Photometric variability of the slow nova V723 Cas

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Abstract. We present UBVR photometry of V723 Cas (Nova Cas 1995) obtained from January 1997 through March 1998. Using these as well as archival photoelectric and visual observations, we have found an 180 day periodicity of the activity on the declining branch of the light-curve. The stages of activity, characterized by flare(s), occurred after the brightness decreases. Period analysis of the short-term brightness variations and the study of phase light-curves in quiescent stage revealed the most significant period as 0.63 days. The same analysis applied on brightness variations in active stage (January-February 1997) revealed the periods 0.61 days or 2.8 days. Detected periods are interpreted in the frame of possible binary and triple-star models. The evolutionary path of the nova in the two-colour diagram is presented. It is shown, that at brightness maximum, discussed as a super-Eddington event, the main envelope of the nova was ejected with the velocity 210 km s^{-1}.

Key words: novae - photometry

1. Introduction

V723 Cas (Nova Cas 1995) was discovered by Yamamoto (1995) on August 24, 1995. It reached the brightness maximum V$_{max}$ = 7.09 and B$_{max}$ = 7.59 on December 16, 1995 (JD 2450068.4). From that time the nova has been slowly fading, but occasional flares occur on the light-curve. In order to illustrate the general photometric behaviour of V723 Cas, the visual magnitude estimates from AFOEV and VSNET archives are presented in Fig. 1. The mean light-curve was computed using the method of running parabolae with a filter width of four days. The light-curve shows large brightness variations, some of which exceed 2 mag.

Chochol and Pribulla (1997) (henceforth C&P) presented UBVR photometry of V723 Cas in the first 16 months following its outburst. They classified the object as the slow nova of the HR Del type with a rate of decline $t_{3,V}$ = 173±5 days and $t_{3,B}$ = 189±5 days and derived from the Maximum Magnitude - Rate of Decline (MMRD) relations the absolute magnitudes of the nova at maximum as MV$_{max}$ = -6.70±0.23 and MB$_{max}$ = -6.49±0.32. The latter value yielded a

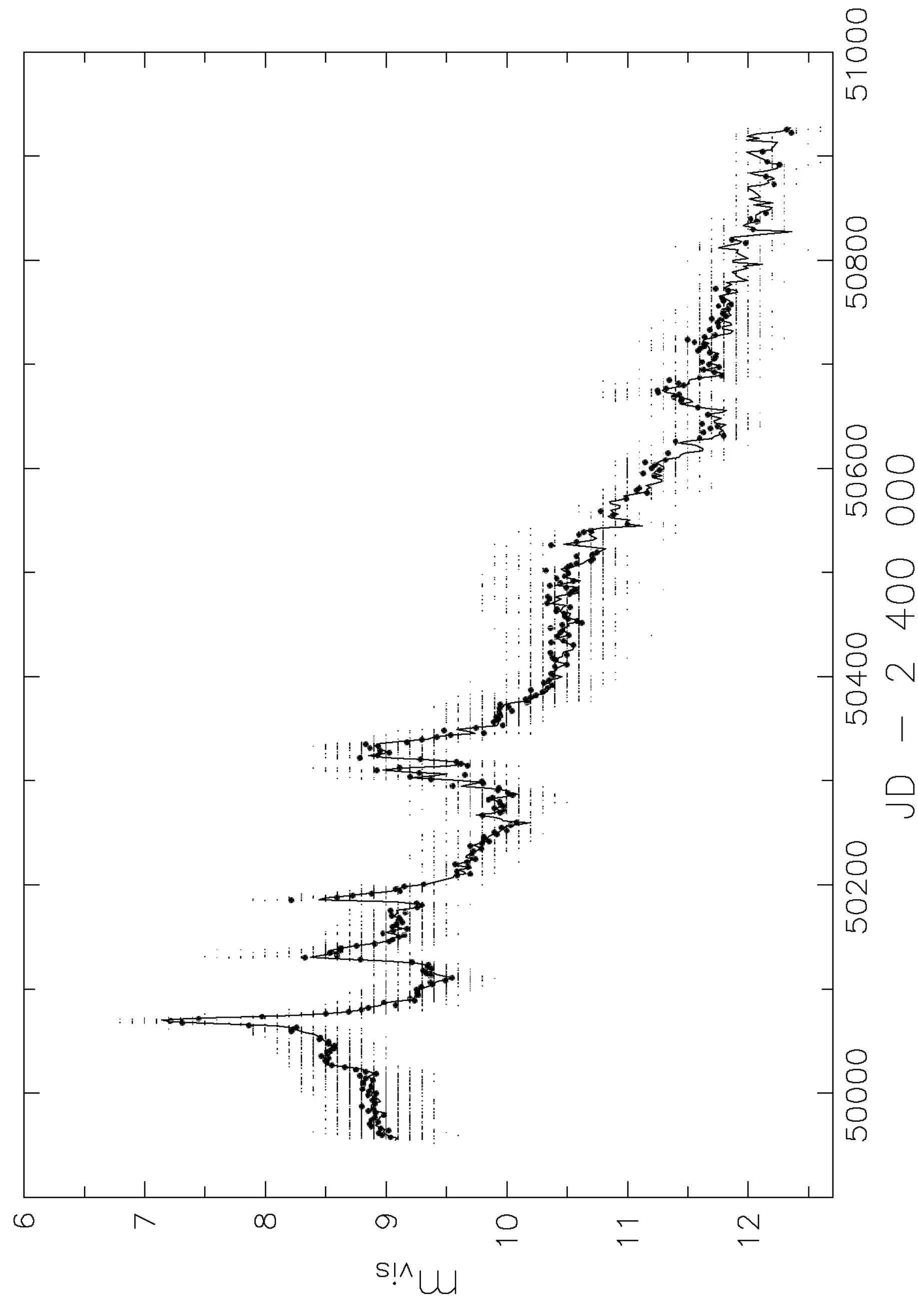


Figure 1. AFOEV and VSNET visual estimates. Large symbols are two-day averages, the solid line is the running mean.

mass of 0.66 ± 0.05 $M_\odot$ for the white dwarf component. C&P determined the colour excess E(B-V) = 0.57±0.01 and estimated the distance to the nova d = 2.39±0.38 kpc.

The spectral evolution of the object described in IAUC's and in the paper of Munari et al. (1996) until the middle of March 1996, was discussed in C&P. At that time the nova was still in a pre-nebular stage. Prominent emission lines of [Fe VII] at 572.1 and 608.6 nm were detected in the spectrum taken by Iijima and Rosino (1997) on July 1, 1997. These lines were not seen on May 30, 1997. The intensity of the He II 468.6 nm line increased during the same period. The presence of nebular lines and the spectral evolution indicates that the nova entered the nebular stage in June 1997 (about 660 days after the outburst). Radio observations taken on January 25, 1997 by Eyres et al. (1997) confirmed the presence of marginally resolved nebula.

The aim of this work is to present new UBVR observations of V723 Cas, to discuss the photometric variations on both long and short time scales, and to describe the evolution of the nova.

2. Observations, light and colour variations

2.1. New observations

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. HD 232357 (BD+53°208, SAO 21952, PPM 25953) served as a comparison star (V = 9.08, B = 9.21, U = 8.96, R = 8.92). Data reduction, atmospheric extinction correction and transformation to the UBVR standard system were carried out using standard techniques. Our photometric observations were obtained over 42 nights between January 6, 1997 and March 17, 1998 and are given in Table 1. The U,B,V,R magnitudes are normal points (averages of individual observations). The number of individual observations n included in one normal point depends on the photometric quality of the night during the observing run. On excellent nights, 3-6 observations were averaged into one normal point, so that its mean error was about 0.01 mag in the V passband. Corresponding average errors were 0.008 mag in R, 0.009 mag in B and 0.013 mag in U passband. The total time of our observations exceeded 71 hours. In order to study short-term variations, 20 hours of our observations were obtained in five runs longer than three hours.

