ON QUASI–PERIODIC INTRINSIC LIGHT VARIABILITY IN A CLOSE SPECTROSCOPIC BINARY CX DRA

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ABSTRACT. Quasi–periodic light variations of bright spectroscopic emission-line binary CX Draconis were discovered based on observations at Tallinn Observatory in 1981-1990.

Key words: Stars: binary; stars: individual: CX Dra.

1. Introduction

CX Draconis is long known as a bright star whose spectra display bright hydrogen lines (Merrill and Burwell 1943).

Lacoarret (1965) found that the star displays variations of the ratio V/R of the emission lines and variations of the ratio E/C of the intensity of this emission to that of the adjacent continuum. The star shows variations of H_α profile with a period of about 7 days, while the E/C variation has been estimated as having a cycle of 3 years.

Merlin (1975) found that this star displays variations in U,B,V larger than $0\overset{m}{.}1$ but shows no true periodicity. Harmanec et al. (1981) called for systematic observations of the object. Guinan et al. (1984) discovered from observations with HEAO 2 Einstein Observatory, that CX Dra is moderately strong X-ray source. Horn et al. (1992) found the orbit parameters for both components.

Šimon (1996) found parameters for both components: a detached primary (B2.5V, 7.3M$_\odot$, 4R$_\odot$) and a secondary (F5III, 1.7M$_\odot$) probably filling in its Roche lobe. The inclination angle i=50°. The equatorial rotational velocity of the primary 210 km/s is highly asynchronous. Emission lines of H_α and HeI 6678Å, were analysed. The V/R ratio of the double peaked emission in the original spectra of H_α smoothly varies with the orbital phase. The difference profiles constructed by subtracting the synthetic spectra of both components from the observed spectra enabled studying the non–photospheric emission (presumably originating in the circumstellar matter). The non–photospheric emission in H_α is interpreted in terms of two distinct components. The broad part following the RV curve of the primary belongs probably to the accretion disk while the other component (narrow peak) cannot be linked with any star. The velocity field of the narrow peak offers a possibility that this feature is connected with the mass stream. The broad double–peaked emission attributed to the accretion disk around the hot primary is visible also in HeI 6678Å. The temperature of the disk must therefore correspond at least to 11000-12000 K and this disk is significantly hotter than in most other Algol–type systems. Conspicuous secular changes of the emission in HeI 6678Å, were revealed. The analysis presented by them led to the conclusion that the Be phenomenon in CX Dra can be explained by the mass transfer in the interacting binary. An extensive collection of spectroscopic observations of CX Dra spanning a 23 year interval have been analyzed by Richards et al. (2000). Their analysis includes a refinement of the orbital solution of CX Dra; equivalent width measurements that show short-, medium-, and long-term behavior of the difference profiles; a calculation of the Balmer decrement; velocity maps based on the velocity curves of the H_α and HeI difference emission peaks; trailed spectrograms of the H_α, H_β, HeI, and SiII lines; and Doppler tomograms at these four wavelengths. The main conclusions by Richards et al. (2000) are:

1. The circumstellar environment in the system changes in cycles of hundreds of days. The length of the cycles is variable. These cycles may be part of a "super" 4000 day cycle.

2. The equivalent widths of the difference H_α and HeI 6678 lines are modulated with the orbital period of $P_{\rm orb} = 6.696$ days.

Berdyugin and Piirola (2002) find from their *UBVRI* polarization measurements that the time scale of several weeks polarization variations clearly correlate with the binary orbital motion and long term changes in polarization are seen in the course of several months. From analysis of the periodic component of polarization they found orbital inclination (i∼73°)

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which is substantially higher than values previously reported. Their two datasets obtained about 9 months apart reveal significant changes in the distribution of the scattering material of the circumbinary envelope.

2. Observations

CX Dra was observed with the Tallinn 50-cm telescope (from 1981, up to 1990 in total 112 nights in *UBVR*). The root–mean–square errors of the normal points, as calculated from the measurements of comparison and the check stars, are less than $0^{m}.004$ for *V*, *B-V* and *V-R*, in *U* may reach up to $0^{m}.006$. It took 30-40 minutes to get one normal point, depending on the weather conditions. The data of CX Dra, comparison, check and red standard stars are given in Table 1.

