UBV MONITORING OF 4 DRACONIS: FIRST YEAR RESULTS

Zdeněk Urban and Ladislav Hric
Astronomical Institute of the Slovak Academy of Sciences,
059 60 Tatranská Lomnica, Czechoslovakia

ABSTRACT. We report the preliminary results of the first year of the UBV monitoring of a unique symbiotic-like/cataclysmic triple system 4 Dra. The observed long-term behaviour of the system in U and B colours, well correlated with the RV -based orbital ephemeris given by Reimers et al. (1988), suggests that we have accomplished the first optical photometric detection of the orbital motion within the 4 Dra A + BC system. The light curves in all three colours demonstrate the presence of an irregular variability on time scale of weeks to months with a general morphological similarity between the filters. The data show also the signs of rapid (hours) changes most apparent in the U-filter.

1. INTRODUCTION

Although the bright M3 IIIa star 4 Dra (HD108907, HR4765) has long been known to be a spectroscopic binary, the catalogues do not contain much specific information about the system. Eggen (1967) has determined 4 Dra to be an irregular photometric variable with an amplitude of about 0.1 mag in the V band. In the GCVS (Kholopov et al., 1985), the star - as CQ Dra - is assigned to be a slow irregular pulsating giant. The new era in the study of 4 Dra has started after the discovery by Reimers (1985) who found that the giant star has a hot companion of a cataclysmic nature (judging from some features of its IUE UV spectra). Brown (1987) has found 4 Dra to be also a radio variable on time scale of weeks to months, with some hints for rapid variability on time scale of hours. In a seminal paper, Reimers et al. (1988) have derived a RV-based orbital solution for the system with the orbital period P_{orb} of about 1703 days, e of about 0.3 and $a_i \sin i$ of about 4 AU. They also found a 4-hour UV spectral modulation and interpreted it as an orbital period related to the hot component. The modulation is superimposed on a longer time scale UV variability. This has affirmed the CV classification of the hot companion which, according to a canonical model of cataclysmic variables (c.f. King, 1989), should be a white dwarf-red dwarf binary with P_{orb} of several hours. The hot companion binary has been assigned as 4 Dra BC, the cool giant being 4 Dra A. With such a unique structure the 4 Dra system combines in itself some basic properties of a symbiotic binary (red giant vs hot companion) and a cataclysmic one (4 Dra BC). This makes 4 Dra to be a place of high importance for our understanding of both above classes of interacting binaries. Eggleton et al. (1989) have already derived constraints on the cataclysmic variable evolution from the observed structure of 4 Dra.

In order to contribute to the understanding of this exciting system we have, as a first step in our study, started the UBV monitoring with the primary aim to improve as yet very poor photometric coverage of 4 Dra. In this paper, we describe some preliminary results of the first year of the monitoring.

2. OBSERVATIONS AND METHODS

All our observations were performed while using the 60 cm reflector of the Skalnaté Pleso Observatory and a single-channel pulse-counting photoelectric photometer with the standard UBV filters. We have obtained a total of 33 observational runs in 32 nigths between 1989 March 12 and 1990 April 1. The details of the observational method and the reduction processing as well as the exact tabulation of the UBV measurements will appear elsewhere in these Contributions (Skopal et al., 1990; another paper now in preparation). Here we only mention that for the sake of the study of long-term trends and longer time scale variability (weeks to months) the mean values in U, B and V colours for individual runs were calculated. Nevertheless, we have looked also into the individual one-run data for getting some preliminary impression of a possible photometric behaviour on time scale of hours.

3. RESULTS

The graphical presentation of our long-term data (Fig. 1) shows that in spite of their still limited extent - we have covered only about 25 % of the 1703-days orbital cycle as yet - the data have already provided us with some interesting findings. These can be summarized in two basic points whose reality seems to be proved by now and a third one which has yet to be confirmed.

(1) We have found no clear long-term trend in the V colour. The U and B data, however, demonstrate the presence of an overall decline by about 0.3 mag in U and 0.2 mag in B. Best fits to the U and B data show that towards the end of the observational interval the decline transforms itself into a kind of plateau.

(2) There are marked longer time scale (weeks to months) irregular variations in all three colours. The amplitude amounts to 0.15 mag in several cases. The variations exhibit a general mutual morphological similarity between the filters. The course of the U, B and V light curves is to a large extent identical except for the general long-term slope.

(3) In several runs (Fig. 2) the data reveal signs of rapid changes on time scale of hours, best pronounced in the U-filter. The amplitude is generally about 0.05 mag but has approached 0.1 mag in a few cases. The changes appear to be above an observational error and thus be real at least in some runs. We plan to obtain some specially designed observational runs which should prove/disprove the reality of these or even more rapid changes presumably connected with the hot component binary in the 4 Dra system.