2.2. Light-curve of the nova and stages of activity

The U,B,V and R light-curves of V723 Cas constructed from our observations as well as the data available from other sources (C&P; Ohsima et al., 1996; VSNET archive; Shugarov & Goranskij, 1997) are depicted in Figs. 2 and 3. The brightness maxima, during the stages of activity, are designated by solid vertical lines. The activity stages through the end of 1996 have already been described by C&P. The new data reveal another three stages of activity characterized by flares with declining amplitude.

The first stage of activity in January and February 1997 (JD* = 50475 - 506)[1] consisted of the series of subsequent small flares with maxima at JD* 50000+(487.4; 498.5; 501.4; 504.2) and minima at JD* 50000+(483.2; 491.3; 497.3; 499.4; 503.3; 505.3). The amplitude of U,B,V variations was about 0.7 mag.

The second stage of activity in August 1997 was characterized by one flare with maximum at JD* 50673.5 (U = 10.71; B = 11.42; V = 11.34). The brightness decrease preceding the flare started at JD* 50623 (U = 11.06; B = 11.74; V = 11.65) and reached the minimum at JD* 50642 (U = 11.50; B = 12.23; V = 12.07). The flare ended at JD* 50681.

The third stage of activity in February 1998 was characterized by one flare with different times of U,B,V maximum brightness JD* 50000+[870.2 (U = 11.50); 868.2 (B = 12.40); 858.2 (V = 12.18)]. The brightness decrease preceding the flare started at JD* 50820 (U = 11.52, B = 12.36, V = 12.23) and reached the minimum at JD* 50848 (U = 11.98, B = 12.76, V = 12.61). The flare ended at JD* 50872.

Every brightness maximum was preceded by the minimum designated in Figs. 2 and 3 by an arrow. One very interesting feature of the light-curves is the long plateau of nearly constant brightness from JD* 50704 to JD* 50793, where a few, very narrow deep minima (ΔV = 0.3 mag) with the duration $\approx$ 0.14 days were detected. A similar plateau was found in the older data (JD* 50421-468).

2.3. Colour indices and the two-colour diagram

The U-B, B-V and V-R colour indices are shown in Fig. 4. Their variations in 1997-98 are related to the onset of the nebular stage in June 1997 (around JD* 50615). From that time, the U-B index decreases, while the B-V index increases. Decrease of the U-B index can be explained by an increase of the temperature of the hot component and corresponding shift of the maximum of the energy distribution towards the shorter wavelengths. Increase of the B-V index is related to the increase of emission line intensities within the V passband during the nebular stage.

In Fig. 5 (top) we present the two-colour diagram using the unredddened U-B, B-V colour indices as well as supergiant and blackbody sequences (Flower,

[1] JD* = JD - 2 400 000

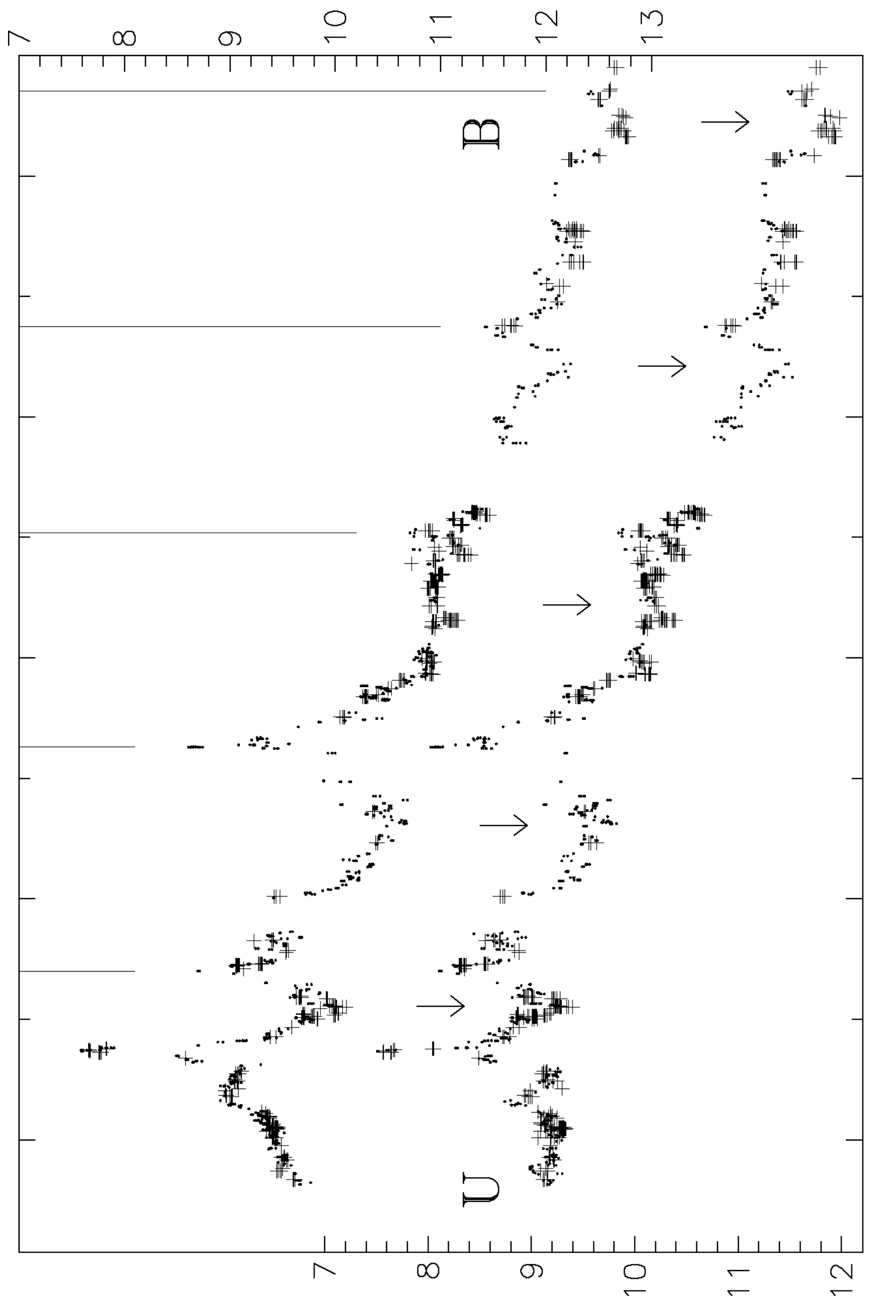


Figure 2. U and B light-curves. Crosses denote our observations. The solid vertical lines designate the maxima of activity, the arrows indicate times of the minima.