Table 1: CX Dra and standard stars

Star		Sp.	*V*	*B-V*	*U-B*
CX Dra	HD 174237	B5	5.9		
comp.	HD 173664	A2	6.19	0.08	0.13
check	HD 172883	B9	5.99	-0.07	-0.23
red std.	HD 175225	G8	5.50	0.84	0.52

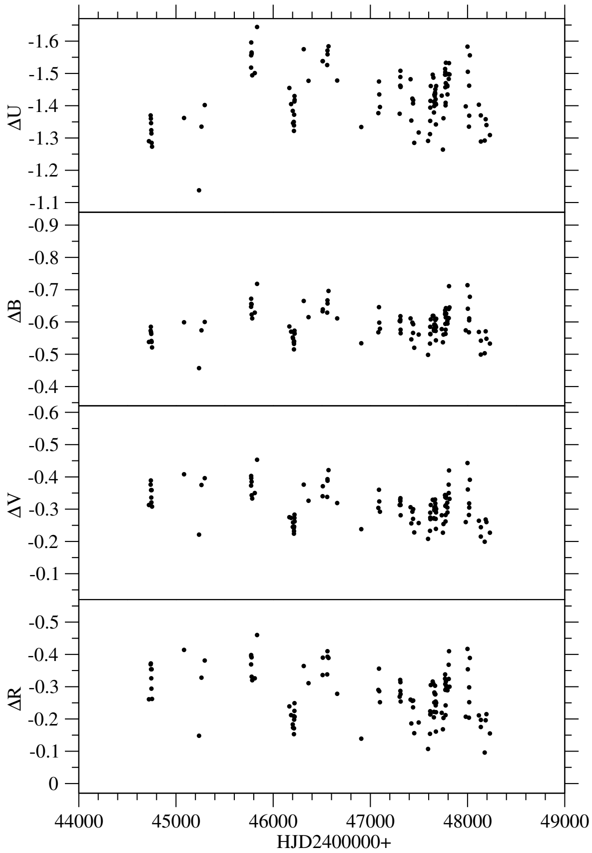

Figure 1: Time diagram for CX Draconis

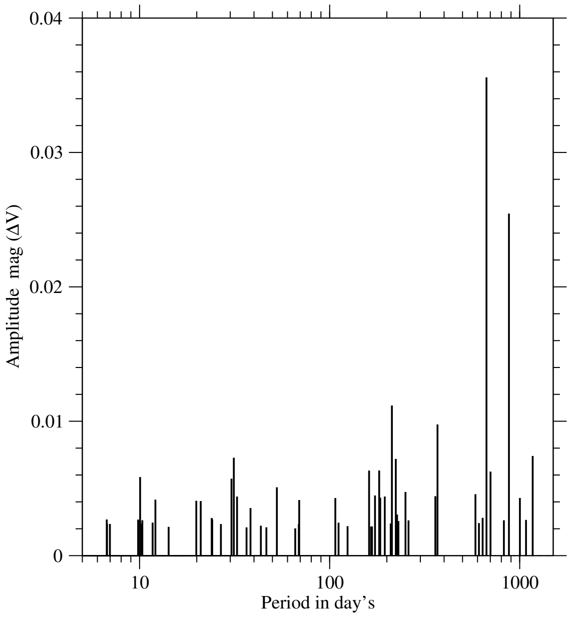

Figure 2: Time–series spectrum of the CX Draconis found by using the CLEAN algorithm (Roberts et al., 1987)

