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UBV PHOTOMETRY OF BD+61°1211 DURING 1986 and 1987

BD+61°1211 (=DM UMa =#75 in the catalog of Strassmeier et al. 1988) is an unusually active noneclipsing RS CVn system. Kimble et al. (1981) report variations of about 0.32 mag during 1979. Mohin et al. (1985) find considerable variation in the amplitude of the light curves from 1980 to 1984. Crampton et al. (1979) find an orbital period of 7.492 days based on radial velocity variations. Nations and Ramsey (1986) find Hα emission variability on timescales as short as a few hours. These observations indicate a high level of chromospheric activity and possible variations in this activity.

We performed the observations between April and July 1986 and between February and July 1987 on the 24" telescope operated by San Diego State University at Mt. Laguna, CA. The photometer employs an EMI 6256 phototube, cooled to -10 F and operating at -1300V, and is equipped with standard Johnson UBV filters. We used a 19" aperture with a larger aperture on a few nights of poor seeing. Data were transformed to the standard Johnson UBV system. BD+60°1301 (= SAO 15365) was the comparison star, and BD+60°1306 (= SAO 15388) was the check star.

The light curves for BD+61°1211 are in Figures 1-3, with the 1986, early 1987 (February - April), and late 1987 (June - July) data indicated. We plot differential magnitudes in the sense star - comparison. Figure 4 shows the ΔV data on the check star plotted to the

same scale. The comparison star shows no evidence for variability. We computed the orbital phase using ϕ =JD 2443881.4 + 7.492E (Crampton et al. 1979).

Our 1986 V light curve (Fig. 1) is roughly similar to the 1979, 1980, 1983, and 1984 V light curves (Kimble et al. 1981, Mohin et al. 1985). However the 1981 and 1982 light curves show double rather than single peaks. In addition, the amplitude of variability and phases of maximum and minimum amplitude vary considerably between 1979 and 1986. The amplitude of variability ranges from 0.32 mag in 1979 to 0.115 mag in 1982. The Δ V at maximum brightness ranges from 0.30 to 0.47 with rapid year to year evolution. In terms of the starspot model a decrease in maximum brightness can be understood if the relatively unspotted hemisphere develops some small spots. A decrease in the amplitude of variation can be understood either as a decrease in the starspot activity if the Δ V at maximum is small (bright) or as a longitudinal spreading of the starspots if the Δ V at maximum is large (faint).

The 1987 light curves show rapid evolution in the behavior of this system. The amplitude decrease between 1986 and early 1987 is obvious. There is also a decrease between early and late 1987. These decreases confirm the very significant evolution on a 1 year timescale and indicate a less dramatic but still significant evolution on a timescale of a few months. The June-July 1987 variations are minimally larger than the variations in the check star ($\tilde{}$0.04 mag), indicating minimal variability during late 1987. The Feb.-April 1987 ΔV light curve has an amplitude of about 0.09 mag compared to the lowest previous amplitude of 0.115 mag.

In terms of the starspot model, we interpret the evolution in our light curves as the large spot (or group) visible in the 1986 data breaking up and becoming more evenly distributed. The maximum