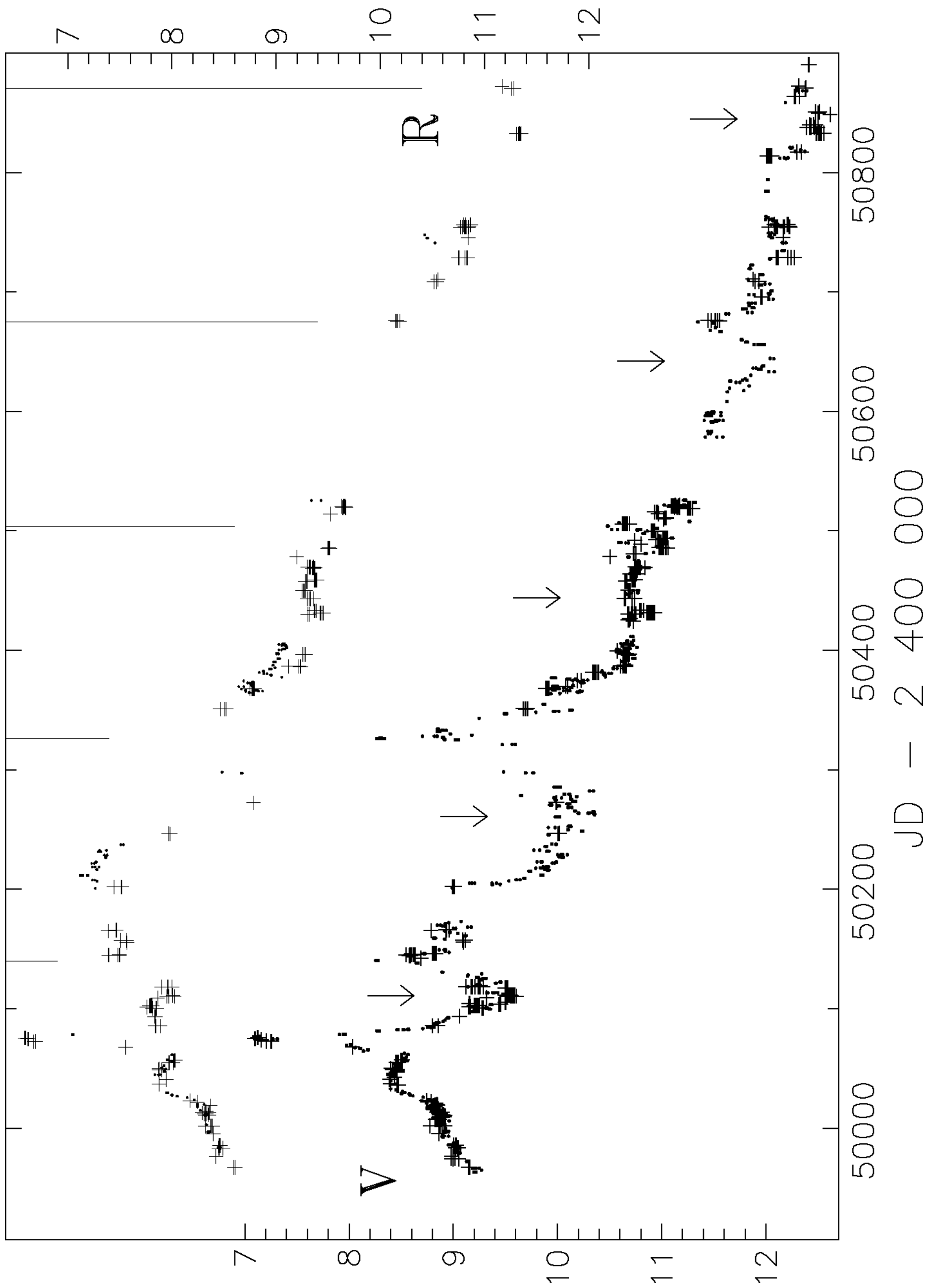


Figure 3. V and R light-curves. Crosses denote our observations. The solid vertical lines designate the maxima of activity, the arrows indicate times of the minima.

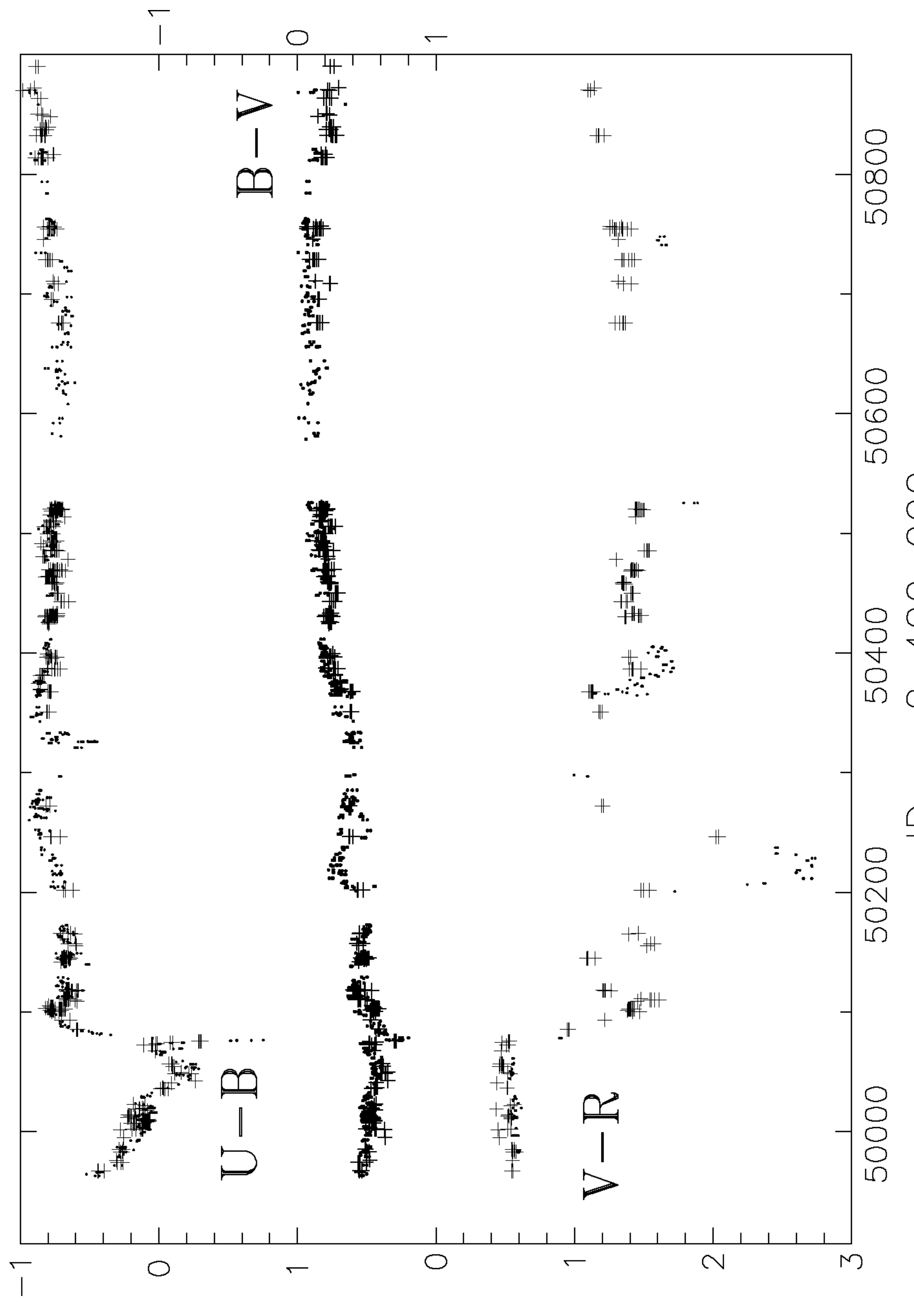
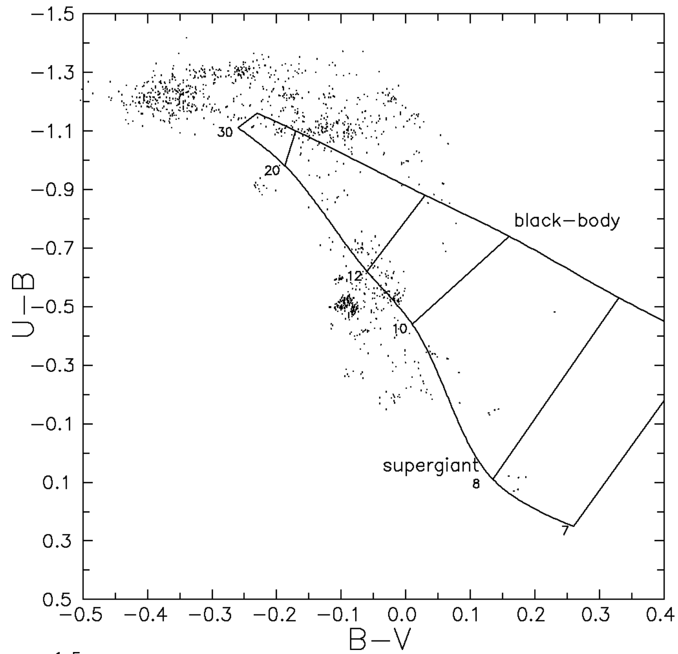


