1960)

$$\log v = 3.7 - 0.5 \log t_3 \tag{10}$$

is v = 380 km/s. This value is in agreement with the expansion velocities observed spectroscopically.

4. Discussion and conclusion

It is no doubts that N Cas 95 is a slow nova. The presence of flares with short recurrence time resemble the flares seen in symbiotic stars so the link to symbiotic novae proposed by Munari (1995) cannot be completely ruled out. However, the outburst amplitude (11.4 mag) exceeds the amplitude detected in other symbiotic novae. The basic result of the present work is the accurate determination of the interstellar extinction to Nova Cas 1995 as E(B-V) = 0.570±0.013 using different methods. On the other hand, the estimate of the absolute magnitude at maximum using the MMRD (maximum magnitude rate of decline) and M_{15} relations has to be viewed with caution. Due to the large brightness variations, which exceed 2^m, and lack of a good MMRD relation for the slow novae, our distance determination of Nova Cas 1995 (d = 2.38±0.40 kpc) can only be taken as the first approximation. The true distance determination has to be based on the nebular expansion parallax. Direct images of the expanding envelope of the nova in the optical and radio region are highly desirable.

Acknowledgements. This work has been supported by VEGA Grant 1282/1996.

Table 3. UBVR observations of Nova Cas 1995

JD^*_{hel} -2 400 000	U	B	V	R	n	cmp	run** h:m	Obs.
49961.382	9.175	9.611	9.145	8.598	13	2	2:24	SP
49961.412	9.187	9.620	9.156	8.599	13	2		SP
49961.443	9.213	9.606	9.157	8.610	11	2		SP
49968.343	9.154	9.451	8.999		8	1	1:35	SL
49968.362	9.218	9.489	9.051		7	1		SL
49968.418		9.463	9.014		8	1		SL
49968.430	9.220	9.478	8.981		7	1		SL
49970.398	9.201	9.504	8.981	8.426	16	2	0:44	SP
49977.553	9.274	9.551	9.048	8.491	7	2	0:33	SP
49977.563	9.283	9.542	9.023	8.451	6	2		SP
49977.573	9.280	9.540	9.039	8.458	7	2		SP
49979.548	9.265	9.520	9.027	8.458	10	2	1:10	SP
49979.560	9.229	9.513	9.021	8.466	10	2		SP
49979.573	9.236	9.493	9.006	8.456	10	2		SP
49989.508	9.243	9.493	8.861	8.399	17	2	1:19	SP
49996.272	9.128	9.405	8.777	8.326	14	2	2:19	SP
49996.302	9.240	9.433	8.913	8.393	14	2		SP
49996.326	9.283	9.415	8.921	8.378	14	2		SP
49996.342	9.249	9.412	8.893	8.374	11	2		SP
49996.307	9.326	9.440	8.872		10	1	2:42	SL
49996.313	9.313	9.436	8.867		10	1		SL
49996.310	9.310	9.427	8.870		8	1		SL
50001.509	9.271	9.410	8.870		14	1	3:47	SL
50001.522	9.257	9.414	8.865		14	1		SL
50001.535	9.240	9.400	8.852		14	1		SL
50001.548	9.241	9.399	8.856		14	1		SL
50001.562	9.241	9.402	8.853		14	1		SL
50001.593	9.218	9.398	8.846		14	1		SL
50001.615	9.203	9.386	8.845		14	1		SL
50001.628	9.203	9.380	8.847		14	1		SL
50001.641	9.199	9.372	8.833		14	1		SL
50001.653	9.148	9.348	8.826		14	1	7:21	SL
50003.338	9.383	9.452	8.892		14	1		SL
50003.355	9.378	9.443	8.895		14	1		SL

Table 3. UBVR observations of Nova Cas 1995 (continued)

