Multi-Wavelength Investigations of Solar Activity
Proceedings IAU Symposium No. 223, 2004
A.V. Stepanov, E.E. Benevolenskaya & A.G. Kosovichev, eds.

DOI: 10.1017/S1743921304007331

The Eclipsing Binary CM Dra: Solar-type Activity and Physical Parameters

A. V. Kozhevnikova[1], V. P. Kozhevnikov[1], P. E. Zakharova[1], T. S. Polushina[1] and M. A. Svechnikov[1]

[1] Astronomical Observatory, Ural State University, 620083, Lenin Av. 51, Russia
email: Kozhevnikova-a@yandex.ru

Abstract. The results of photometric investigations of the eclipsing binary CM Dra are presented. The observations of CM Dra were taken with the 70-cm telescope and two-star photometer of the Ural State University Astronomical Observatory in 1996–1997 (the total duration was 155 hours). The solution of the composite lightcurve yielded some fundamental physical parameters of CM Dra components. Four flares were observed, the calculated flare rate was 0.026. The Flares power was about handred times larger than solar ones. The CM Dra composite lightcurve shows the outside-eclipse low-amplitude (0.024mag) brightness variations which appeared to be shifted by 120 degrees in phase over a 20-years period. It may be explained supposing an appearance of the star spots on another longitude.

1. Introduction

CM Dra is a spotted eclipsing BY Dra star with a period of 1.27d. The BY Dra stars and their cousins, the RS CVn stars, often show brightness variations caused by star spots. Such variations in CM Dra were observed by Lacy (1977). Probably, because of their low amplitude (0.02mag) these variations were not described in the literature after 1977. In this paper we report results regarding the investigation of spot and flare activity of CM Dra and accurate definition of fundamental system parameters from our observations obtained at Kourovka observatory of the Ural State University during 1996–97.

The CM Dra is unique in its small size (the total surface area is 12 % of the Sun), its low temperature (dM4.5e+dM4.5e) and its nearly edge-on inclination of 89.8. At Kourovka observatory, we performed the CM Dra observations as a part of the TEP (Search for Transits of Extrasolar Planets) network observations (Deeg et al. 1998).

2. Spot and flare activity

The composite lightcurve of CM Dra is shown in Fig. 1. Each point is the average magnitude of 4–6 individual measurements obtained in different nights. The standard deviation of one point is less then 0.005mag. The outside-eclipse brightness variations with an amplitude of 0.024±0.004mag, which usually considered to be effects of starspots, are clearly visible. Similar sinusoidal variations of CM Dra with the similar amplitude were found by Lacy (1977). However, there is a remarkable distinction between the results obtained in 1977 and our results. The phase of the maximal brightness that was obtained twenty years ago was 0.28. The phase of maximal brightness in our observations is 0.60. The difference is approximately equal to 1/3 of the orbital period.

Our observations were made in R band only, so we could not use any starspot-modeling program. CM Dra brightness variations are rather small in comparison with amplitudes of other BY Dra stars (up to several tenth of mag), so we may suppose: if the spotted

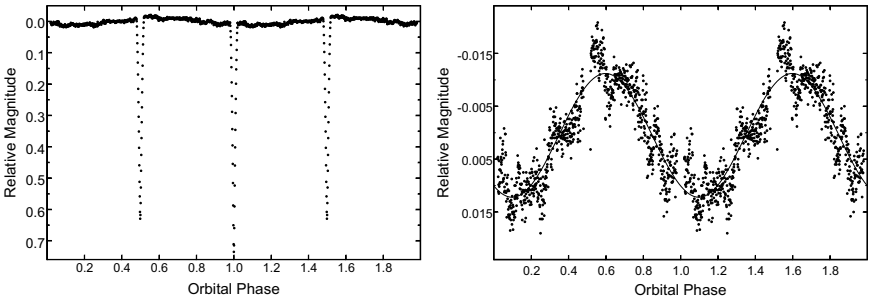

Figure 1. Lightcurve (left) and outside-eclipse brightness variations (right) of CM Dra

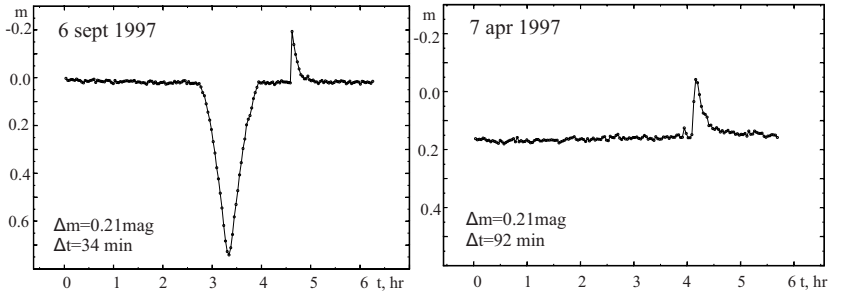

Figure 2. Two powerfull flares, their dates, amplitudes and durations

area in CM Dra is similar to spotted areas in most of the BY Dra stars, then the small amplitude of the brightness variations may be explained by a slightly nonsymmetrical shape of the great polar spot. CM Dra is old and tidally locked system, so differences in phases may be explained supposing appearing the star spot on another longitude (1/3 period, i.e. 120 degrees) (Kozhevnikov & Kozhevnikova 2002).

During two years of our observations 4 flare events were detected. The flare profiles are typical for solar ones (Fig. 2). The flare powers are grater then solar ones for up to 2 orders. The calculated flare rate (0.026 fl/hr) is very low for Population I flare stars, that is in good agreement with the results of Deeg et al. (1998).

3. Absolute dimensions and elements of photometrical orbit

The lightcurve solution was made by method of differential corrections. We obtained a good approximation of our photometric data for the following values: relative radii r_1=0.0681±0.0002, r_2=0.0612±0.0002, the relative light contribution of the primary star L_1=0.557±0.002. Absolute dimensions were calculated using the spectroscopic data of Lacy (1977): M_1=0.237±0.017, M_2=0.207 ±0.015, R_1=0.256±0.007, R_2=0.233±0.007 (in solar units).

Acknowledgements

We would like to acknowledge the useful comments of H.Deeg and L.Doyle.

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