Figure 4. The V-R, B-V and U-B colour indices. Crosses denote our observations.



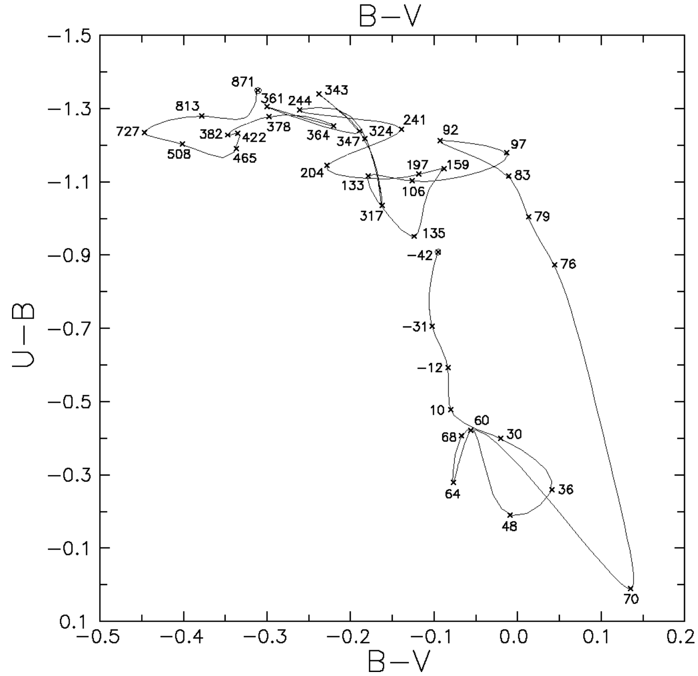


Figure 5. The two-colour diagram for the unreddened indices. The blackbody and supergiant sequences are connected by the isothermal lines corresponding to indicated temperatures $\times 10^3$K (top). The evolutionary path was constructed using two-day averages and the cubic spline. The important dates are given in JD - 2 450 000 (bottom).

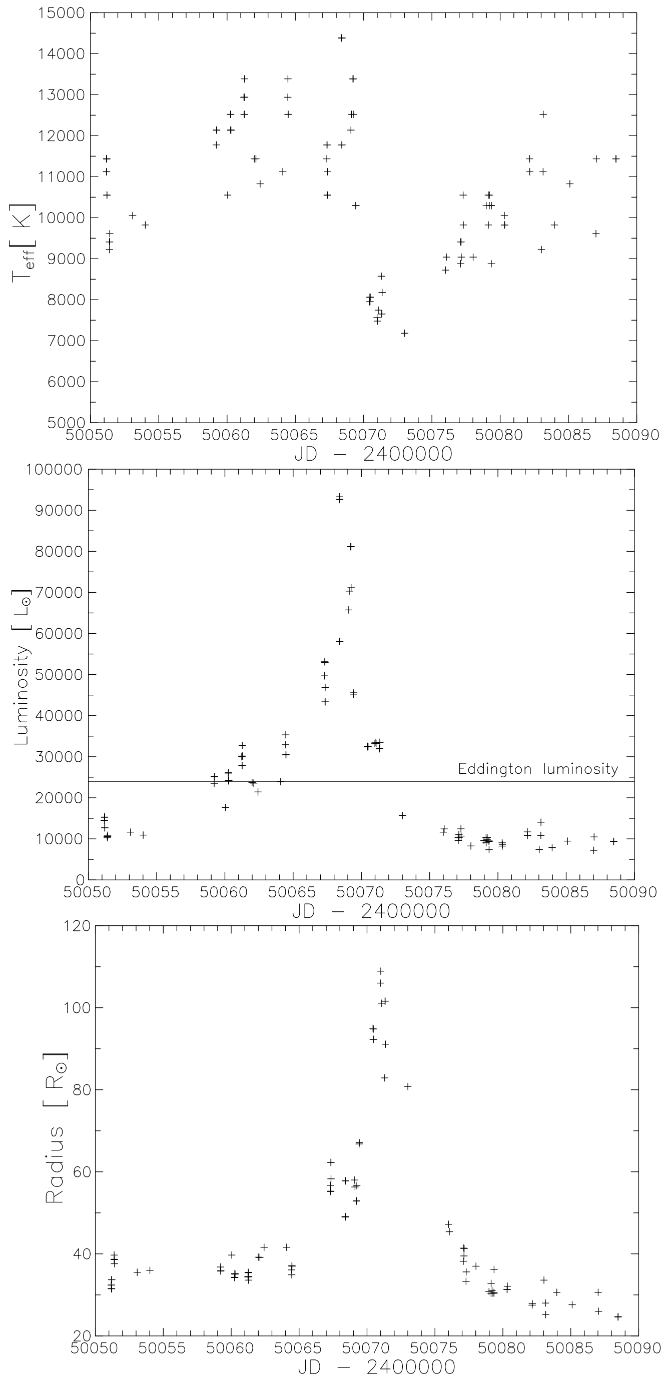


Figure 6. The time dependence of the temperature, luminosity and radius of the expanding supergiant during the main outburst.

1996; Duerbeck & Seiter, 1979). A colour correction E(B-V) = 0.57 was adopted from C&P. E(U-B) = 0.44 was calculated from the relation E(U-B)/E(B-V) = 0.75 + 0.05E(B-V) (Allen, 1976). The evolution of V723 Cas in the two-colour diagram is shown in Fig. 5 (bottom). The following is seen:

a) During the increase of brightness to the main maximum the U-B colour index changes drastically. The colour indices of the nova at maximum resemble to that of an F supergiant (the effective temperature reaches minimum). During the contraction phase the effective temperature increases and the energy distribution shifts towards black bodies.

b) During the further evolution, the colours shift towards higher temperatures near the blackbody sequence. This evolution is interrupted by changes in both colours corresponding to the large flares at JD* 50135 and JD* 50322, when the nova shifts towards the supergiant sequence. The path of these two flares in the two-colour diagram differs. While the path of the first flare was similar to the path of the main outburst (but on a much smaller scale), the path of the second flare to maximum and back was identical. The large increase of the V-R index starting at JD* 50071 with two maxima at JD* 50110 and JD* 50230 shows that during the main outburst and the first flare the nova ejected dense envelopes. During the first flare the V-R index increased by 1.3 mag. During the second flare the hot component expanded and subsequently contracted. The V-R index increased by only 0.6 mag, so the mass ejected during the second flare was much smaller in comparison to the first one.

c) One interesting feature of the two-colour diagram is the small variations of the colour indices even during the large changes of brightness after the main outburst. The amplitude and shape of the flares were the same in all three passbands, so the colour changes were negligible. On the other hand, colour oscillations were present during the small brightness changes.

