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1983/84 PHOTOMETRY OF THE SPOTTED STAR V 711 TAURI (HR 1099)

Intermediate and narrow band photoelectric observations of the bright (<V> = + 5.8 mag), active RS Canum Venaticorum-type star V711 Tauri (HR 1099, ADS 2644 A; K1 IV + G5 IV; P = 2.84 days) were obtained at Villanova University Observatory on 22 nights, from 1983 September 9 UT through 1984 February 27 UT. A description of the instrumentation, observing procedure, data reduction technique, and discussion of the differential color and H-alpha indices have been given elsewhere (Guinan and Wacker 1985). The comparison and check stars were the same used in previous photometric studies (Dorren et al. 1981; Nha and Oh 1986; Wacker and Guinan 1986). All measures of the variable included the faint visual companion ADS 2644 B (K3 V, V = + 8.83 mag). Nightly mean differential magnitudes were computed, in the sense variable minus comparison, for the intermediate band blue (λ4530), red (λ6600), and narrow band red (λ6568) observations, from which corresponding differential color and H-alpha indices were calculated. The seasonal mean errors for the nightly λλ4530, 6600, 6568, Δ (b-r)' , and Δ α (v-c) data sets are, respectively: 0.008, 0.007, 0.010, 0.011, and 0.013 mag.

The top panel of Figure 1 presents the intermediate band red observations. The orbital phases were computed from the ephemeris of Bopp and Fekel (1976). The amplitude of the red light curve is approximately 0.11 mag. Minimum light occurs at about 0.43P, while maximum light occurs near 0.73P. Maximum, mean, and minimum light have the following differential values, respectively: +1.125, 1.180, and 1.230 mag. The blue light curve (not shown) is similar in shape and amplitude. Continuous photometric coverage of V711 Tauri has been maintained between late 1975 (Bopp et al. 1977) and early 1986 (Wacker and Guinan 1986). Our intermediate band red observations presented in Figure 1, when transformed to V magnitudes, indicates the mean light level of V711 Tauri achieved its brightest value during 1983/84, corresponding to the epoch of minimum total spotted surface area.

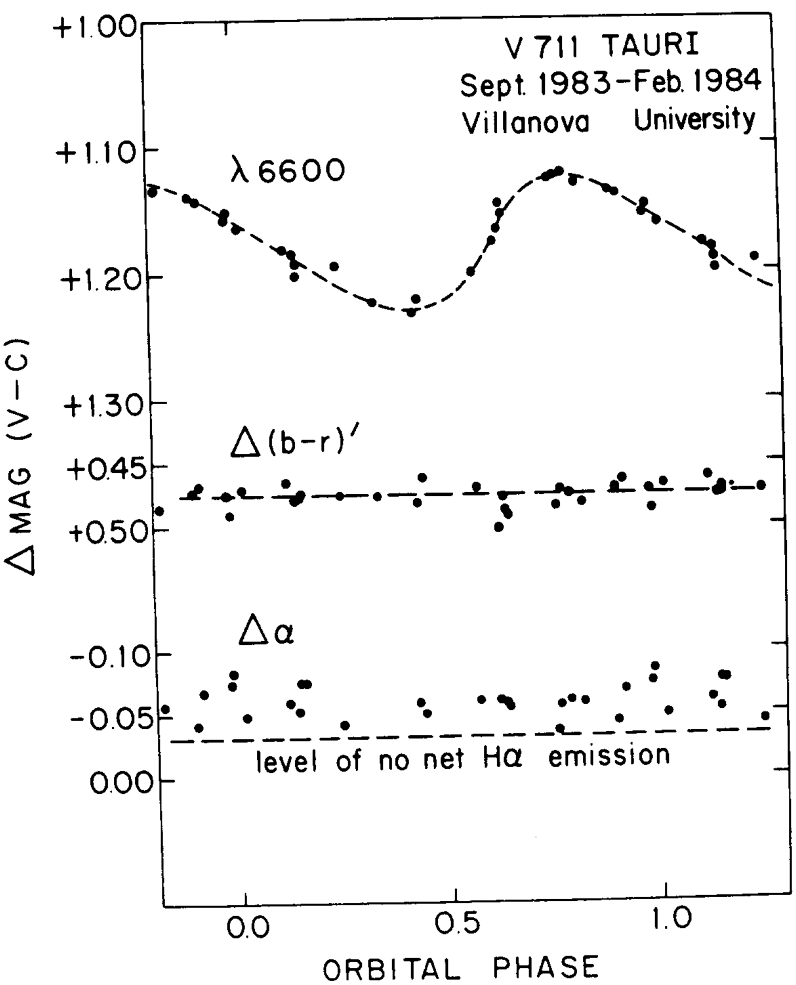

FIGURE 1

The 1983/84 photoelectric observations of V711 Tauri, made differentially with respect to the comparison star 10 Tauri, are presented. The upper panel is a plot of the nightly mean differential red magnitudes. The middle panel is a plot of the differential color index formed from the intermediate band blue and red observations. The lower panel is a plot of the differential H-alpha index, where more negative values indicate greater net H-alpha emission.

