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STARSPOT ACTIVITY ON THE G0 III STAR 31 COMAE

31 Comae is a rapidly rotating, single G0III star with rather weak Ca II H and K emission lines due to large rotational broadening (Wilson 1966) but with very high chromospheric line fluxes of $\log \mathcal{F}(K) \geq 6.6 \text{ erg cm}^{-2}\text{s}^{-1}$ (Strassmeier et al. 1990). It is one of the few stars found within the Hertzsprung gap in the H-R diagram. IUE observations by Simon (1984) show the presence of bright chromospheric and transition-region lines. On the contrary, Bopp et al. (1988) and Strassmeier et al. (1990) found no sign of chromospheric emission at H α nor does the equivalent width vary on time scales ranging from days to years (Bopp et al. 1988). An IUE search for rotational modulation of ultraviolet line fluxes was negative too (Simon 1986). Photometric monitoring of 31 Com with an Automatic Photoelectric Telescope in the years 1983–1986 (Strassmeier & Hall 1988) also did not show any variability greater than $\pm 0.009 \text{ mag}$ in *V*. Is the convection zone of 31 Com too shallow for large spots or has it just a symmetric spot distribution so that no rotational modulation would occur?

In this IBVS paper we report the discovery of photospheric line profile deformations, most likely caused by cool starspots, and also present some evidence that the profile shape is varying. We interpret these changes to be due to rotational modulation. Additionally, a single spectrum of the spectral region around 6700 Å shows the presence of a strong Li I 6707 Å resonance line. The observations in this paper were obtained with the Canada-France-Hawaii Telescope in December 1993. We used the 600 l/mm mosaic grating in first order with the *f*8.2 camera. The instrumental resolution was 27,000 and the 2048² Lick CCD allowed for a wavelength coverage of 200 Å and S/N up to 500:1.

Figure 1 shows the profiles of four photospheric lines with different values for the excitation potential and $\log gf$: Ca I 6439 ($\chi = 2.51 \text{ eV}$, $\log gf = +0.4$), Fe I 6430 ($\chi = 2.18 \text{ eV}$, $\log gf = -1.85$), Fe I 6411 ($\chi = 3.65 \text{ eV}$, $\log gf = -0.1$), and Fe I 6393 ($\chi = 2.43 \text{ eV}$, $\log gf = -1.62$). The upper profile in the panels in Fig. 1 is from 23 Dec. 1993 and the lower profile from 29 Dec. 1993 and the exact time difference between the two exposures is 6.045 days. The characteristic “emission bumps”, signatures of an inhomogeneous surface temperature distribution, are seen in all four lines. Note that the Fe I line at 6430 Å is blended with the strong Fe II line at 6432 Å. The measured line ratio Fe I/Fe II is 1.42 ± 0.05 , in good agreement with the G0 classification. The other three lines in Fig. 1 (6439, 6411, 6393 Å) are basically unblended and have equivalent widths of 185, 130, and 160 mÅ, respectively. From their average FWHM of $2.08 \pm 0.05 \text{ Å}$ we compute a projected rotational velocity for 31 Com of $57.0 \pm 1.5 \text{ km s}^{-1}$, assuming a macroturbulence of 5 km s^{-1} . With this $v \sin i$ measure, and a typical stellar radius for a G0III star of $6 R_{\odot}$ (Schmidt-Kaler 1982), and correcting for $\langle \sin i \rangle = \pi/4$, we estimate a rotational period of approximately 4.2 days. Thus, our line