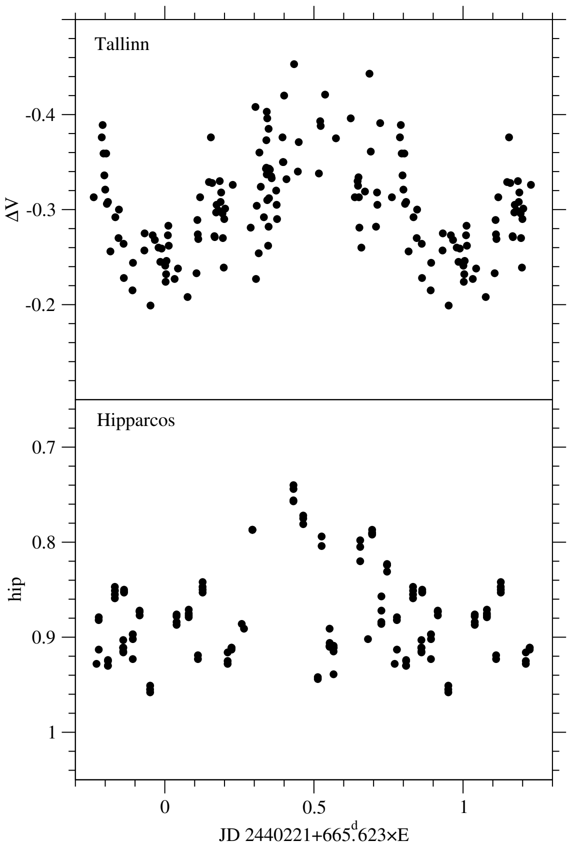

Figure 3: Phase diagram for CX Draconis: upper graph JD 2444721-2448230 and bottom graph JD 2447892-2449050

All measurements have been reduced to the Johnson's system and are available in Kalv et al. (2004) and indicated in Figure 1. The observations were carried out at Tallinn Observatory (former observational station of Tartu Observatory and now is the educational observatory of Tallinn University of Technology). The photoelctric photometers were attached to the Cassegrain focus of the 48 cm reflector AZT-14A (d/f=16).

Photomultiplier Tubes used:

1. EMI 9502B from JD 2439430 to JD 2444000
2. EMI 9502SA
   (a) from JD 2444100 to JD 2444317
   (b) from JD 2445500 to JD 2450220
3. FEU-79 from JD 2444317 to JD 2445000

Filters:

1. B BG–12 + GG–13 (1mm+2mm)
   V GG–11 (2mm)
2. U UG–2 (2mm)
   B BG–12 (1mm)
   V GG–11 (2mm)
   R Photographic
3. U UG–2 + SZS–21 (2mm+3mm (for red leak))
   B BG–12 + SZS–21 (1mm+3mm)
   V GG–11 + SZS–21 (2mm+3mm)
   R Interference Filter $H_\alpha \pm 450$Å
   H_α Interference Filter $H_\alpha \pm 45$Å

As only differential observations of variable stars relative to a comparison stars are made in Tallinn, attention was given to the determination of the mean extinction coefficients. Among several methods of the determination of extinction the differential method (Hardie 1962) is the most suitable for our purposes.

The generic formulae for reductions of observations are:

$$\Delta(U-B) = [\Delta(u-b) - k'_{u-b} \times \Delta X] \times C_1$$
$$\Delta(B-V) = [(1+k''_{b-v} \times \overline{X}) \times \Delta(b-v) - k'_{b-v} \times \Delta X] \times C_2$$
$$\Delta V = \Delta v - k'_{v} \times \Delta X - C_3 \times \Delta(B-V)$$
$$\Delta(V-R) = [\Delta(v-r) - k'_{v-r} \times \Delta X] \times C_4$$

And the coefficients in formulae above are:

	JD 2439430–2444000	JD 2444100–2444317 JD 2445500–2450220	JD 2444317–2445000
k'_{u-b}		0.26	0.32
k'_{b-v}	0.20	0.20	0.18
k'_{v}	0.36	0.36	0.24
k'_{v-r}		0.11	0.11
k''_{b-v}	0.05	0.05	0.04
C_1		1.19	1.12
C_2	1.19	0.94	1.00
C_3	0.07	0.09	0.11
C_4		1.09	1.09

3. Discussion of results

CX Draconis is relatively well observed for tens of years and the spectral observations of different investigators are in rather good agreement. At same time almost every photometric study gives the new significantly different results. To find period of light variations we used Roberts et al. (1987) time–series spectral analysis CLEAN algorithm. In time of our observation the quasi–period of intrinsic variations of light was about 665.6 days.

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