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1985/86 MULTI-COLOR PHOTOELECTRIC OBSERVATIONS OF THE STARSPOT ACTIVITY ON V711 TAURI (HR 1099)

Multi-color, intermediate and narrow band photoelectric photometry of the active, non-eclipsing RS CVn-type binary V711 Tauri (HR 1099, HD 22468, ADS 2644 A: K1 IV + G5 V; <V> = +5.8 mag; P = 2.84 days) has been obtained on 21 nights from 1985 September 7 UT through 1986 January 12 UT. The observations were carried out at the Villanova University Observatory using the 38 cm Cassegrain telescope which utilizes a photoelectric photometer that is equipped with a refrigerated EMI 9658 photomultiplier tube, and a microprocessor controlled data acquisition system. The characteristics of the intermediate band blue (λ4530), yellow (λ5500) red (λ6600), and narrow band red (λ6568) filters, as well as the observing procedure, data reduction technique, and explanation of the differential color and Hα indices have been given elsewhere (Guinan and Wacker 1985). All measures of the variable star included the fainter visual companion ADS 2644 B. The comparison star was 10 Tauri (HR 1101, HD 22484; F9 V; V = +4.28 mag). Unpublished observations obtained at Villanova during the 1983/84 and 1984/85 observing seasons which have monitored 10 Tauri with respect to 12 Tauri (HR 1115, HD 22796; gG6 ; V = +5.57 mag) indicate both stars are of constant brightness. Nightly mean differential magnitudes were computed, in the sense variable minus comparison, for the blue, yellow, and red observations, from which corresponding differential color and Hα indices were determined. The mean seasonal errors for the nightly $\lambda\lambda$4530, 5500, 6600, 6568, Δ(b-r) , Δ(b-y) , and $\Delta\alpha$(V-C) data sets are, respectively: 0.008, 0.006, 0.007, 0.012, 0.011, 0.010, and 0.014 mag.

The top panel of Figure 1 presents the nightly mean differential λ5500 magnitudes. The orbital phases were determined according to the ephemeris of Bopp and Fekel (1976).

$$HJD = 2442766.069 + 2^{d}.83782E$$

where zero phase corresponds to conjunction with the more active (K1 IV) component nearest the earth.