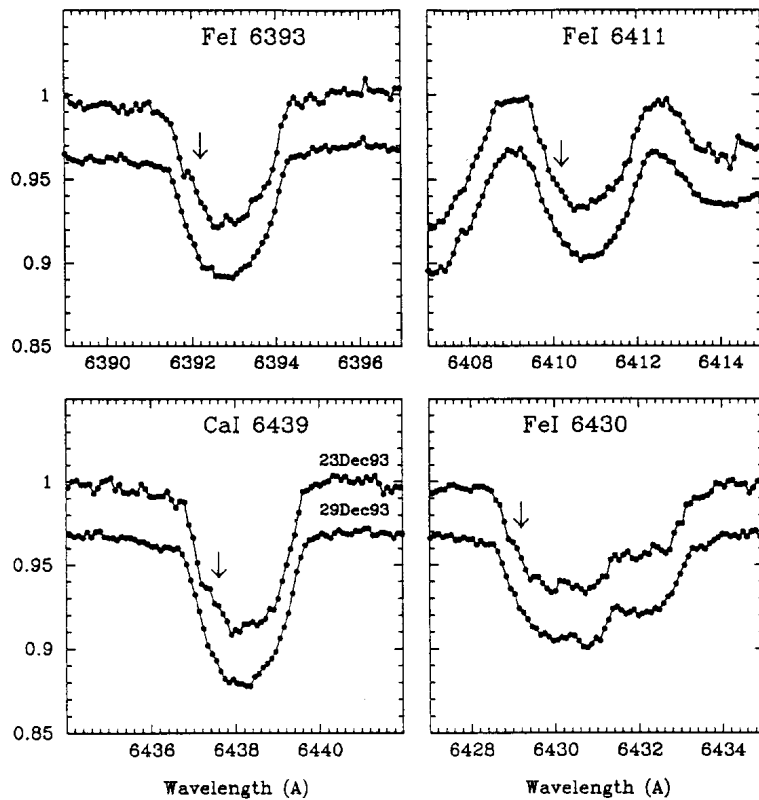


Figure 1: Four line profiles of 31 Comae. The four lines are Ca I 6439, Fe I 6430 (blended with Fe II 6432), Fe I 6411, and Fe I 6393. Each panel shows two observations taken 6 days apart. The arrow marks an “emission bump” typical for cool starspots.

profile from “29Dec93” most likely shows the opposite side of the star as compared to the profile from “23Dec93”. If we believe that the line profile deformations are indeed real and due to spots, 31 Comae would be one of the “earliest” stars with cool surface spots.

We have also obtained a single spectrum of the 6700-Å region (Fig. 2) to search for the presence of the resonance line of neutral lithium at 6707 Å. The presence of lithium would suggest a fairly young stellar system that had not had time yet to deplete its surface lithium. However, it is still not fully clear whether stellar magnetic activity affects the amount of observed surface lithium, but there is some evidence now that the effects of surface activity are less pronounced than previously thought (Pallavicini et al. 1993).

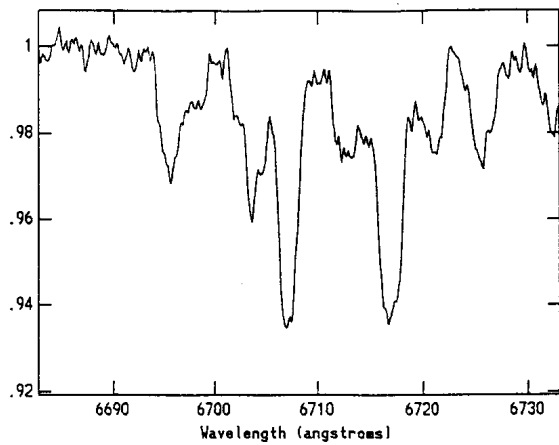


Figure 2: A spectrum of the 6700-Å region of 31 Comae. The spectrum shows a strong Li I 6707 absorption line comparable to the strength of the nearby Ca I 6717 line. We measured a lithium abundance of $\log n(\text{Li}) = 3.0$, indicating that 31 Com must be a relatively young giant.

A multicomponent Gaussian fit to the 6700-6710 Å region of 31 Com yields an equivalent width of 135 ± 10 mÅ for Li I 6707 and similarly 160 ± 10 mÅ for Ca I 6717. The Li I equivalent width is converted to an abundance of $\log n(\text{Li}) = 3.0$ using the curves of growth of Pallavicini et al. (1987) for $T_{\text{eff}} = 5760$ K and $\log g = 3.0$ (Bell & Gustafsson 1989).

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