2.4. Outburst of the nova as a super-Eddington event

We have studied the expansion of the supergiant, caused by the outburst of the white dwarf, around the brightness maximum. We have used MV_{max} = -6.70 and E(B-V) = 0.57 given in C&P. Using the supergiant sequence calibration of Flower (1996) and the unreddened B-V indices, we have determined the most important parameters: effective temperature, luminosity and radius of the supergiant. The results are presented in Fig.6. Nova reached maximum temperature 14 500 K and luminosity 94 000 $L_\odot$ in principal maximum at JD* 50068.4. The radius of the expanding photosphere reached 67 $R_\odot$ at JD* 50069.4. The maximum radius of the expanding photosphere 109 $R_\odot$ was reached at JD* 50071.0, when the temperature decreased to 7500 K, corresponding to F1 supergiant. According to Iijima and Rosino (1996), a pure F-type supergiant spectrum appeared at JD* 50071.3. There is no doubts that the supergiant envelope was ejected on that day. The velocity of expansion of supergiant calculated from the radii given above was 210 km s^{-1}. The spectra of V723 Cas in its nebular stage show the same velocity of expansion of the main envelope (O'Brien et al., 1998). After the ejection of the supergiant envelope the temperature decreased to T = 7200 K at JD* 50073.0.

C&P derived the mass of the CO white dwarf as 0.66 $M_{\odot}$. The Eddington luminosity corresponding to its mass is 24 000 $L_{\odot}$. It is clear that the nova in maximum exceeded the Eddington luminosity and ejected the envelope. Thereafter the photosphere of the outbursted white dwarf rapidly shrank.

3. Period analysis of the brightness variations

3.1. Long-term variations

As shown in Figs. 2 and 3, the overall brightness decrease after the main outburst (from JD* 50100) was interrupted by the stages of activity. Altogether, five stages of activity accompanied by flares of decreasing amplitude were observed. The following ephemeris, found by linear regression, is valid for the maxima of brightness JD* 50000+(135.3; 322.4; 501.4; 673.5; 870.2):

$$JD_{max} = 2\,450\,136\ (\pm 5) + 182\ (\pm 2) \times E. \tag{1}$$

The minima of brightness preceded the maxima by 43±8 days. The declines to the last two minima are preceded by the plateaus, so they are not only artefacts caused by successive outbursts. To find periodicities in the photoelectric and visual data, we removed the trend by fitting the data after JD* 50100 by the third-order polynomial. The phase dispersion minimisation (PDM) method developed by Stellingwerf (1978) applied to the residuals led to the same period 180.4 days in U,B,V and visual data. The period significance for the U photoelectric data and the two-day visual averages are presented in Fig. 7.

3.2. Short-term variations

The U,B,V light-curves presented in Figs. 2 and 3, also exhibit short-term variability, affected by the intermittent activity. Nevertheless, there are two plateaus of nearly constant brightness (see Section 2.2) interrupted by minima lasting about ≈ 0.14 days. If these minima are interpreted as eclipses, the orbital period must certainly be longer than ≈ 0.4 days. The classical novae are binary systems with orbital periods usually shorter than one day. Thus we have confined our period search to the range of 0.4 - 1 day for the data obtained during quiescent stages at JD* 50000+(421-468; 704-794). We have searched for photometric periods in the residuals (after the mean brightness removal) by the PDM method. The results are presented in Fig. 8. As shown in Fig. 9, the phase light-curve constructed using the ephemeris:

$$JD_{min} = 2\,450\,421.4405\ + 0.63501 \times E, \tag{2}$$

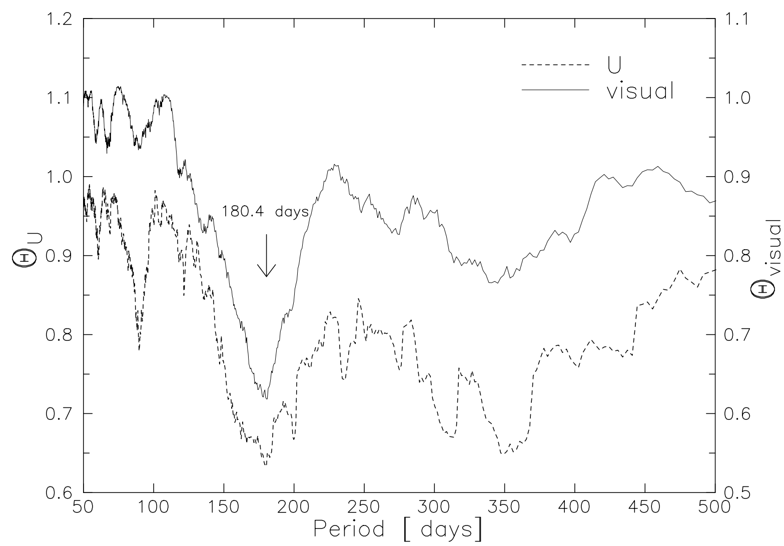


Figure 7. Period significance Θ in the U photoelectric data and the two-day visual averages

can be interpreted as the light-curve of an eclipsing binary system. The presence of eclipses of the hot component by a red dwarf suggests the large inclination angle of the binary system. This view is supported by the study of kinematics of the expanding envelope. O'Brien et al. (1998) found the inclination angle of the polar ejecta $i \approx 70^o$.

During the series of flares in January and February 1997 (JD* 50475-504) the light-curve exhibits well defined brightness maxima and minima. The PDM analysis of the U data in the period range 0.4 - 5 days revealed three most significant periods: 2.79, 0.61 and 0.88 days (Fig. 10). The phase light-curves corresponding to the first two periods are depicted in Fig. 11. The third period does not give reasonable phase light-curve.

The phase light-curve corresponding to the period 0.61 days can be interpreted as an eclipse of a bright spot in the accretion disk surrounding the white dwarf. The bright spot could be formed during the enhanced mass transfer from the red dwarf. The discrepancy between the 0.63 days photometric period in quiescent stage and 0.61 days period in active stage remains unexplained.

The phase light-curve corresponding to the most significant period 2.79 days suggests the following tentative interpretation: during the TNR in January 1997 the outbursted white dwarf formed the common envelope surrounding the binary system. Rotation of this object and the polar outflow along the magnetic axis, which is inclined to rotational axis, could explain short term maxima and minima, mutually shifted by half of the period and lasting about 0.1 of the period. However, the presence of magnetic field in V 723 Cas was not yet prooved.