JD^{*}_{hel} -2 400 000	U	B	V	R	n	cmp	run** h:m	Obs.
50003.375	9.355	9.446	8.884		14	1		SL
50003.391	9.392	9.455	8.898		14	1		SL
50003.408	9.373	9.449	8.890		14	1		SL
50003.422	9.364	9.447	8.888		14	1		SL
50003.436	9.371	9.450	8.892		14	1		SL
50003.450	9.366	9.452	8.893		14	1		SL
50003.463	9.365	9.452	8.900		14	1		SL
50003.476	9.362	9.448	8.896		14	1		SL
50003.491	9.373	9.457	8.911		14	1		SL
50003.510	9.377	9.459	8.906		14	1		SL
50003.524	9.368	9.450	8.893		14	1		SL
50003.539	9.359	9.449	8.896		14	1		SL
50003.554	9.354	9.450	8.898		14	1		SL
50003.572	9.345	9.446	8.901		14	1		SL
50003.590	9.342	9.444	8.887		14	1		SL
50003.603	9.346	9.437	8.886		14	1		SL
50003.617	9.356	9.434	8.874		14	1		SL
50003.628	9.341	9.431	8.889		9	1		SL
50004.290	9.340	9.442	8.898		14	1	0:26	SL
50004.493	9.322	9.437	8.899		14	1	4:16	SL
50004.505	9.330	9.440	8.900		14	1		SL
50004.520	9.342	9.435	8.898		14	1		SL
50004.533	9.336	9.443	8.906		14	1		SL
50004.546	9.340	9.448	8.909		14	1		SL
50004.559	9.340	9.453	8.908		14	1		SL
50004.574	9.374	9.448	8.905		14	1		SL
50004.590	9.327	9.441	8.898		14	1		SL
50004.605	9.365	9.456	8.920		14	1		SL
50004.618	9.347	9.455	8.918		14	1		SL
50004.633	9.350	9.462	8.921		14	1		SL
50004.652	9.361	9.432	8.908		14	1		SL
50005.497	9.244	9.419	8.868	8.322	14	2	0:50	SP
50005.509	9.277	9.441	8.901	8.358	6	2		SP
50006.448	9.184	9.409	8.876	8.332	16	2	1:11	SP
50006.468	9.192	9.407	8.861	8.312	16	2		SP
50007.383	9.222	9.417	8.890	8.360	8	2	0:58	SP
50007.393	9.204	9.378	8.869	8.348	8	2		SP
50007.404	9.154	9.355	8.843	8.296	8	2		SP
50008.435	9.157	9.368	8.851	8.327	10	2	0:49	SP
50008.447	9.150	9.371	8.853	8.330	10	2		SP
50012.340	9.304	9.384	8.821		25	1	0:48	SL
50013.356	9.183	9.351	8.808	8.370	21	1	1:12	SP
50013.504	9.227	9.367	8.828		12	1	2:17	SL

Table 3. UBVR observations of Nova Cas 1995 (continued)

JD^{*}_{hel} -2 400 000	U	B	V	R	n	cmp	run** h:m	Obs.
50013.525	9.227	9.362	8.822		12	1		SL
50013.545	9.247	9.381	8.849		12	1		SL
50013.564	9.247	9.354	8.835		12	1		SL
50013.580	9.245	9.364	8.832		10	1		SL
50014.300	9.264	9.380	8.844		14	1	1:07	SL
50016.464	9.244	9.342	8.788	8.248	24	2	0:57	SP
50017.575	9.128	9.308	8.741	8.174	12	2	0:35	SP
50030.360	9.035	9.020	8.461		20	1	0:53	SL
50030.411	9.069	9.000	8.468		12	1	1:01	SL
50030.425	9.052	9.016	8.460		12	1		SL
50030.438	9.070	9.025	8.472		12	1		SL
50031.415	9.005	8.974	8.398	7.879	8	1	0:46	SP
50031.430	8.993	8.965	8.398	7.882	8	1		SP
50035.418	9.048	8.957	8.388	7.946	20	1	1:09	SP
50037.340	9.355	9.087	8.433		9	1	0:36	SL
50043.359	9.172	9.054	8.418	7.876	8	1	0:41	SP
50043.372	9.194	9.078	8.444	7.903	8	1		SP
50043.294	9.270	9.048	8.445		11	1	0:59	SL
50043.313	9.308	9.068	8.459		11	1		SL
50044.354	9.217	9.053	8.400	7.881	11	1	0:30	SP
50049.430	9.162	9.061	8.450	7.973	12	1	1:49	SP
50049.445	9.175	9.074	8.458	7.973	12	1		SP
50049.460	9.203	9.092	8.473	8.014	12	1		SP
50049.477	9.180	9.080	8.468	7.978	12	1		SP
50051.377	9.181	9.107	8.501	8.026	8	1	1:00	SP
50051.387	9.214	9.114	8.499	8.034	8	1		SP
50051.397	9.204	9.112	8.504	8.022	8	1		SP
50051.407	9.207	9.112	8.510	8.031	8	1		SP
50062.421	8.561	8.584	8.031	7.558	29	1	1:01	SP
50067.337	7.657	7.765	7.205	6.677	8	1	0:48	SP
50067.353	7.659	7.764	7.205	6.695	8	1		SP
50067.305	7.736	7.784	7.251		12	1	1:19	SL
50067.318	7.732	7.772	7.251		12	1		SL
50067.332	7.731	7.772	7.255		12	1		SL
50067.347	7.729	7.782	7.246		12	1		SL
50068.397	7.658	7.679	7.155		8	1	0:46	SL
50068.412	7.664	7.671	7.155		8	1		SL
50069.420	7.758	7.672	7.103	6.626	8	1	0:44	SP
50069.434	7.768	7.664	7.095	6.618	8	1		SP
50070.435	8.124	7.835	7.121	6.590	9	1	1:44	SP
50070.451	8.129	7.827	7.128	6.602	9	1		SP
50070.469	8.126	7.834	7.126	6.590	9	1		SP
50070.489	8.136	7.828	7.128	6.598	9	1		SP