The middle panel of Figure 1 displays the differential color index, Δ (b-r)' , formed from the intermediate band blue and red differential magnitudes. This index provides a measure of the color changes of the variable relative to the comparison star. No apparent phase dependency exists for the color curve. The seasonal mean value for the Δ(b-r)' data set =+0.479 mag.

The bottom panel of Figure 1 is a plot of the differential H-alpha index, $\Delta\alpha$ (v-c), formed from the intermediate and narrow band red differential magnitudes. As with the color curve, no apparent phase dependency exists. The seasonal mean value for the $\Delta\alpha$ (v-c) data set =-0.054 mag. Based upon the spectral types of the variable and comparison stars, $\Delta\alpha$ (v-c) = -0.035 $\pm$ 0.010 mag corresponds to the level of zero net H-alpha emission.

It is generally accepted that the low amplitude light variations of chromospherically active stars arise from the rotational modulation in brightness of sub-luminous surface regions (i.e. starspots) assumed to be located on the cooler, more active binary component. Photoelectric monitoring of V711 Tauri has been in progress since late 1975. In the context of the starspot hypothesis. Dorren and Guinan (1982) successfully interpreted the seasonal changes in amplitude, maximum, mean, and minimum light of V711 Tauri using two large circular spots cooler than the surrounding photosphere. Utilizing high resolution, high signal-to-noise spectroscopy obtained in September/October 1981, the Doppler imaging study of V711 Tauri by Vogt and Penrod (1983) produced spatially resolved images of the spot distribution on the K1 component. Their results revealed the existence of two cool, large spot regions separated by about 110^{o} in longitude, with the larger spot located near the rotation pole, the other positioned slightly above the equator.

The spectroscopic study by Fekel (1983) presented revised determinations of the fundamental parameters of V711 Tauri, including the inclination of the binary system and the light contribution from the presumed unspotted components (the G5 secondary and the distant companion ADS 2644 B). Incorporating these parameters into the computer code developed at Villanova (cf. Dorren et al. 1981), Wacker and Guinan (1986) carried out light curve modeling of their 1985/86 observations of V711 Tauri and determined a temperature difference between the cooler spots and the surrounding photosphere of 1100 $\pm$ 150 K. The lack of a strong wavelength dependence for our 1983/84 observations is consistent with this temperature determination.

Based on observations obtained between August 25 and October 25, 1983, Gondoin (1986) applied the Doppler imaging technique to photospheric (Fe I) absorption lines and chromospheric (Ca II and H-alpha) emission lines of V711 Tauri.

The results of Gondoin's line profile modeling indicate the presence of two spot regions located on the K1 component. These spots cover about 20% of the stellar disk, are about 1000 K cooler than the surrounding photosphere, and are overlapped by bright solar-like chromospheric plages. The spots were located at latitudes of 62° and 65°, and were separated in longitude by 180°.

Using the spot model program, we generated theoretical light curves based on Gondoin's results assuming the two dark regions have equal areas (see Figure 10 of Gondoin's paper). The resultant light curves have two maxima and two minima, both of equal brightness, separated in phase by 0.50P, and having a small light amplitude of 0.02 to 0.03 mag at visible wavelengths. The characteristics of these theoretical light curves are not consistent with our observed light curves. Although the epochs of our photometry and Gondoin's spectroscopy do not coincide exactly, the stability of our light curves over the six month interval make it unlikely that any significant evolution of the spots, in terms of area or surface distribution, took place. Preliminary modeling of our 1983/84 light curves suggests the two spot regions are about 110° to 140° apart in longitude, are of different areas (2:1), and/or located at different latitudes. The results of both light curve and line profile modeling generally agree in that there exist two extensive spot regions, about 1000 to 1200 K cooler than the photosphere, with at least one spot located at high stellar latitudes. Vogt and Penrod (1983) have commented that line profile modeling is more sensitive to the latitude distribution of the spots, while light curve modeling is more sensitive to the longitude distribution. It would be ideal to develop a procedure involving iterative modeling of both the line profiles and the light curves.

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