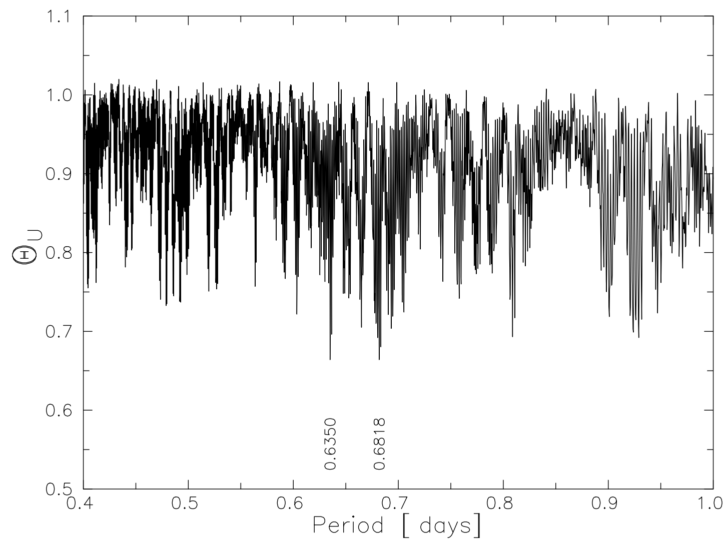


Figure 8. Period significance Θ in the photoelectric U data during the quiescent phase

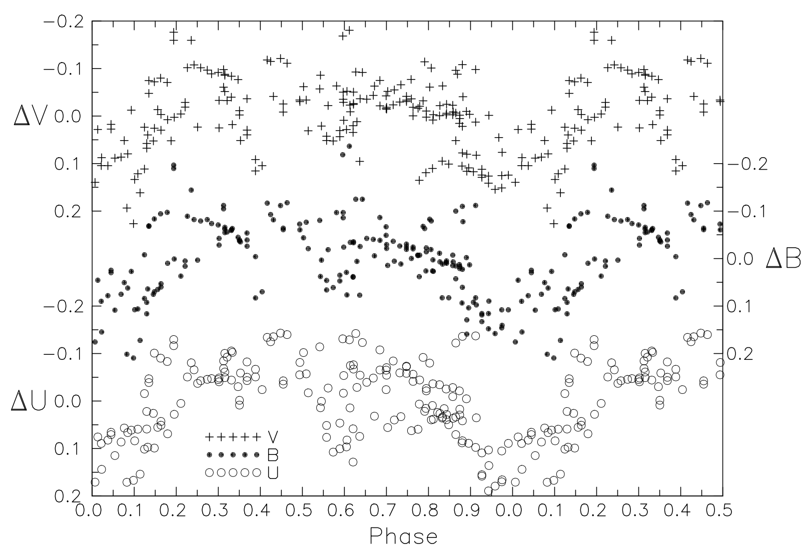


Figure 9. The U,B,V phase light-curves for 0.63501 day during the quiescent phase

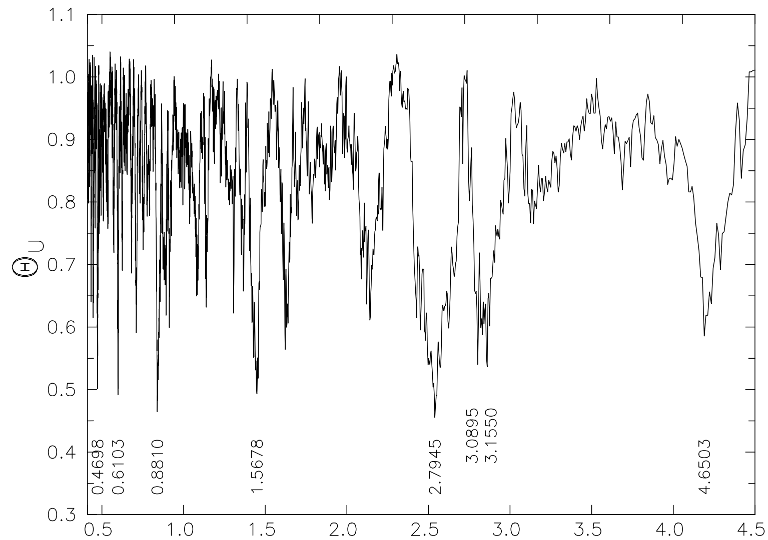


Figure 10. Period significance Θ in the photoelectric U data during the flares

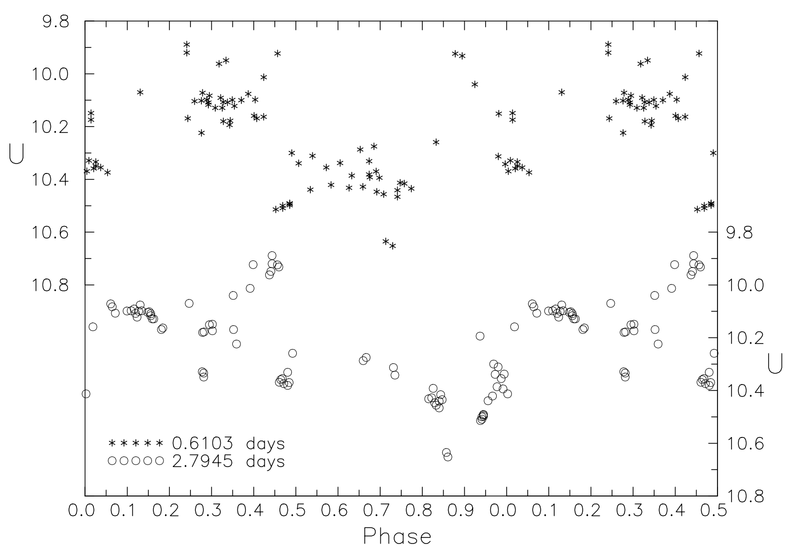


Figure 11. The U phase light-curves for 0.6103 and 2.794 days during the flares

Table 1. UBVR observations of Nova Cas 1995

JD^{*}_{hel} -2 400 000	U	B	V	R	n	run** h:m	Obs.
50455.282	10.140	10.878	10.652	9.300	6	1:12	SP
50455.289	10.142	10.881	10.649	9.293	6		SP
50455.298	10.126	10.897	10.655	9.301	6		SP
50455.305	10.138	10.886	10.653	9.302	6		SP
50455.313	10.143	10.891	10.657	9.284	6		SP
50455.321	10.157	10.907	10.664	9.302	6		SP
50456.255	10.225	10.978	10.738	9.395	5	1:12	SP
50456.261	10.213	10.958	10.719	9.368	5		SP
50456.267	10.215	10.961	10.716	9.368	5		SP
50456.273	10.226	10.956	10.735	9.378	5		SP
50456.279	10.223	10.958	10.732	9.377	5		SP
50456.285	10.204	10.968	10.739	9.381	5		SP
50456.291	10.216	10.972	10.746	9.384	5		SP
50456.297	10.182	10.949	10.731	9.371	5		SP
50461.206	10.118	10.913	10.715		4	4:20	SL
50461.214	10.109	10.915	10.717		4		SL
50461.223	10.131	10.923	10.705		4		SL
50461.232	10.146	10.906	10.706		4		SL
50461.242	10.137	10.908	10.698		4		SL
50461.249	10.120	10.910	10.720		4		SL
50461.256	10.115	10.927	10.727		4		SL
50461.263	10.131	10.919	10.723		4		SL
50461.270	10.101	10.912	10.718		4		SL
50461.278	10.126	10.922	10.712		4		SL
50461.285	10.113	10.929	10.711		4		SL
50461.289	10.112	10.918	10.700		4		SL
50461.291	10.127	10.924	10.708		4		SL
50461.295	10.144	10.928	10.741		4		SL
50461.303	10.129	10.924	10.723		4		SL
50461.309	10.141	10.941	10.721		4		SL
50461.316	10.164	10.926	10.731		4		SL
50461.323	10.159	10.934	10.744		4		SL
50461.331	10.149	10.951	10.750		4		SL
50461.339	10.151	10.937	10.741		4		SL
50461.347	10.160	10.956	10.739		4		SL
50461.354	10.176	10.963	10.739		4		SL
50461.361	10.157	10.941	10.719		4		SL
50461.367	10.164	10.961	10.757		4		SL
50466.249	10.238	10.994	10.787	9.359	5	1:20	SP
50466.254	10.263	11.014	10.796	9.360	5		SP
50466.260	10.294	11.009	10.797	9.358	5		SP
50466.266	10.233	10.995	10.775	9.355	5		SP
50466.272	10.287	10.983	10.788	9.367	5		SP