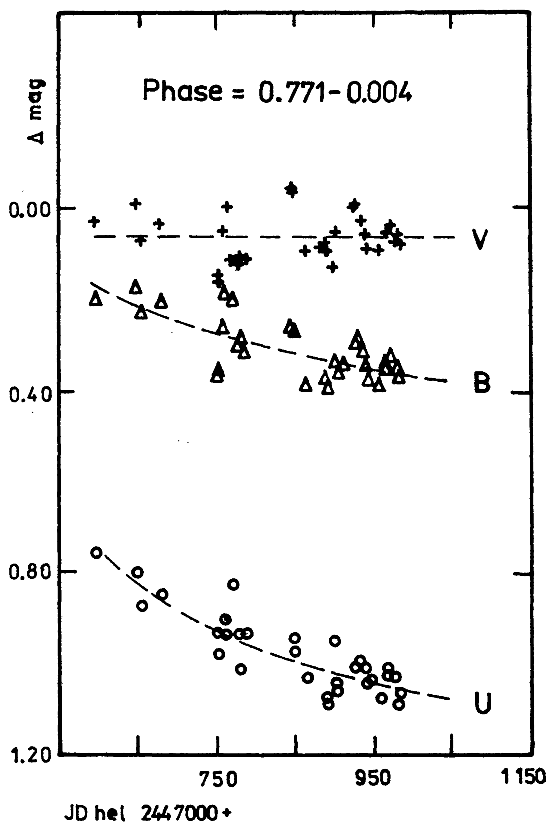

Fig. 1. The long-term UBV behaviour of the 4 Dra system between 1989 March 12 and 1990 April 1.

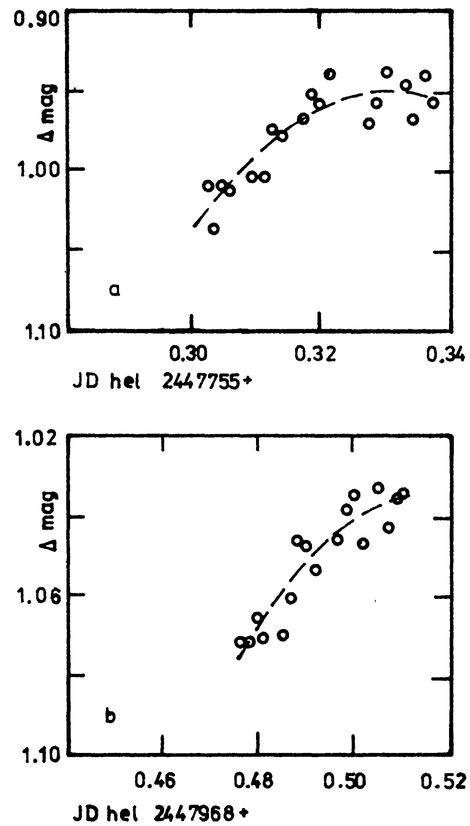

Fig. 2. Two examples of rapid changes (hours) observed in the U-filter data: Fig. 2a - 16/17 Aug 1989 (upper); Fig. 2b - 17/18 Mar 1990 (lower).

4. DISCUSSION

(1) The long-term decline observed in the U and B data covers the phase interval 0.771-0.004 of the orbital ephemeris given by Reimers et al. (1988). This very fact along with the decline-plateau transition evident in our U and B data before the expected phase zero lead us naturally to the conclusion that a kind of eclipse/obscuration is taking place within the 4 Dra A + BC system. The observed decline in the higher energy bands (U and B), not evident in the V band, seems to be a logical consequence of the expected system geometry for the hot 4 Dra BC component, now somewhere behind the 4 Dra A when viewed from the Earth, contributes mainly to U and B but much less to V.

(2) The observed irregular weeks to months variations correspond to V changes found already by Eggen (1967). They are simultaneously present in all three colours with some differences in amplitude and shape. We attribute them tentatively to the red giant component activity. The contribution of 4 Dra BC to this mode of variability (through an intrinsic cataclysmic activity) seems to be not apparent from our data.

(3) The real existence of rapid (hours) 0.05-0.1 mag optical variations in 4 Dra still cannot be considered to be proved definitely. The evidence is suggestive but needs further confirmation through the observational material with better resolution.

Summing it all up, we view as the main result of the first year of our UBV monitoring of the 4 Dra system the long-term U and B trend discussed in point 1. The data obtained lead us to the conclusion that we have accomplished the first optical photometric detection of the orbital motion within the 4 Dra A+BC system.

ACKNOWLEDGEMENTS

We are indebted to Messrs. Milan Gliviak and Miroslav Kandra of the Staff of the Skalnaté Pleso Observatory as well as to Dr. Milan Zboril for the obtaining of the parts of the observational material presented in this paper.

REFERENCES

Brown, A.: 1987, Astrophys. J. Lett. 312, L51.
Eggen, O.J.: 1967, Astrophys. J. Suppl. Ser. 14, 307.
Eggleton, P.P., Bailyn, C.D., Tout, C.A.: 1989, Astrophys. J. 345, 489.
Kholopov, P.N. et al. (eds.): 1985, General Catalogue of Variable Stars, "Nauka", Moscow.
King, A.R.: 1989, In Classical Novae, M.F. Bode and A. Evans (eds.), John Wiley and Sons, Chichester, p. 17.
Reimers, D.: 1985, Astron. Astrophys. 142, L16.
Reimers, D., Griffin, R.F., Brown, A.: 1988, Astron. Astrophys. 193, 180.
Skopal, A., Hric, L., Urban, Z.: 1990, Contr. Astron. Obs. Skalnaté Pleso 19, 123.