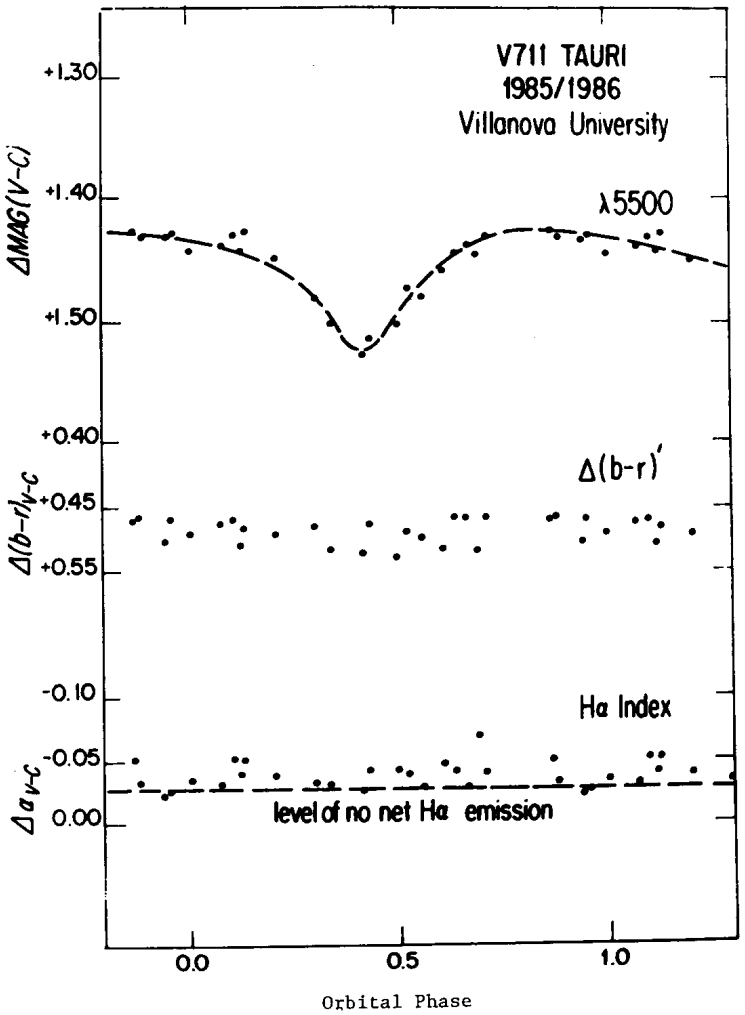

Figure 1. The 1985/86 photoelectric observations of V711 Tauri made with respect to the comparison star, 10 Tauri are plotted. The top panel is a plot of the nightly mean differential yellow magnitudes. The middle panel is a plot of the differential color index formed from the blue and red observations. The bottom panel is a plot of the differential H-alpha index, where more negative values indicate greater net H-alpha emission.

The differential yellow light curve possesses a broad, perhaps flat-topped, maximum extending from ≈ 0.70P to ≈ 0.15P, with minimum light occurring in the vicinity of 0.41P. Maximum, mean, and minimum light have the following approximate values, respectively (all expressed differentially relative to 10 Tauri): +1.430, 1.475, and 1.520 mag. The corresponding light amplitude is about 0.09 mag. The red light curve (not shown) is identical in shape, and has an amplitude of about 0.08 mag. Also not shown is the blue light curve whose shape is similar to the yellow and red light curves. The amplitude of the blue light curve is about 0.095 mag, but has an uncertainty of ±0.015 mag due to large scatter in the observations.

The middle and bottom panels of Figure 1 present the differential color curve, $\Delta(b-r)$, and the differential Hα index, $\Delta\alpha(V-C)$, respectively. No apparent phase dependency exists for both of these curves. The mean value for the $\Delta(b-r)$ data set ≈ +0.468 mag. The mean value for the $\Delta\alpha(V-C)$ data set ≈ -0.039 mag. Based upon the spectral types of the variable and comparison stars, $\Delta\alpha(V-C) \approx -0.035$ mag corresponds to the level of zero net Hα emission. When these $\Delta\alpha$ measures are compared with measures made in previous years at Villanova using the same equipment and filters, it appears that the overall level of Hα emission has significantly diminished. It would, however, be useful to verify this with direct spectroscopic observations of the Hα feature.

V711 Tauri is a constituent of the classical group of RS CVn-type binaries, a class of chromospherically active stars whose light variability is believed to be due to the rotational modulation of starspots located on the surface of the cooler component.The photometric behavior of V711 Tauri has been thoroughly monitored since 1976. The light curves often change dramatically from season to season in both shape and amplitude, as well as in mean, maximum and minimum light. Dorren et al. (1981), and Dorren and Guinan (1982) have successfully interpreted these seasonal photometric variations in the context of the starspot model, incorporating two large circular spots that are cooler than the surrounding photosphere. Unpublished observations obtained at Villanova during 1984/85 indicate the light curve of V711 Tauri at this time was quasi-sinusoidal in shape, with maximum light occurring near 0.78P and minimum light occurring at about 0.40P. At λ5500, the light amplitude had a value of 0.15 mag, with maximum, mean, and minimum light having the following values, respectively: +1.35, 1.43, and 1.50 mag (measured differentially relative to 10 Tauri). Comparing these values with those reported here for the 1985/86 light curve reveals that during the intervening six months the light curve of V711 Tauri experienced a large transition.

Although the phase of minimum light remained virtually unchanged, maximum, mean, and minimum light became considerably fainter, while the shape and amplitude of the light curve changed markedly.

Exploratory starspot modeling of the light curves of V711 Tauri obtained at Villanova over the past three observing seasons indicate the presence of two large circular spots located on the visible hemisphere approximately 1100 $\pm$ 150 K cooler than the surrounding photosphere. This temperature difference between the photosphere and the spots is in excellent agreement with the value of 1200 K derived by the Doppler-imaging study of V711 Tauri by Vogt and Penrod (1983), and with the lower limit of 1000 K determined from the TiO band spectroscopic measurements of Ramsey and Nations (1980). To reproduce the 1985/86 light curve, our preliminary modeling necessitates a large polar spot region, the majority of which always remains in view, accompanied by a smaller spot located close to the equator, and thus passing completely out of view as the star rotates.Furthermore, the decrease in the mean light level between the 1984/85 and 1985/86 light curves of 0.05 mag is indicative of an appreciable increase in the total spotted surface area of the active component. A more detailed analysis of these observations is in process and will be published elsewhere.

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