COMMISSIONS 27 AND 42 OF THE IAU
INFORMATION BULLETIN ON VARIABLE STARS
Number 4733

Konkoly Observatory
Budapest
7 July 1999

HU ISSN 0374 – 0676

A PHOTOMETRIC UPDATE ON δ CORONAE BOREALIS

J.D. FERNIE

David Dunlap Observatory, University of Toronto, Canada, e-mail: fernie@astro.utoronto.ca

δ CrB (HR 5889, HD 141714) is a G5 giant star that has the unexpected property of being chromospherically active. Maggio et al. (1990) found it to be one of only two single giants out of 380 giants and supergiants studied that have an X-ray flux as high as RS Canum Venaticorum stars, while Young, Ajir, and Thurman (1989) report it to have one of the highest Ca II H and K reversal fluxes among the many stars they surveyed. Evans (1987) found it to show ultraviolet emission lines, such as C IV λ1549, that were similar to though less strong than those in λ And, a chromospherically active G8 III star.

Some years ago I accidentally discovered δ CrB to be variable in light with a V amplitude of about 0.06 mag and a quasi-period near 50 days (Fernie 1987, 1989, 1990, 1991). Since the fundamental radial pulsation period of such a star would be much less than 1 day, and since the star is chromospherically active, these results were interpreted in terms of a starspot model in which a few large spots on a limited region of the stellar surface modulate the light as the star rotates. The photometric data were in the UBV system, and the fact that the amplitude was (at least to first order) the same in each filter lent support to this interpretation. The fluctuating period was interpreted as due to starspots forming in and/or drifting to different stellar latitudes which presumably have different rotation rates. Choi et al. (1995) found similar photometric results, and provide Ca II flux measures (which vary strongly and inversely with visual brightness) as well as an extended discussion on the nature of the star. It might also be noted that O'Neal and Neff (1997), in a study of other active stars, used δ CrB as one of their 'inactive' comparison stars.

δ CrB has remained on my Automatic Photometric Telescope program, and I report here briefly on the star's photometric behaviour since my last published data nearly a decade ago. The complete file of individual UBV observations is available from the IAU Commission 27 archives of unpublished data as file no. 339E.

The data were analysed by annual season, this being a compromise between using enough data to get meaningful results (since the variability is small in the presence of relatively noisy data) on the one hand, while minimizing the effects of the known period instability on the other. Light curves for the seasons of higher amplitude are shown in the above cited papers.

All the data for a given season were plotted against Julian Date, and where a light curve was discernible a simple first-order sine curve was fitted. The amplitude, mean V magnitude, period, and time of maximum light as determined by this fit were then recorded. In the 1991, 1993, 1994, 1995, and 1996 seasons, however, no light curve was

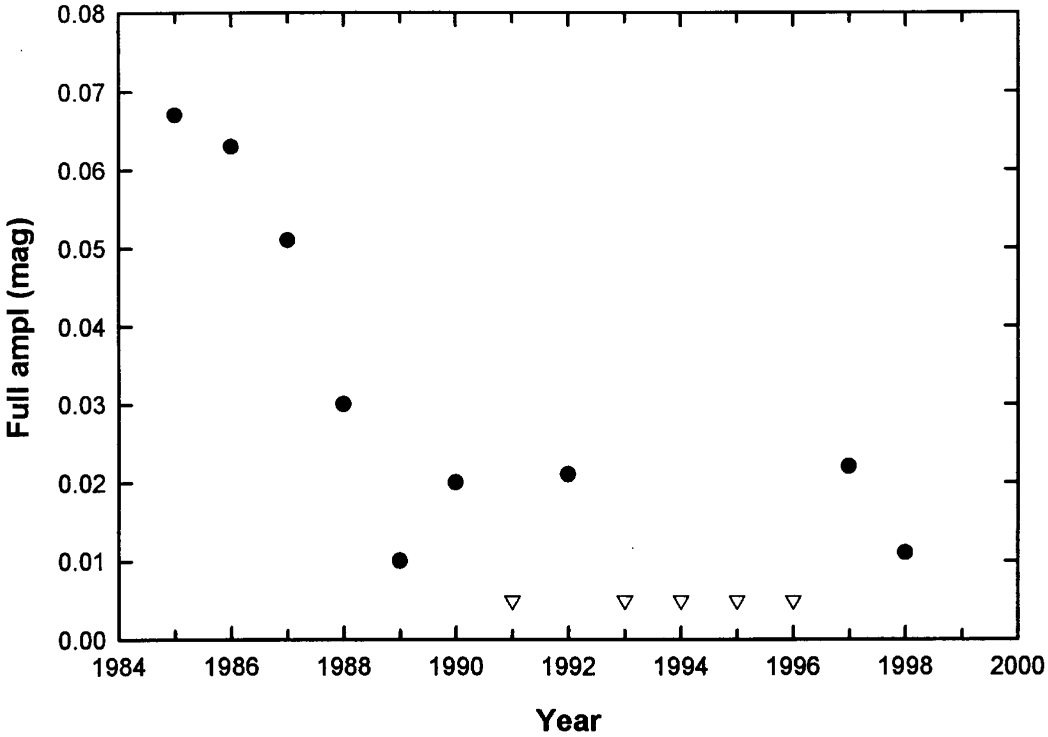

Figure 1. The changing V amplitude of δ CrB with time. The open symbols represent upper limits. Standard errors of the filled circles are approximately the size of the circles.