Table 1. UBVR observations of Nova Cas 1995 (continued)

JD^{*}_{hel} -2 400 000	U	B	V	R	n	run** h:m	Obs.
50466.278	10.283	10.977	10.773	9.351	5		SP
50466.284	10.245	10.986	10.765	9.359	5		SP
50466.290	10.315	10.987	10.779	9.367	5		SP
50466.296	10.261	11.025	10.840	9.375	4		SP
50467.254	10.284	11.012	10.785	9.365	6	1:12	SP
50467.261	10.286	11.018	10.771	9.359	6		SP
50467.268	10.238	11.001	10.775	9.357	6		SP
50467.275	10.230	11.008	10.742	9.327	6		SP
50467.283	10.256	10.958	10.753	9.302	6		SP
50467.290	10.215	10.949	10.748	9.319	6		SP
50467.296	10.192	10.985	10.741	9.331	4		SP
50475.693	10.070	10.724	10.503	9.200	16	0:33	SP
50478.212	10.104	10.931	10.734		4	1:14	SL
50478.219	10.102	10.937	10.732		4		SL
50478.229	10.109	10.932	10.734		4		SL
50478.236	10.117	10.928	10.729		4		SL
50478.244	10.129	10.956	10.751		4		SL
50478.253	10.129	10.950	10.729		4		SL
50483.212	10.514	11.291	11.033	9.497	4	0:51	SP
50483.217	10.509	11.261	11.041	9.518	4		SP
50483.222	10.500	11.220	11.059	9.518	4		SP
50483.227	10.493	11.224	11.015	9.508	4		SP
50483.232	10.491	11.230	11.036	9.514	4		SP
50483.236	10.498	11.233	11.033	9.507	4		SP
50483.259	10.439	11.184	10.988		15		SL
50483.291	10.421	11.174	10.991		15		SL
50483.325	10.386	11.160	10.972		15		SL
50483.363	10.394	11.160	10.974		15		SL
50483.394	10.413	11.159	11.006		15		SL
50486.225	10.159	10.987	10.798		4	0:13	SL
50489.245	10.099	10.946	10.737		19	1:03	SL
50490.258	10.369	11.123	10.940		3	1:40	SL
50490.266	10.359	11.119	10.945		3		SL
50490.276	10.355	11.124	10.941		3		SL
50490.287	10.374	11.140	10.961		3		SL
50491.255	10.432	11.189	11.037		6	1:53	SL
50491.269	10.428	11.204	11.050		6		SL
50491.282	10.392	11.174	11.008		6		SL
50491.293	10.447	11.191	11.015		6		SL
50491.305	10.456	11.189	11.008		6		SL
50491.316	10.466	11.205	11.027		6		SL
50491.323	10.441	11.191	11.053		2		SL
50497.265	10.300	11.085	10.897		8	2:35	SL

Table 1. UBVR observations of Nova Cas 1995 (continued)

JD^{*}_{hel} -2 400 000	U	B	V	R	n	run** h:m	Obs.
50497.283	10.339	11.096	10.909		8		SL
50497.304	10.311	11.114	10.919		8		SL
50497.324	10.355	11.130	10.930		8		SL
50497.341	10.338	11.111	10.906		8		SL
50503.254	10.098	10.887	10.641		6	1:47	SL
50503.265	10.091	10.902	10.657		6		SL
50503.277	10.108	10.893	10.671		6		SL
50503.288	10.122	10.927	10.691		6		SL
50503.298	10.100	10.897	10.645		6		SL
50503.309	10.076	10.902	10.627		6		SL
50503.318	10.098	10.855	10.620		4		SL
50507.254	10.419	11.194	11.019		8	0:53	SL
50507.269	10.447	11.189	11.016		8		SL
50508.254	10.434	11.208	11.027		6	1:37	SL
50508.265	10.440	11.200	11.042		6		SL
50508.273	10.448	11.205	11.041		6		SL
50508.281	10.446	11.200	11.028		6		SL
50508.290	10.434	11.213	11.039		6		SL
50508.298	10.445	11.203	11.046		6		SL
50508.305	10.435	11.212	11.042		5		SL
50511.629	10.451	11.129	10.966	9.524	8	0:28	SP
50513.262	10.368	11.127	10.958		4	1:24	SL
50513.268	10.351	11.128	10.949		4		SL
50513.275	10.348	11.135	10.946		4		SL
50513.282	10.356	11.123	10.948		4		SL
50513.289	10.355	11.132	10.963		4		SL
50513.296	10.362	11.128	10.962		4		SL
50513.304	10.380	11.119	10.934		4		SL
50513.311	10.366	11.129	10.930		4		SL
50516.309	10.699	11.444	11.273		3	0:56	SL
50516.313	10.659	11.435	11.254		3		SL
50516.317	10.666	11.431	11.245		3		SL
50516.321	10.659	11.436	11.261		3		SL
50516.324	10.683	11.427	11.266		3		SL
50516.328	10.699	11.426	11.269		3		SL
50516.332	10.700	11.434	11.296		3		SL
50516.336	10.706	11.443	11.262		3		SL
50516.341	10.710	11.466	11.262		3		SL
50517.289	10.679	11.372	11.175	9.672	8	1:09	SP
50517.300	10.621	11.351	11.163	9.663	8		SP
50517.312	10.638	11.341	11.122	9.642	8		SP
50517.324	10.639	11.337	11.146	9.653	8		SP
50518.258	10.613	11.325	11.116	9.663	5	2:15	SP

Table 1. UBVR observations of Nova Cas 1995 (continued)

JD^{*}_{hel} -2 400 000	U	B	V	R	n	run** h:m	Obs.
50518.266	10.595	11.306	11.126	9.652	5		SP
50518.273	10.596	11.328	11.109	9.664	5		SP
50518.280	10.580	11.307	11.116	9.654	5		SP
50518.287	10.614	11.315	11.100	9.660	5		SP
50518.295	10.596	11.318	11.107	9.654	5		SP
50518.302	10.601	11.319	11.110	9.646	5		SP
50518.309	10.608	11.321	11.115	9.654	5		SP
50518.316	10.598	11.313	11.098	9.653	5		SP
50518.323	10.577	11.299	11.095	9.644	5		SP
50518.332	10.616	11.305	11.100	9.645	5		SP
50518.339	10.560	11.308	11.092	9.631	4		SP
50518.280	10.562	11.333	11.168		6	1:11	SL
50518.291	10.515	11.299	11.134		6		SL
50518.303	10.549	11.323	11.165		6		SL
50518.316	10.576	11.322	11.161		6		SL
50519.276	10.593	11.346	11.169		12	1:23	SL
50519.303	10.556	11.300	11.130		12		SL
50674.511	10.995	11.713	11.534	10.164	6	1:47	SP
50674.523	10.974	11.697	11.557	10.188	6		SP
50674.535	10.971	11.666	11.518	10.163	6		SP
50674.547	10.952	11.672	11.509	10.157	6		SP
50674.560	10.912	11.611	11.474	10.148	6		SP
50674.572	10.899	11.584	11.443	10.147	6		SP
50694.497	11.348	12.110	11.962		16	1:06	SL
50694.519	11.336	12.111	11.952		16		SL
50707.574	11.377	12.129	11.896	10.541	20	1:42	SP
50707.607	11.445	12.168	11.930	10.517	20		SP
50709.402	11.243	12.005	11.874	10.556	32	1:46	SP
50727.598	11.575	12.352	12.241	10.826	6	1:15	SP
50727.605	11.571	12.360	12.274	10.840	6		SP
50727.616	11.558	12.323	12.209	10.817	6		SP
50727.624	11.463	12.267	12.115	10.757	6		SP
50727.631	11.426	12.243	12.105	10.752	6		SP
50727.639	11.430	12.226	12.100	10.758	6		SP
50744.638	11.448	12.277	12.164	10.844	40	1:15	SP
50753.479	11.440	12.197	12.027	10.771	13	4:52	SP
50753.496	11.477	12.228	12.084	10.791	13		SP
50753.513	11.490	12.246	12.112	10.806	13		SP
50753.530	11.504	12.268	12.103	10.812	13		SP
50753.550	11.542	12.275	12.089	10.792	13		SP
50753.568	11.572	12.326	12.167	10.820	13		SP
50753.585	11.577	12.361	12.230	10.847	13		SP
50753.601	11.550	12.340	12.178	10.851	13		SP

