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(NASA-CR-169711) ROTATIONAL MODULATION OF THE CHROMOSPHERIC ACTIVITY IN THE YOUNG SOLAR-TYPE STAR, X-1 ORIONIS (Hawaii Univ., Honolulu.) 4 p HC A02/MF A01 CSCL 03A

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ROTATIONAL MODULATION OF THE CHROMOSPHERIC ACTIVITY IN THE YOUNG SOLAR-TYPE STAR, χ^1 ORIONIS

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INTRODUCTION

Young main-sequence stars are known to have active chromospheres as observed by their high Ca II emission flux. Vaughan (1980) has found that the younger solar-type stars show chaotic variations in the Ca II K-line flux over a range of time scales. Evidence has been presented by Vaughan et al. (1981) that the short-term variations result from stellar rotation as different active areas rotate into view. One of the youngest G stars is χ^1 Ori (G0 V) for which Duncan (1981) derives an age of 6 x 10^8 yrs. from the Li abundance. Stimets and Giles (1980) have found a rotation period for χ^1 Ori of 5.10 days from an analysis of Wilson's (1978) data of the Ca II emission flux. The periodic variations found in this young star persist for a time > 500 days according to their analysis. If we combine Soderblom's (1981) value for v sin i = 9.4 km/s with log R/R_o = +0.02 and Stimets and Giles rotation period, we find i = 65°. We have looked for rotational modulation in the emission flux in the chromospheric and transition region lines in χ^1 Ori with the IUE satellite and for variations in the Ca II K-line profile with the CFH telescope at Mauna Kea.

OBSERVATIONS

With the IUE satellite we have observed χ^1 Ori during 3 different cycles over a time span of about 4 days each time during March 1981, October 1981 and February 1982. Four phases were observed at each cycle. Observations at high resolution of the Mg II resonance lines with the LWR camera and at low resolution with the SWP camera were made. Figure 1 shows the variations we found in the emission flux of the transition region line of C IV at 1549 Å. Note how well the observations from the 3 cycles, spread over 325 days, phase together.

No variations were found in the Mg II h and k lines at 2800 Å, however, as seen in Figure 2. The mean value of f_{line}/ℓ_{bol} = 6.35

(±0.22) x 10^5; that standard deviation corresponds to a flux constancy of ±3.5 percent.

As Figure 3 shows the emission from He II at 1640 Å seems to show variations in the same phase as those of C IV. This line may be formed by photoionization from coronal x-ray emission at an even higher temperature than the C IV line.

No definite periodic variations were found for any of the other lines measured: N V (1240 Å), OI (1305 Å), C II (1335 Å), Si IV (1400 Å), or C I (1657).

High-resolution (0.07 Å), high signal-to-noise observations of the Ca II K line-profile were made with the Reticon and coude spectrograph of the 3.6 m Canada-France-Hawaii telescope on Mauna Kea on 2 successive nights in January 1982. Figure 4 shows that not only does the total emission intensity increase (in proper phase with the C IV observations), but also that the blue-to-red K_2 intensities reverse.

CONCLUSIONS

It is clear that the same modulation of the emission flux of Ca II due to stellar rotation is present in the transition region feature of C IV, and probably of He II. For other UV lines the modulation is not apparent, due to a more complex surface distribution of the active areas or supergranulation network, or a shorter lifetime of the conditions which give rise to those features, or to the uncertainties in the measured line strengths. The Mg II emission flux is constant to within ± 3.5 percent implying a rather uniform distribution of Mg II emission areas. The Ca II emission not only shows a measurable variation in intensity, but also variations in detailed line profile shape when observed at high resolution. The combination of these data from various temperature regimes in stars will clarify the nature of their chromospheres and chromospheric activity.

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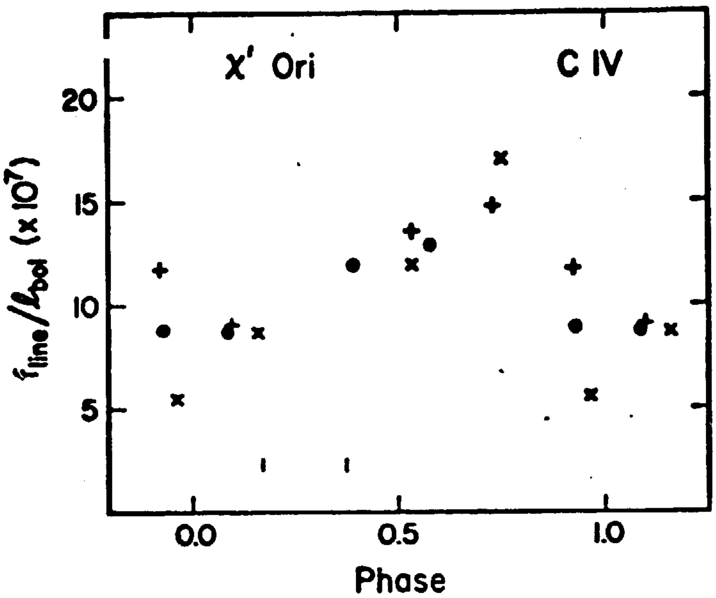

Figure 1 -- Observed variations in the emission flux of the C IV line at 1549 A in χ^1 Ori, a GO V star. The crosses represent observations in March 23-27, 1981, the pluses are from October 7-10, 1981, and the filled circles from February 11-14, 1982. The period used in 5.097 days, adjusted from the 5.10 day period of Stimets and Giles (1980), to fit our uv data, and phase zero is March 20, 1981. There is a slow increase in f_{line}/l_{bol} to 16 x 10^7 at phase 0.75 and a steep drop to 7 x 10^7 at phase 0.0. The two faint marks at phase 0.169 and 0.374 show the phases of the two observations of the Ca II K-line profile (see Figure 4).