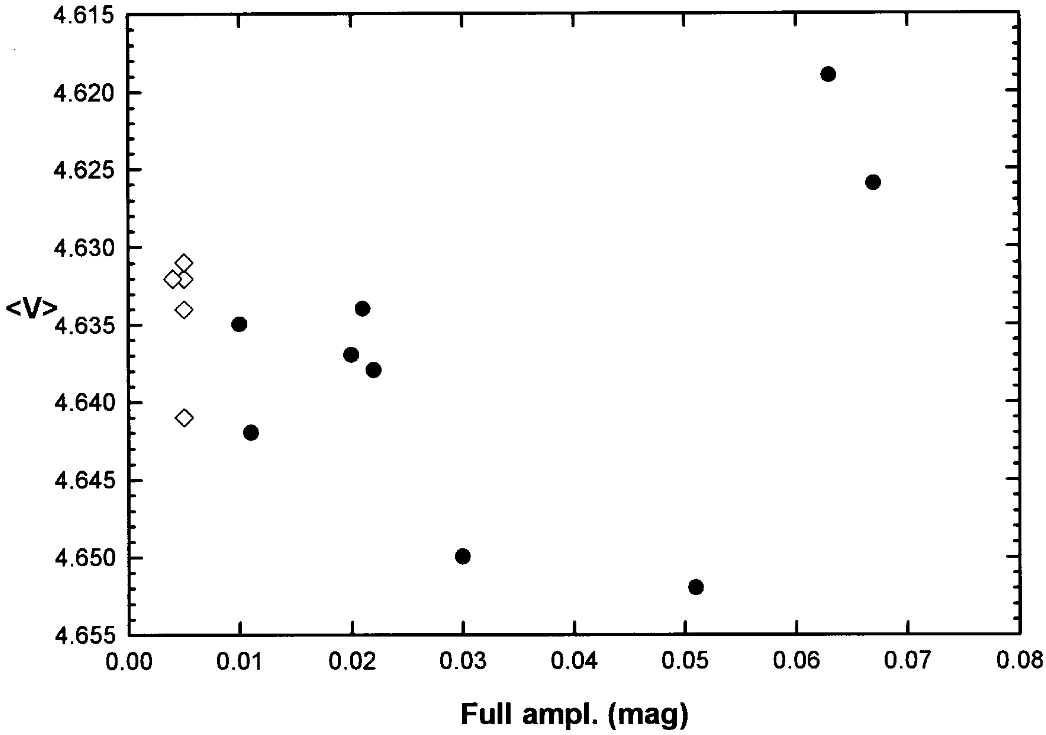

Figure 2. The change in mean magnitude with amplitude. The open symbols represent upper limits on the detectible amplitude.

Table 1: Amplitude & mean mag.

Year	Ampl.	$\langle V \rangle$
1985	0.067	4.626
1986	0.063	4.619
1987	0.051	4.652
1988	0.030	4.650
1989	0.010	4.635
1990	0.020	4.637
1991	< 0.005	4.632
1992	0.021	4.634
1993	< 0.004	4.632
1994	< 0.005	4.631
1995	< 0.005	4.641
1996	< 0.005	4.634
1997	0.022	4.638
1998	0.011	4.642

seen above the noise, and only the arithmetically averaged V magnitude was recorded, and an upper limit on the amplitude estimated.

For a spotted star only a characteristic period of variability can be given because of the differential rotation and the probably ever-changing spot pattern near the stellar surface. This problem is aggravated by the small amplitude and long time-scale of the variation observed in the case of δ CrB. For this giant star, summing up the photometric and spectroscopic observations obtained so far, we may adopt a characteristic period of the light variations (and hence, the rotation) as 58-59 days.

Figure 1 illustrates the change in amplitude over the 14 seasons. It steadily declined during the first 5 seasons, since when it has remained at a barely detectable or undetectable level. Thus if δ CrB has a spot cycle analogous to that of the sun, these data suggest it is longer than 15 years. It is also notable that whereas the solar cycle, having reached minimum, immediately starts up towards maximum again, in δ CrB it appears to remain at minimum for many years. There may, of course, be structure in Fig. 1 during the later years that is hidden by the noisy data, but if the cycle is sinusoidal then a discernible rise should have become apparent well before 1998. This extended interval near minimum was probably a factor which contributed to this 4th magnitude star not having been found earlier to be variable.

Figure 2 addresses the question of whether the overall brightness of the star varies with amplitude, that is, with degree of activity. The mean magnitude in this plot is derived from a sinusoidal fit to the light curve, or, in seasons of no discernible light curve, from an average of all the season's V measurements. The internal standard error of each point is about the size of the symbol in the figure, so there does seem to be a slight but definite change in brightness with amplitude, although the functional relationship is unclear and likely involves other parameters as well. At minimum amplitude the star is very close to $V = 4.633$, and as activity begins there is an initial fading towards $V = 4.653$ possibly caused by the increasing area of dark spots. When most active, however, the star is brighter than usual, perhaps because bright plages overwhelm the dimming effect of the spots.

It is a pleasure to thank the APT managers for their inestimable services. I am also grateful to Dr. Katalin Oláh for her suggestions as referee.

References:

Choi, H-J., Soon, W., Donahue, R.A., Baliunas, S.L., and Henry, G.W., 1995, PASP, 107, 744

Evans, N.R., 1987, Private Communication

Fernie, J.D., 1987, PASP, 99, 183

Fernie, J.D., 1989, PASP, 101, 175

Fernie, J.D., 1990, PASP, 102, 783

Fernie, J.D., 1991, PASP, 103, 1091

Maggio, A., Vaiana, G.S., Haisch, B.M., Stern, R.A., Bookbinder, J., Harnden, F.R., and Rosner, R., 1990, ApJ, 348, 253

O'Neal, D., and Neff, J.E., 1997, AJ, 113, 1129

Young, A., Ajir, F., and Thurman, G., 1989, PASP, 101, 1017