Table 3. UBVR observations of Nova Cas 1995 (continued)

JD^{*}_{hel} -2 400 000	U	B	V	R	n	cmp	run** h:m	Obs.
50080.308	8.803	9.384	8.801	7.842	9	1	0:58	SP
50080.321	8.857	9.444	8.853	7.891	9	1		SP
50080.334	8.795	9.386	8.799	7.849	9	1		SP
50088.472	8.949	9.587	9.062	7.842	8	1	0:34	SP
50088.483	8.888	9.590	9.060	7.838	8	1		SP
50095.262	9.116	9.834	9.272	7.850	8	1	1:03	SP
50095.281	9.090	9.838	9.273	7.853	9	1		SP
50095.293	9.069	9.837	9.289	7.817	8	1		SP
50096.322	8.988	9.688	9.148	7.764	21	1	0:44	SP
50096.293	8.917	9.685	9.160		11	1	2:18	SL
50096.306	8.933	9.688	9.152		11	1		SL
50096.319	8.918	9.700	9.157		11	1		SL
50096.332	8.921	9.704	9.165		11	1		SL
50096.346	8.936	9.706	9.158		11	1		SL
50096.359	8.929	9.701	9.153		11	1		SL
50096.371	8.916	9.701	9.158		10	1		SL
50097.364	9.080	9.791	9.202	7.812	8	1	3:05	SP
50097.374	9.077	9.793	9.206	7.804	8	1		SP
50097.385	9.071	9.789	9.199	7.809	8	1		SP
50097.396	9.089	9.792	9.207	7.805	8	1		SP
50097.407	9.086	9.786	9.210	7.802	8	1		SP
50097.417	9.076	9.790	9.210	7.799	8	1		SP
50097.427	9.078	9.790	9.211	7.814	8	1		SP
50097.440	9.107	9.793	9.209	7.814	8	1		SP
50097.452	9.113	9.788	9.221	7.810	8	1		SP
50097.461	9.087	9.806	9.223	7.803	8	1		SP
50097.471	9.102	9.775	9.220	7.785	8	1		SP
50097.481	9.095	9.789	9.216	7.792	7	1		SP
50097.454	9.039	9.787	9.249		8	1	1:09	SL
50097.487	9.024	9.793	9.238		7	1		SL
50097.494	9.027	9.790	9.244		7	1		SL
50098.344	9.180	9.996	9.437		8	1	0:43	SL
50098.352	9.193	9.996	9.446		8	1		SL
50098.359	9.184	9.988	9.447		8	1		SL
50098.366	9.210	10.001	9.456		8	1		SL
50099.291	8.931	9.710	9.159		10	1	1:50	SL
50099.302	8.938	9.701	9.158		10	1		SL
50099.315	8.925	9.699	9.150		10	1		SL
50099.328	8.934	9.701	9.149		10	1		SL
50099.340	8.932	9.700	9.152		10	1		SL
50099.351	8.938	9.699	9.151		10	1		SL
50100.362	9.239	10.031	9.497		10	1	1:42	SL
50100.382	9.246	10.037	9.502		10	1		SL

Table 3. UBVR observations of Nova Cas 1995 (continued)

