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The orbital periodicity in the different outburst stages of Nova Cassiopeiae 1995 (V723 Cas)

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Abstract. The amplitude of the orbital periodicity with $P = 0^d.693265$ changed from $0^m.07$ V in September 1997 to $0^m.73$ V in the second part of 2000. The system displays the properties of an eclipsing interacting binary. The small amplitude orbital light variations were found in the pre-maximum stage. The structure of system in outburst, and the nature of flaring episodes during the light decay are discussed.

V723 Cas ($1^h05^m05^s.353$, $+54°00'40''.13$, 2000.0) was discovered by Yamamoto (1995), and reached peak brightness of $7^m.10V$ in JD 2 450 069. Goranskij et al. (1998) measured its quiescent brightness in DSS of $19^m.0 \pm 0^m.2B$ and $17^m.5 \pm 0^m.5R$. V723 Cas had a 100 day long pre-maximum stage of stable photosphere F supergiant (Munari et al. 1996). The slow decay was followed by several local outbursts or flaring episodes. The orbital period of $P = 0^d.69325$ is observed since September 1997 (Goranskij et al. 2000).

Our photoelectric and CCD $UBVR_J$ photometry was carried out since August 1995 till January 2001 with 9 telescopes having apertures between 0.38 and 1.25 m at Sternberg Astronomical Institute and its Crimean station, Crimean Astrophysical Observatory (Ukraine), Tien-Shan Astronomical Observatory (Kazakhstan), Special Astrophysical Observatory and Institute of Astronomy Zvenigirod station. Different CCDs, single- and multichannel photometers were used. In 1999–2000, many long time series in R band were taken with different telescopes. The published data by Chochol & Pribulla (1997,1998) were used in the analysis, too. All the data have been combined and reduced to a single uniform series, taken by N.V. Metlova with V.M. Lyuty's UBV-photometer. We have also two spectra with the resolution of 5 Å taken with 6-m telescope BTA in January 2001.

The amplitude of the periodicity detected in September 1997 at the level of $0^m.07$ is gradually increasing, and has already reached the values of $0^m.71, 0^m.73$, $0^m.68$, and $0^m.54$ in U, B, V, and R filters between July 2000 and January 2001.

Mean brightness and colours were $V = 14^m.1$, $U-B = -0^m.90$, $B-V = 0^m.30$, and $V-R_J = 0^m.45$ at the end of 2000. The light curve had a sawtooth shape, with rapid raise, slow decay, deep Min I with a flat bottom, and Max I near the phase of $0^m.35$. Max II is strongly depressed, and sometimes looks like a hump. Apparently, the system is highly inclined and may be eclipsing. O-C analysis gives the following ephemeris for mid-eclipse:

$$\mathrm{Min\,I} = 2451842.666 + 0^d.693265(\pm 8) \times E \qquad (1)$$

The spectra taken in the eclipse show the blue continuum, and the bright emission lines characteristic of nebular phase. Hα has a Gaussian profile with EW= –690Å. He II λ 4686 takes the second place of the brightness scale with EW= –120Å being 20 per cent brighter than Hβ. There are many bright forbidden lines of highly ionized atoms, e.g. [Fe VII], [Fe VI], [O III], [Ca V]. Taking into account the emission line contribution of the nebular component, we find the amplitudes of orbital light variation in continuum of about $1^m.0$ in BVR bands.

With the known orbital period, we have found some traces of orbital periodicity in the early stages of outburst. The trend subtraction procedure, and cleaning of light curve for the low frequency noise components of Fourier spectra were applied. The periodic component with amplitude of 1.4 per cent was present in the B and V bands in the pre-maximum stage. The system was embedded inside the stable photosphere of the F supergiant at that time. The light curve was single-wave shaped with the light minimum at phase $\phi = 0^m.75$. The variations were apparently due to nonuniform brightness distribution of the photosphere, but were not due to elongated shape of its equipotential surface. The periodicity with the amplitude of $0^m.12$ was detected also in the 2.5 month time interval after May 15, 1996 being single-wave shaped with minimum at $\phi = 0^m.75$, too.

We assume the following scenario of Nova V723 Cas in the decay of its light curve. In the common envelope F supergiant phase, the cool companion of binary was heated. Its mass loss had increased highly, that led to formation of massive internal accretion disc around the white dwarf. The instabilities of this disc might be the cause of repeating flaring during the light curve decay. The radius of the photosphere was gradually decreasing, and the moment began (late 1997) when the photosphere had detached, getting the Roche lobe of the white dwarf. The sawtooth light curve in 1998–2000 suggests that the accretion rate stays very high this time, because the absorption in the optically thick gaseous stream and in the rim of the disc depresses brightness in Max II. This scenario goes by many years in V723 Cas being a slow nova.

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