Table 1. UBVR observations of Nova Cas 1995 (continued)

JD^{*}_{hel} -2 400 000	U	B	V	R	n	run** h:m	Obs.
50753.620	11.521	12.294	12.179	10.830	13		SP
50753.651	11.490	12.293	12.224	10.812	11		SP
50755.545	11.465	12.213	12.079	10.801	11	1:28	SP
50755.559	11.463	12.292	12.213	10.871	11		SP
50755.573	11.505	12.270	12.203	10.863	11		SP
50755.589	11.459	12.251	12.078	10.821	11		SP
50813.385	11.383	12.221	12.012		7	2:39	SL
50813.393	11.420	12.220	12.015		7		SL
50813.401	11.387	12.222	12.008		7		SL
50813.410	11.398	12.244	12.032		7		SL
50813.418	11.366	12.216	12.034		7		SL
50813.426	11.368	12.234	12.054		7		SL
50813.435	11.349	12.240	12.056		7		SL
50813.443	11.389	12.219	12.047		7		SL
50813.451	11.424	12.222	12.024		7		SL
50813.458	11.383	12.226	12.048		5		SL
50816.424	11.748	12.510	12.339		12	1:15	SL
50816.445	11.745	12.501	12.299		12		SL
50832.218	11.921	12.768	12.484	11.310	15	4:16	SP
50832.236	11.937	12.759	12.486	11.325	15		SP
50832.255	11.923	12.772	12.519	11.345	15		SP
50832.280	11.947	12.766	12.509	11.336	15		SP
50832.297	11.941	12.786	12.531	11.353	15		SP
50832.315	11.913	12.754	12.512	11.332	15		SP
50832.334	11.882	12.765	12.554	11.339	14		SP
50837.218	11.810	12.626	12.392		15	3:25	SL
50837.260	11.782	12.638	12.429		15		SL
50837.290	11.818	12.644	12.418		15		SL
50837.311	11.860	12.693	12.467		15		SL
50837.327	11.937	12.743	12.498		15		SL
50839.213	11.865	12.682	12.421		15	3:18	SL
50839.236	11.858	12.671	12.434		15		SL
50839.270	11.859	12.703	12.459		15		SL
50839.305	11.837	12.650	12.419		15		SL
50839.387	11.926	12.718	12.473		18		SL
50848.268	11.984	12.762	12.615		13	0:29	SL
50849.226	11.900	12.735	12.503		18	0:50	SL
50850.332	11.846	12.689	12.476		12	0:57	SL
50850.350	11.850	12.723	12.513		12		SL
50863.254	11.630	12.501	12.270		10	1:37	SL
50863.280	11.671	12.521	12.277		10		SL
50863.291	11.644	12.495	12.285		10		SL
50863.302	11.659	12.510	12.318		10		SL

Table 1. UBVR observations of Nova Cas 1995 (continued)

JD^*_{hel} -2 400 000	U	B	V	R	n	run** h:m	Obs.
50870.255	11.628	12.607	12.376	11.260	31	2:35	SP
50870.310	11.675	12.600	12.381	11.284	31		SP
50872.267	11.719	12.614	12.316	11.170	44	1:28	SP
50890.257	11.803	12.672	12.405		8	0:53	SL
50890.271	11.761	12.648	12.412		8		SL

* Mean time of the observation, ** length of the observation

4. Discussion and conclusion

Munari et al. (1996) pointed out that V723 Cas has some resemblance to classical novae like HR Del (close binary with a cool dwarf) but also to symbiotic novae (wider pair harbouring a cool giant).

There are three possible interpretations of detected periods and overall behaviour of the object:

1. Classical nova. Then V723 Cas is a binary system consisting of a white and cool dwarf on 0.63 days orbit. The 180.4 day periodicity of flares and obscuration effects has to be the result of the mass transfer bursts from the red to white dwarf, caused by an internal variability of the cool component.

2. Symbiotic nova. In this case the 180.4 days periodicity can be interpreted as the orbital period of a binary system consisting of a cool giant moving on eccentric orbit around the outbursted white dwarf. The flares are the TNRs or accretion phenomena caused by the mass transfer bursts from the cool giant onto the hot component during the periastron passages. The brightness minima, which preceded the flares, are obscuration effects caused by the transferred matter. This model, however, does not explain 0.63 days periodicity.

3. A triple system. This interpretation combines previous cases. The system consists of a close binary (red and white dwarf) with orbital period P = 0.63 days and a third body on the 180.4 days orbit. The observed stages of activity are caused either by the direct mass transfer bursts from a cool giant on eccentric orbit or by periodic perturbations of the binary system by an unspecified third body.

We can explain the observational facts most easily by a triple-star model with a cool giant third body. An obscuration effect caused by the transferred matter from the cool giant onto the inner binary in periastron explains the deep minimum, following the main outburst, which lasted from JD* 50077 to

JD* 50125. The 2.5 mag decrease in V band during 36 days following the main maximum can lead to the misleading classification of the object as a fast nova (see C&P). It is interesting that the stages of activity always occur after the obscuration of the hot component by transferred matter. This effect is best visible in the last two minima, which occurred after the onset of the nebular stage.

The physical nature of the brightness increases during the stages of activity differs. The main outburst was caused by the TNR on the cool white dwarf. Both stages of activity in 1996, well registered by visual observers, consist of two subsequent flares (Fig. 1). They could be powered by the TNR on the surface of the white dwarf leading to the common envelope object surrounding the inner binary followed by the accretion of the transferred matter onto the surface of this object. The increase of activity in January and February 1997 was caused either by the enhanced mass transfer from the red dwarf to the hot component, or by the TNR on the surface of the hot white dwarf. The increase of activity in August 1997 was certainly caused by the TNR on the hot white dwarf. The spectra in maximum brightness resemble to that of a WR star, while before and after the outburst they exhibit typical emission features of an expanding envelope (O'Brien et al., 1998).

Although photometric data support the view that V723 Cas is a triple system consisting of a close binary with the orbital period 0.63 days and a third body (most probably a cool giant) with a 180 days eccentric orbit, further photometric and spectroscopic observations are needed to prove this model.

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