STELLAR SPECTROSCOPY AT 1.1 μ

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This is a progress report on the program of stellar spectroscopy at 1.1 μ reported on by Vaughan and Zirin (1968) and by Zirin (1971). About 450 plates of about 200 stars have been obtained, using a magnetically focused RCA image converter with the 144″ and 72″ Palomar coudé cameras, giving dispersion of 8 and 17 Å mm^{-1} respectively. Most of the plates were taken at the latter dispersion and cover about 300 Å. In good seeing a star with $J=3$ is obtained in about 90 min. A tube with a fibre optic backplate is now in use. Cooling such a tube is difficult because the cathode is held at high voltage. By completely insulating the cold box, we may use dry ice cooling, and 2 h exposures, reaching $J=5$, may be made with this ITT tube.

Our principal interest in this region of the spectrum is the He I 10830 line, but there are other features of interest such as Paschen γ and a series of CN bands. λ10830 is of particular interest because it is produced at relatively high temperatures and thus its presence in stars later than B5 can only be explained by the existence of a high temperature corona or chromosphere or of a strong ultraviolet source, which amounts to the same thing. Vaughan and Zirin found the presence of such chromospheres in a number of stars, and I have pursued the matter since then to determine the existence of chromospheric variability. The 10830 absorption in the Sun is very small from the normal chromosphere and is principally due to the presence of active regions. Emission is only found in large flares. Thus cyclic variations in Sun-like stars could be attributed to sunspot cycles. Unfortunately, main sequence stars are near the limit of our observations. Although definite 10830 absorption has been found in such main sequence stars as 61 Cyg A and B, 70 Oph br, K Cet and ε Eri, the absorption is just barely detectable and variation from plate to plate could be explained by variable quality.

On the other hand, definite variation, possibly cyclic, has been observed in giant stars, in particular θ Her and ε Gem. In both these stars the He line has been seen in emission, absorption and absence. In θ Her the following sequence has been observed

May, 1966	str emission
May, 1968	wk emission
Sept., 1969	nothing
Oct., 1970	some abs
June, 1970	mod emission
May, 1972	nothing
February, 1973	str emission

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Thus there is irregular variation, and the determination of periodicity if any awaits more accurate measurements. ε Gem was in emission in 1965 but has only shown irregularly varying absorption since then. Whatever periodicities exist in these stars are only a few years long.

Continuing observation has confirmed the original conclusion of Vaughan and Zirin that strong K emission was a necessary but not sufficient condition for the presence of 10830, and that close double stars had a strong tendency to show 10830. Emission has only been found in giant stars and late type variables.

Various CN band heads are found in this region of the spectrum and we have measured the band intensities in all our plates, but there seems no definite advantage to observing these bands instead of visible wavelengths.

We have obtained spectra of a number of late type stars because they are so easy. He emission and Pγ emission is found in R Aqr, R Hya and R And, but not in any other late stars. In R Aqr, I found emission in the La II line at 11012 Å, the furthest emission line I have found in the IR. He emission was also found in the RV Tau variable R Scu, but disappeared later. Some of these spectra appear in the papers cited, and a new comprehensive report will appear soon.

The following stars show moderate to strong 10830 emission or absorption. The list is presented in the hope that someone will look at these stars in the ultraviolet, where they should have strong emission lines:

TABLE I

Emission		Absorption	
R Sct	η Aql	θ Tau	β Dra (str)
ε Crv	α Cet	β Gem	58 Per
θ Her		61 Cyg A and B	λ And
12 Peg (str)		ε Lep	ε Gem
θ Cet		σ Gem (str)	α Tri
ξ Cyg		HD 131977	ζ And (str)
μ Her		β Cam (str)	ε Leo (str)
μ Per		β Cet	31 Mon (str)
R Hya		β Sct	HD 88236
R And		α Aur	70 Oph br
R Aqr		ϱ Cas (str)	

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References

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Zirin, H.: 1971, *Phil. Trans. Roy. Soc. London* **A270**, 183.

DISCUSSION

Vardya: Have you measured the radial velocities of this line?

Zirin: Normally the line is very broad. In a few cases one gets this sort of P Cyg type variation with emission with an absorption on the blue side, and that typically is shifted by about 1 Å or so, which would be one part in 10000 or whatever that is, 30 km s^{-1}. But in cases of absorption the absorption is normally well centred on the line.

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