JD^{*}_{hel} -2 400 000	U	B	V	R	n	cmp	run** h:m	Obs.
50104.238	9.272	9.858	9.321	7.865		1	0:25	SP
50105.237	9.454	10.107	9.604	8.027	21	1	3:00	SP
50105.266	9.417	10.071	9.583	8.026	21	1		SP
50105.304	9.346	10.001	9.566	7.953	21	1		SP
50105.333	9.398	10.002	9.515	7.970	20	1		SP
50105.332	9.342	10.010	9.569		9	1	1:37	SL
50105.345	9.349	10.017	9.563		9	1		SL
50105.358	9.334	10.003	9.556		9	1		SL
50105.373	9.332	9.993	9.546		9	1		SL
50105.386	9.342	9.990	9.553		7	1		SL
50106.241	9.309	9.948	9.494	8.012	31	1	1:01	SP
50106.219	9.315	9.986	9.551		16	1	4:00	SL
50106.235	9.312	9.985	9.543		16	1		SL
50106.252	9.298	9.973	9.533		16	1		SL
50106.268	9.290	9.972	9.536		16	1		SL
50106.285	9.297	9.970	9.528		16	1		SL
50106.301	9.284	9.970	9.531		16	1		SL
50106.318	9.294	9.974	9.538		16	1		SL
50106.335	9.327	9.988	9.539		16	1		SL
50106.352	9.330	10.004	9.547		16	1		SL
50106.368	9.316	9.988	9.546		16	1		SL
50112.337	9.256	9.920	9.497		10	1	2:46	SL
50112.355	9.271	9.915	9.504		10	1		SL
50112.370	9.274	9.926	9.508		10	1		SL
50112.382	9.301	9.931	9.512		8	1		SL
50112.405	9.286	9.931	9.515		10	1		SL
50112.416	9.304	9.926	9.515		10	1		SL
50112.424		9.931	9.523		7	1		SL
50112.435	9.335				6	1		SL
50113.217	9.078	9.658	9.122	7.902	14	1	2:02	SP
50113.235	9.066	9.656	9.170	7.904	14	1		SP
50113.255	9.089	9.671	9.184	7.961	14	1		SP
50113.271	9.008	9.632	9.179	7.968	14	1		SP
50113.285	9.072	9.663	9.208	8.003	14	1		SP
50113.250	8.997	9.655	9.241		10	1	2:32	SL
50113.266	8.994	9.656	9.236		10	1		SL
50113.282	8.989	9.657	9.247		10	1		SL
50113.299	8.992	9.658	9.240		10	1		SL
50113.315	9.007	9.668	9.259		10	1		SL
50113.335	9.035	9.684	9.285		10	1		SL
50114.261	9.020	9.665	9.244		11	1	2:27	SL
50114.281	9.007	9.676	9.255		11	1		SL
50114.299	9.020	9.672	9.242		11	1		SL

Table 3. UBVR observations of Nova Cas 1995 (continued)