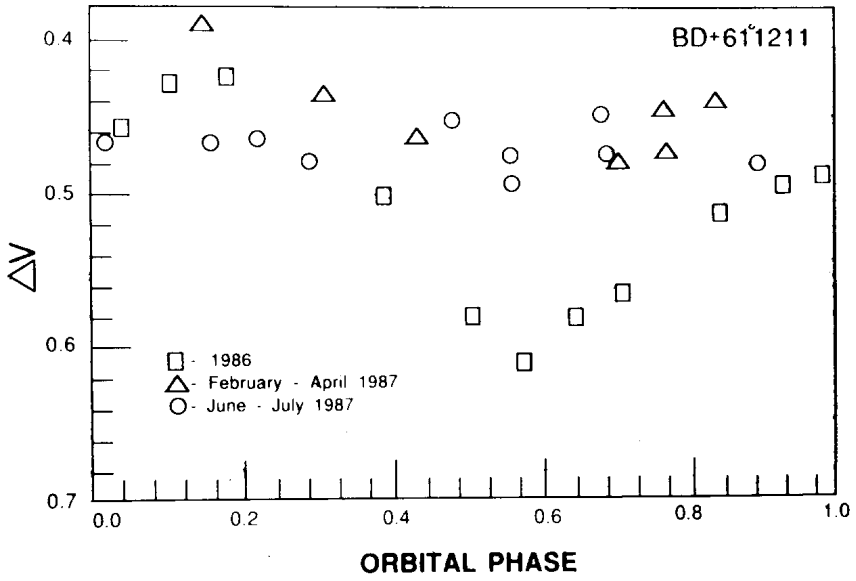

Figure 1

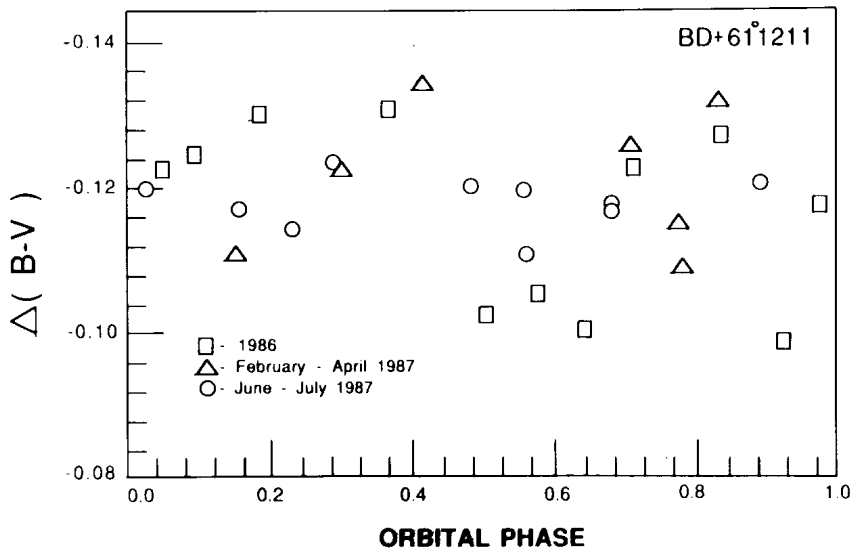

Figure 2

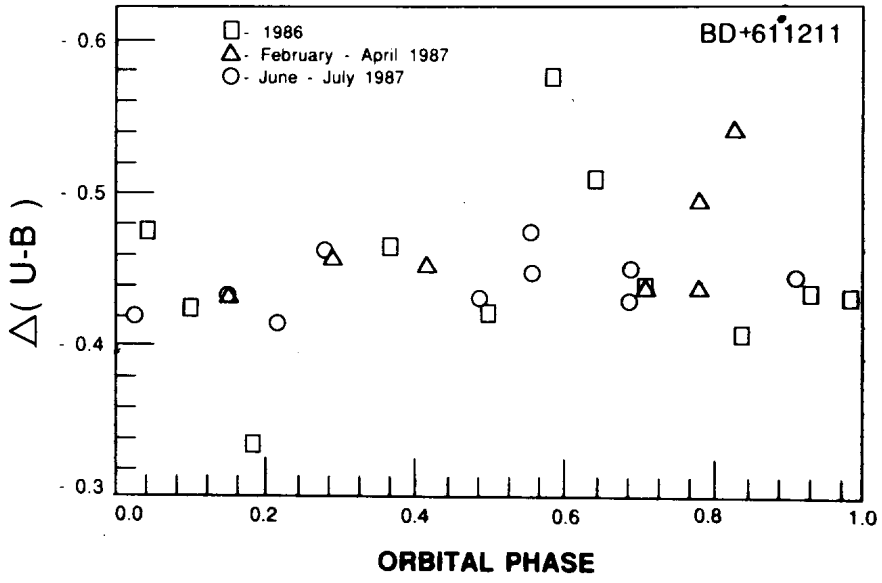

Figure 3

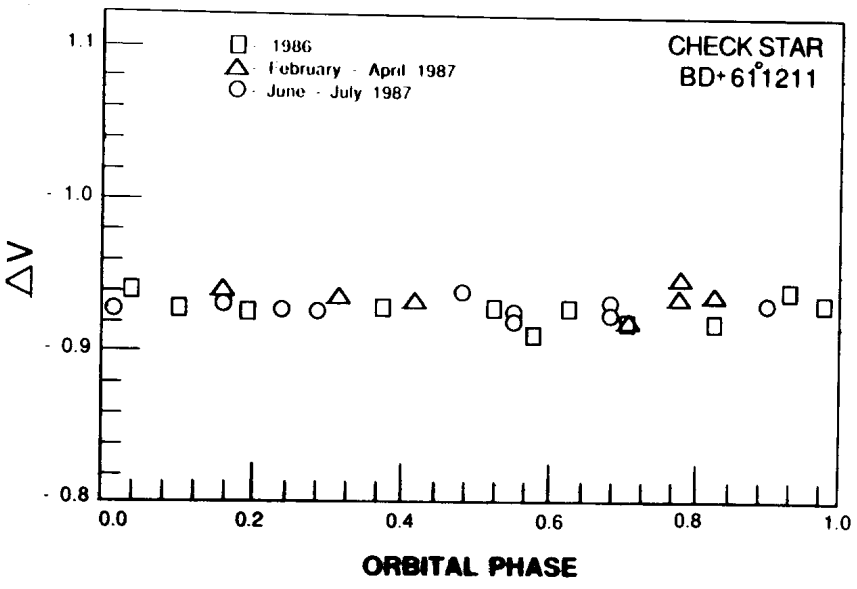

Figure 4

brightness in 1986 and early 1987 is roughly the same; so the spot concentration in the unspotted hemisphere did not increase significantly from 1986 to early 1987. Meanwhile the starspot activity in the spotted hemisphere decreased significantly during the same time, as shown by the decrease in the Δ V amplitude. Between early 1987 (Feb. - April) and late 1987 (June - July) the amplitude of the ΔV curve decreased even more, suggesting a near cessation of the spot activity on the formerly spotted hemisphere. During late 1987 however, the system is about 0.08 mag fainter in V than the maximum brightness during 1986 and early 1987. We therefore infer that the spots did not disappear completely, rather they became more uniformly distributed over the star's surface.

Our Δ(B-V) and Δ(U-B) color curves show similar evolution. Kimble et al. (1981) find that their Δ(B-V) curve has a large amplitude with the maximum and minimum at roughly the same phase as the ΔV curve. We find the same trend in our 1986 Δ(B-V) curve and the opposite trend (with somewhat more scatter) in the 1986 Δ(U-B) curve. As the amplitude of the ΔV curves decreases the amplitudes of the Δ(B-V) and Δ(U-B) color curves also decrease. The color curves are consistent with the hypothesis that spots cooler than the rest of the star cause the variations.

In conclusion, BD+61°1211 showed considerable variations in starspot activity between 1979 and 1986 and a rapid decrease during mid 1987. The starspots did not entirely disappear during 1987, rather they spread out more evenly over the entire surface.

During May 1988 one of the authors (PAH) obtained additional UBV photometry, which will be reported in a future paper. We plan to continue monitoring this system to determine long term cycles.

Ron Angione scheduled generous amounts of time on the Mt. Laguna 24" telescope for this work. Harold Nations suggested observing these stars and provided helpful comments.

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