BY DRACONIS AND RS CANUM VENATICORUM STARS: THE DISCOVERIES OF CLASSICAL PHOTOMETRY AND SPECTROSCOPY

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Physically quite dissimilar, the BY Dra and RS CVn stars have the common characteristic of extraordinarily high levels of stellar surface activity.

The RS CVn group, as defined by Hall, consists of detached binaries both components of types F, G, or K. The orbital periods are from a few days to a few weeks, and the mass ratios are generally near unity. Spectroscopically, the stars are remarkable in that they show very strong Ca II H and K emission outside eclipse. Masses and radii are known for many of these systems; physical parameters indicate these systems contain a moderately evolved subgiant, with mass slightly greater than 1 $M_{\odot}$. The ages (which may be verified by data on visual companions) are a few 10^9 years.

In contrast, the BY Dra variables are late-type dwarfs, with spectral types ranging from dK5e to dM4e. The e designation indicates the presence of Balmer emission, which is generally visible in moderate strength at Hα and only very weakly present in the blue. The BY Dra stars do exhibit strong emission at H and K, however, and also show UV Ceti-type flares. Approximately 75% of the BY Dra variables are known as double-line spectroscopic binaries.

Both the RS CVn binaries and the BY Dra stars exhibit light variations (outside of eclipse in the case of the RS CVn's) with amplitudes typically 0.1 - 0.2 mag. This variability may show changes in phase, slope, amplitude and even period from season to season. This behavior is best explained by cooler, darker areas on the surfaces of rotating stars. Starspot models have been fit to many of the light curves; though there are difficulties in finding a unique solution, essentially all the models have the spots covering 5 - 15% of the visible hemisphere, with T(photosphere) - T(spot) ~ 500 - 1000 K. Using a solar analogy, the spot model also suggests localization of Hα emission on the stellar surface, implying that a modulation of Hα should be seen in *antiphase* with the V light curve. This has in fact been observed in the RS CVn system UX Ari and the BY Dra variable CC Eri.

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Why are these particular stars prone to surface activity? We could argue that the underlying reason for the development of large active regions is *not* duplicity, as attractive as this initially seems to be. The BY Dra stars are not, in fact, all binaries; several show no velocity variations whatever, and since a pole-on BY Dra star could not have been detected, these stars must be truly single. But with photometric periods of a few days, these same single stars rotate considerably faster than their non-variable dM counterparts. "Rapid" [v(equatorial) $\geq$ 5 - 10 km/s] rotation appears to be the necessary and sufficient condition for the development of extreme surface activity in BY Dra and RS CVn stars. Single BY Dra stars are young and not yet rotationally braked; the binary objects are synchronously locked and thus have higher than normal rotation speeds. Certainly the RS CVn's have had their rotation characteristics altered by duplicity. Do "single" RS CVn's exist? Perhaps further observations of ξ Boo A and 31 Com are needed...

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