JD^*_{hel} -2 400 000	U	B	V	R	n	cmp	run** h:m	Obs.
50114.320	9.032	9.680	9.244		11	1		SL
50114.343	9.022	9.680	9.256		10	1		SL
50137.330	8.430	9.135	8.691		28	1	1:04	SL
50139.280	8.402	9.073	8.574		9	1	1:12	SL
50139.297	8.402	9.066	8.580		9	1		SL
50139.312	8.429	9.072	8.591		8	1		SL
50140.240	8.419	9.056	8.547	7.399	9	1	2:18	SP
50140.254	8.419	9.060	8.543	7.394	9	1		SP
50140.270	8.432	9.070	8.582	7.486	9	1		SP
50140.284	8.426	9.066	8.585	7.498	9	1		SP
50140.300	8.447	9.080	8.594	7.496	9	1		SP
50140.314	8.444	9.092	8.599	7.500	7	1		SP
50140.251	8.388	9.071	8.617		10	1	2:18	SL
50140.265	8.387	9.077	8.614		10	1		SL
50140.279	8.380	9.073	8.610		10	1		SL
50140.294	8.393	9.080	8.615		10	1		SL
50140.305	8.391	9.083	8.618		10	1		SL
50140.318	8.403	9.091	8.632		10	1		SL
50140.332	8.401	9.099	8.632		8	1		SL
50141.239	8.611	9.277	8.798		12	1	3:05	SL
50141.254	8.631	9.283	8.808		12	1		SL
50141.270	8.624	9.293	8.812		12	1		SL
50141.284	8.619	9.295	8.813		12	1		SL
50141.296	8.634	9.303	8.822		12	1		SL
50141.311	8.622	9.307	8.826		12	1		SL
50141.325	8.634	9.297	8.818		12	1		SL
50141.339	8.648	9.310	8.820		12	1		SL
50141.352	8.626	9.308	8.833		10	1		SL
50150.653	8.944	9.538	9.094	7.569	8	1	0:18	SP
50152.633	8.906	9.561	9.087	7.510	10	1	0:44	SP
50152.647	8.944	9.543	9.117	7.566	10	1		SP
50160.639	8.628	9.230	8.785	7.392	8	1	0:16	SP
50161.263	8.764	9.415	8.933	7.469	12	1	0:45	SP
50161.277	8.767	9.401	8.928	7.465	12	1		SP
50161.262	8.703	9.412	8.963		12	1	1:05	SL
50161.282	8.718	9.408	8.960		11	1		SL
50197.513	8.808	9.426	8.990	7.448	8	1	0:47	SP
50197.523	8.790	9.477	9.004	7.522	8	1		SP
50197.533	8.768	9.442	9.011	7.512	8	1		SP
50242.408	9.629	10.402	10.004	7.983	8	1	0:44	SP
50242.418	9.680	10.390	10.016	7.974	8	1		SP
50242.428	9.608	10.389	10.013	7.970	8	1		SP
50268.456	9.577	10.359	9.985	8.786	12	1	0:52	SP

Table 3. UBVR observations of Nova Cas 1995 (continued)

JD^*_{hel} -2 400 000	U	B	V	R	n	cmp	run** h:m	Obs.
50268.471	9.564	10.375	9.995	8.786	11	1		SP
50347.467	9.278	10.084	9.694	8.506	8	1	1:31	SP
50347.476	9.284	10.093	9.712	8.524	8	1		SP
50347.484	9.285	10.072	9.690	8.511	8	1		SP
50347.493	9.247	10.049	9.668	8.468	8	1		SP
50364.523	9.485	10.265	9.885	8.751	8	1	3:02	SP
50364.532	9.506	10.295	9.893	8.781	8	1		SP
50364.546	9.508	10.291	9.909	8.778	8	1		SP
50364.567	9.510	10.293	9.907	8.778	8	1		SP
50364.576	9.514	10.287	9.897	8.770	8	1		SP
50364.585	9.510	10.309	9.908	8.778	8	1		SP
50364.595	9.527	10.301	9.919	8.782	8	1		SP
50364.604	9.523	10.309	9.909	8.788	8	1		SP
50364.614	9.519	10.293	9.897	8.793	8	1		SP
50364.623	9.521	10.303	9.910	8.789	8	1		SP
50364.631	9.516	10.301	9.909	8.787	8	1		SP
50364.640	9.501	10.283	9.890	8.775	7	1		SP
50366.406	9.556	10.409	10.096		8	1	2:29	SL
50366.434	9.543	10.395	10.080		8	1		SL
50366.464	9.538	10.393	10.074		8	1		SL
50371.334	9.648	10.503	10.192		16	1	2:54	SL
50371.385	9.666	10.536	10.227		15	1		SL
50378.324	9.791	10.648	10.388		9	1	2:44	SL
50378.343	9.809	10.656	10.396		9	1		SL
50378.363	9.793	10.644	10.368		9	1		SL
50378.380	9.805	10.631	10.358		9	1		SL
50378.397	9.783	10.621	10.346		9	1		SL
50378.412	9.773	10.608	10.334		7	1		SL
50383.409	10.192	10.918	10.649	9.232	12	1	3:04	SP
50383.424	10.175	10.920	10.658	9.241	12	1		SP
50383.439	10.178	10.931	10.656	9.234	12	1		SP
50383.457	10.146	10.898	10.631	9.232	12	1		SP
50383.479	10.140	10.911	10.647	9.223	12	1		SP
50383.496	10.189	10.898	10.603	9.123	11	1		SP
50384.270	10.061	10.863	10.637		8	1	1:31	SL
50384.287	10.061	10.861	10.637		8	1		SL
50384.307	10.049	10.853	10.652		8	1		SL
50392.290	10.130	10.900	10.680		7	1	1:04	SL
50393.400	10.202	10.935	10.665	9.271	8	2	1:12	SP
50393.410	10.180	10.920	10.649	9.258	8	2		SP
50393.422	10.198	10.945	10.688	9.282	8	2		SP
50393.334	10.131	10.921	10.680		9	1	2:18	SL
50393.357	10.132	10.920	10.663		9	1		SL