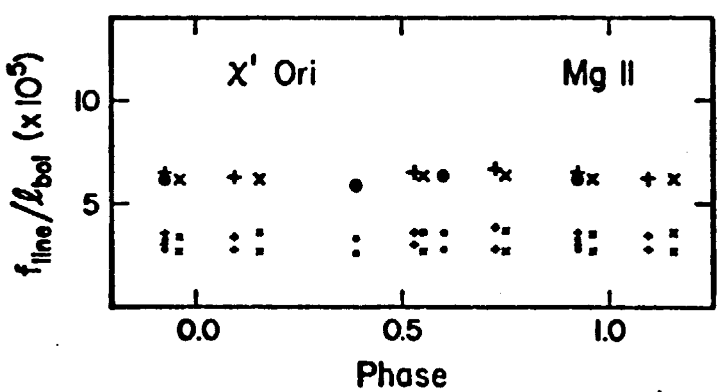

Figure 2 -- The observed flux in the Mg II h and k line at 2800 A throughout the 5.1 day rotation cycle of χ^1 Ori. The three observing periods are indicated by different symbols as in Figure 1. The large symbols correspond to the sum of the h and k lines while the smaller ones show the individual h (lower) and k (upper) lines. No variations are seen in the flux, or in the shapes of the line profiles. The mean value for f_{line}/l_{bol} is 6.35 x 10^5 $\pm$ 0.22 x 10^5 or $\pm$ 3.5 percent.

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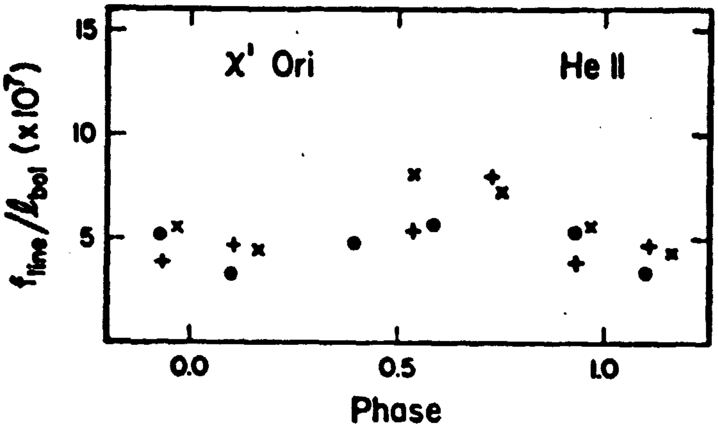

Figure 3 -- The observed flux in the He II line at 1640 A throughout the 5.1 day rotation cycle of χ^1 Ori. The three observing periods are indicated as in Figure 1. The shape of the variation is similar to that found for C IV with the maximum near phase 0.75 and the minimum near 0.0. The amplitude of the variation is less.

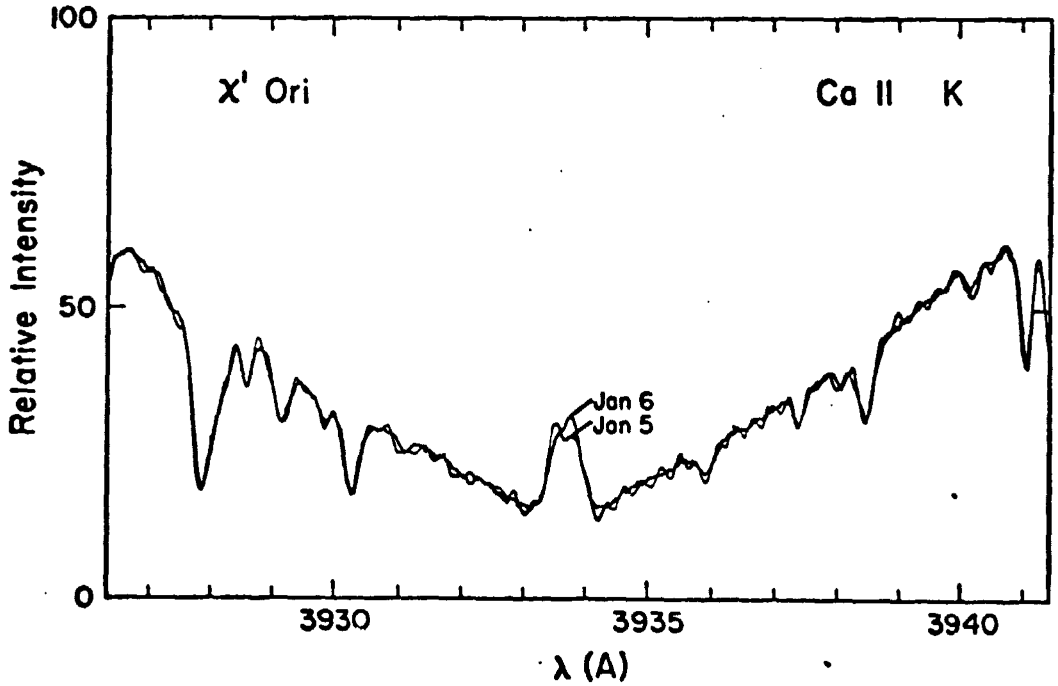

Figure 4 -- The region of the core of the Ca II K line on two successive nights (a 25 hour interval) during the rising part of the C IV emission cycle. This is a 15 A region of the 67 A observed with the CFHT Reticon. The signal-to-noise ratio in the continuum is 380 for the January 5, 1982 data (phase = 0.169) and 160 for the January 6, 1982 data (phase = 0.374). The K_2 emission intensity increases (as does the C IV emission) and the ratio of the blue-to-red peak K_2 intensity reverses.