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CHROMOSPHERIC VARIABILITY IN THE M7 GIANT θ APODIS

It is well known that the mean fraction of a cool giant star's luminosity emitted in chromospheric lines decreases with advancing spectral type (e.g., Linsky and Ayres 1978; Steiman-Cameron, Johnson, and Honeycutt 1985; Judge 1986). The temporal variability is less well understood or even studied, however. Chromospheric emission can change in cool stars for a variety of reasons. For instance, the chromosphere may simply grow through the addition of active regions, spicules, or whatever. The heating may change for several causes, such as the passage of discrete shock waves through the atmosphere of a pulsating star or modification of magnetic field structures. Alternatively, the emission can be absorbed in circumstellar shells so that we cannot receive the photons, though they were emitted.

K giants, such as α Boo, are normally assumed to have roughly constant chromospheric emission on short timescales. Limited observations for α Boo obtained by McClintock et al. (1978) show no evidence for variation in either flux or profile. Similarly, the K giant in the interacting binary system 5 Ceti (gK2-4 + Fp) appears to have constant Mg II flux to within ~ 15% in 8 observations covering 2 years. On the other hand, Baliunas et al. (1981) report rapid variability of Ca II in α Tau (K5 III) and λ And (G8 III-IV), albeit at only the 10% level. A recent analysis of IUE photometry for cool giants by Brozius et al. (1986) finds some evidence for rotational modulation of chromospheric flux, especially in the hybrid-chromosphere stars which are thought to have solar type active regions in addition to the extended chromospheres of cool giants. Again, this is at only the 10% level.

The chromospheric emission of cooler giants can be variable too, in some cases by considerable amounts. Dupree et al. (1984) have found the supergiant irregular variable α Ori to be chromospherically variable by up to ±50%. Carpenter (1986) has recently reported changes in the profiles of chromospheric Fe II lines in the M3 giant γ Cru. Moreover, extensive series of spectra of the warm carbon stars TW Hor (Querci and Querci 1985) and TX Psc (Johnson et al. 1986) show variations in chromospheric Mg II emission of up to an order of magnitude. The Mira variables, in which shock heating of the photospheres is well documented, have even greater variability associated with the passage of individual shocks through the ambient chromosphere.

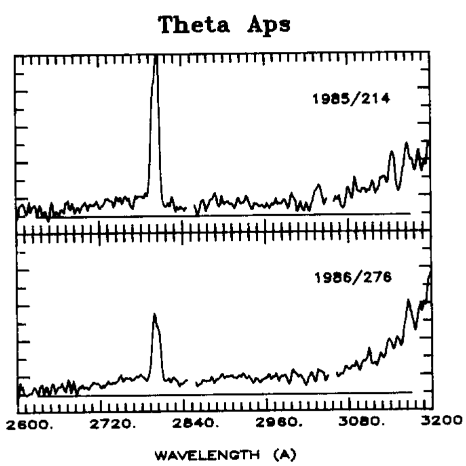

Figure 1. Ultraviolet observations of θ Aps at two epochs. In the upper panel we have an observation at 1985/Aug 2 (JD 2,446,279.9); in the lower panel, 1986/Oct 2 (JD 2,446,706.6). Flux in the ultraviolet continuum is essentially the same at both times, being 0.3 mag brighter at the second epoch. Optical flux determined with the fine error sensor was brighter by roughly the same amount. Chromospheric emission as determined by Mg II flux was much lower at the second epoch. Furthermore, the profile of this partially resolved pair of lines indicates that the flux ratio k/h changed as well, the 2796 Å k line becoming stronger as the flux decreased. This was in the sense that would be expected from a decrease in electron density or a decrease in circumstellar shell absorption.

We report here observations of a semi-regular variable at two epochs that show a large difference in the level of chromospheric emission. θ Aps (HD 122250) is a cool M giant in the circumpolar region of the southern sky. Payne-Gaposchkin (1952) found it to be variable (type SRb) in data consisting of 578 patrol plates obtained in Chile. The star showed a range of 6.35-8.35 photographic magnitudes with a ~ 119 day period. Being unfavourably placed for observation from the northern hemisphere, it has not attracted the attention that such a bright variable might deserve. However, Eggen (1975) obtained limited optical photometry which shows variability on a ~ 10 day timescale. Also, in a group of 593 southern red giants studied by Eggen and Stokes (1970), θ Aps was the reddest in a (105,62) color. We have observed the star twice with the IUE satellite, once on 1985/Aug 2 and again on 1986/Oct 2. Visual magnitudes have been obtained from the fine error sensor signal on the two days with the formulas given by Imhoff and Wasatonic (1986), but the results likely contain large systematic errors. The FES was used in different modes at the two epochs, the first measurement being taken in the overlap mode with a ~ 35% coincidence correction. In addition, the derived magnitudes are much brighter than expected from ground based photometry. The magnitude difference, however, indicates that the star was 0.3 ± 0.15 mag brighter at the time of the second IUE observation. The ultraviolet continuum was also brighter by roughly this amount. In contrast, the Mg II λ2800 emission was lower by nearly 0.9 mag. Other chromospheric features in this wavelength region are generally quite weak in comparison to Mg II, and none can be measured reliably in our spectra. C II] λ2325 is lost in the noise, Al II] λ2669 is possibly present but weak, Fe I UV44 is detected at high dispersion - λ2823 but not λ2844 (Eaton and Johnson 1986) but is a very weak feature in the low dispersion spectra.

The profile of Mg II appears to have changed with the decrease in flux. As the emission became weaker, the 2796 Å k line became stronger relative to the 2803 Å h line. This difference in k/h ratio suggests two causes: 1) the circumstellar shell could have become less dense, intercepting less of the k line for which the circumstellar extinction is expected to be greater (Eriksson et al. 1986), or 2) the electron density could have decreased in the chromosphere giving rise to less emission but less collisional deexcitation and mixing of the upper levels, hence less suppression of the k line. The former explanation would predict a brighter Mg II feature, in contradiction to what was observed, and it therefore is clear that changes in the cool circumstellar envelope alone are not an appealing explanation of the reduced Mg II emission.

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