Table 3. UBVR observations of Nova Cas 1995 (continued)

JD^{*}_{hel} -2 400 000	U	B	V	R	n	cmp	run** h:m	Obs.
50393.378	10.107	10.917	10.677		9	1		SL
50393.399	10.122	10.915	10.683		8	1		SL
50394.456	10.083	10.861	10.627		7	1	2:01	SL
50394.482	10.092	10.868	10.625		7	1		SL
50394.506	10.095	10.873	10.632		7	1		SL
50396.297	10.026	10.829	10.572		12	1	0:54	SL
50421.240	10.161	10.952	10.726		6	1	0:19	SL
50422.339	10.130	10.917	10.679		8	1	1:06	SL
50422.354	10.121	10.922	10.676		8	1		SL
50422.369	10.124	10.916	10.686		8	1		SL
50423.258	10.138	10.930	10.698		8	1	1:09	SL
50423.275	10.124	10.920	10.686		8	1		SL
50423.289	10.123	10.918	10.696		8	1		SL
50427.252	10.144	10.931	10.710		15	1	1:41	SL
50427.302	10.194	10.925	10.680	9.305	7	1	0:52	SP
50427.310	10.179	10.932	10.674	9.306	7	1		SP
50427.319	10.202	10.935	10.680	9.308	7	1		SP
50427.328	10.199	10.932	10.685	9.319	7	1		SP
50427.359	10.152	10.958	10.749		14	1	4:22	SL
50427.391	10.162	10.960	10.745		14	1		SL
50427.430	10.109	10.932	10.740		14	1		SL
50427.469	10.163	10.953	10.751		14	1		SL
50427.500	10.130	10.933	10.724		12	1		SL
50428.315	10.277	11.093	10.874		8	1	4:47	SL
50428.330	10.291	11.093	10.880		8	1		SL
50428.346	10.329	11.104	10.884		8	1		SL
50428.361	10.330	11.114	10.888		8	1		SL
50428.377	10.350	11.129	10.908		8	1		SL
50428.393	10.344	11.126	10.905		8	1		SL
50428.408	10.346	11.118	10.904		8	1		SL
50428.423	10.330	11.118	10.903		8	1		SL
50428.438	10.330	11.100	10.883		8	1		SL
50428.453	10.323	11.088	10.883		8	1		SL
50428.468	10.327	11.085	10.865		8	1		SL
50428.481	10.307	11.072	10.858		7	1		SL
50428.375	10.396	11.126	10.891	9.424	8	1	1:15	SP
50428.384	10.399	11.143	10.903	9.428	8	1		SP
50428.394	10.430	11.158	10.920	9.455	8	1		SP
50428.404	10.420	11.168	10.933	9.456	8	1		SP
50428.414	10.411	11.156	10.930	9.442	8	1		SP
50430.343	10.310	11.049	10.802	9.386	9	1	1:07	SP
50430.355	10.300	11.028	10.791	9.368	9	1		SP
50430.365	10.305	11.033	10.801	9.372	9	1		SP

Table 3. UBVR observations of Nova Cas 1995 (continued)

JD^*_{hel} -2 400 000	U	B	V	R	n	cmp	run** h:m	Obs.
50430.376	10.291	11.054	10.825	9.389	9	1		SP
50440.340	10.270	10.975	10.717	9.335	8	1	1:07	SP
50440.350	10.267	10.969	10.737	9.361	8	1		SP
50440.360	10.229	10.912	10.639	9.300	8	1		SP
50440.372	10.247	10.896	10.652	9.317	8	1		SP
50447.275	10.227	10.956	10.682	9.261	8	1	1:10	SP
50447.286	10.251	10.976	10.693	9.284	8	1		SP
50447.297	10.235	10.967	10.690	9.273	8	1		SP
50447.308	10.228	10.973	10.679	9.253	8	1		SP

* Mean time of the observations, ** lenght of the observation

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