ULTRAVIOLET AND OPTICAL SPECTROSCOPY AND POLARIMETRY OF THE HELIUM WEAK STAR HD 21699: EVIDENCE FOR A MAGNETICALLY CONTROLLED STELLAR WIND

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ABSTRACT

We have obtained high dispersion SWP spectra with IUE, and contemporaneous optical Zeeman polarimetry and spectroscopy, of the helium weak star HD 21699 = HR 1063. All IUE observations were made during Sept. 1983 and Feb. 1984. The C IV 1548,1550 doublet varies on a timescale consistent with the photometric and magnetic period, while no other strong lines in the UV display obvious variations in profile or strength. Only the helium weak star HD 5737 = α Scl shows a similarly strong C IV line among the helium weaks. We discuss this set of observations in the context of a magnetic star which is losing mass, having constrained that outflow to corotate with the stellar surface. If the magnetic period is correct, the greatest mass outflow seems to be from above the polar regions. The comparison between optical and UV spectrum phenomenology is also briefly discussed.

INTRODUCTION

The helium weak star HD 21699 = HR 1063 is a member of the α Persei cluster, and was discussed as such by Molnar et al.(1978). The MK type for the star is B8, but the UBV colors indicate a B4 or B5 effective temperature and extreme helium deficiency (leading to a too late MK type). Mallama and Molnar (1974) determined an effective temperature of 15050 K (log g = 4.0) with a helium depletion of a factor of 3. The star would have to be cooler than 13000 K in order to render it helium normal, as is typically the result for the helium weak stars.

Winzer (1974) published UBV photometry for the star. He found a single wave variation (roughly sinusoidal) with all colors in phase and a U amplitude larger than B or V, and a period of 2.47 days. Mallama and Molnar (1974) revised this period to $2^{d}.4928$ using additional UBV photometry. Spectrum variations were first mentioned by Bruckner (1973, M.Sc. thesis,Toronto),who also provided a line identification list.

Our interest in this star arose from its membership in the cluster and as part of our general survey of the 1540 - 1560 region among the helium peculiar main sequence stars. HD 21699 is a slow rotator, and the velocity and published period are nearly identical to HD 34452, the most extreme Si star. Otherwise, it appeared undistinguished. Somewhat to our surprise, the behavior of HD 21699 has proven exciting in its own way. We here merely

present a summary of our results. A complete paper is in preparation.

ULTRAVIOLET VARIATIONS

We have obtained eight high dispersion SWP spectra (SWP 21081,21096, 21110, 21118,21123,21127,21133) during 1983 Sept. and SWP 22197 in 1984 Feb. All are 7 min. exposures. Since all of the September 1983 data was obtained in a one week period, we shall concentrate on this set. The Feb.1984 spectrum is consistent with the average Sept. spectra. The gallery of CIV results is shown in fig.1. The region is dominated by numerous strong FeIII lines, but there is clearly a strong, variable and broad line at each of the C IV lines. In fact, these are the only lines in the region which are varying with any amplitude. Figure 2 shows the differenced spectra, relative to SWP 21081. Note the asymmetry of the CIV line and that the FeIII 1558,1559 lines disappear on differencing. Fig.3 shows the SiIV 1400 region for the most extreme SWP spectra. Again note that the CIV is variable with a far greater amplitude than even SiIV. The FeIII is not variable. For comparison we refer the reader to the theoretical spectra in the accompanying CIV survey paper for T_{eff} = 17000 K and 90 km s^{-1}. The most nearly equal spectra (SWP 21081,21110) are $2^d.25$ apart and we feel the evidence is good for periodic, rather than stochastic, variation of C IV.

Having examined especially the 1800 - 1900 region (FeII and FeIII,Al III dominant) and the SiIV 1400 region, we again emphasise that only C IV appears to be distinctly variable. The terminal velocity is about 600 km s^{-1}.

MAGNETIC MEASUREMENTS

The magnetic measurements were performed at the Mt. Palomar 1.5 m telescope using the Univ. of Michigan filter polarimeter (Brown et al. 1977) modified for Hβ Zeeman polarimetry. The technique is identical to that of Landstreet (1980). Observations of well known magnetic CP stars confirm the comparability of measurements made with the UM and UWO polarimeters. The data re shown in fig.4. Clearly, HD 21699 is a magnetic star and it appears that the field reverses sign. It was not previously known to be magnetic. The best fitting magnetic period does not differ substantially from Mallama and Molnar's period (and the timescale for comparison of the Zeeman and IUE data being sufficiently short can be taken as about $2^d.5$). The measured values range from -1.3 to +1.0 kilogauss. A sinusoidal variation gives the crude oblique rotator parameters i = 60±20°(inclination),β ≃70°(obliquity). This high value is not unusual among the CP2 stars, and the measured field is of the same magnitude as observed for the helium weak stars by Borra et al. (1983).

OPTICAL SPECTROSCOPY

As part of a continuing program, over the past decade 8 and 12 A mm^{-1} IIaO and IIIaJ spectra have been obtained at DDO with the cassegrain spectrograph on the 1.88 m. Preliminary analysis of this material confirms that the Si II optical lines vary by about a factor of two, and also vary in v_{rad}, but the best fitting periods for Si II are $1^d.01$ and $1^d.99$. The magnetic, UV and photometric period doesn't give significent results in the power spectrum analysis. The hydrogen lines display a long term variation (the two data

sets are 1970-1980 and 1983-1984) of about 7.5 km s^{-1}, but the details are still uncertain.

DISCUSSION

At present, we can only provide a crude interpretation of these data. If the magnetic and photometric periods are correct, the C IV variations can be explained by a wind emerging from above the magnetic poles of HD 21699. As the rotation of the star transports this "plume" across the line of sight the absorption profile and terminal velocity change. The cylindrical structure of the plume would explain both the single wave variation and the lack of emission, as well as qualitatively fitting the line profile. We cannot now specify the required mass loss rate, but the profile we are observing at C IV should be entirely from the wind. The constancy of the Fe III lines, we believe, argues forcefully for the intrinsic variability of the C IV lines as opposed to merely blending. It is interesting to note that of the dozen stars in our sample of helium weaks, only the two "sn" stars (Abt's classification showing diffuse and sharp lines) display strong C IV. We hope to observe other members of this class for comparison.

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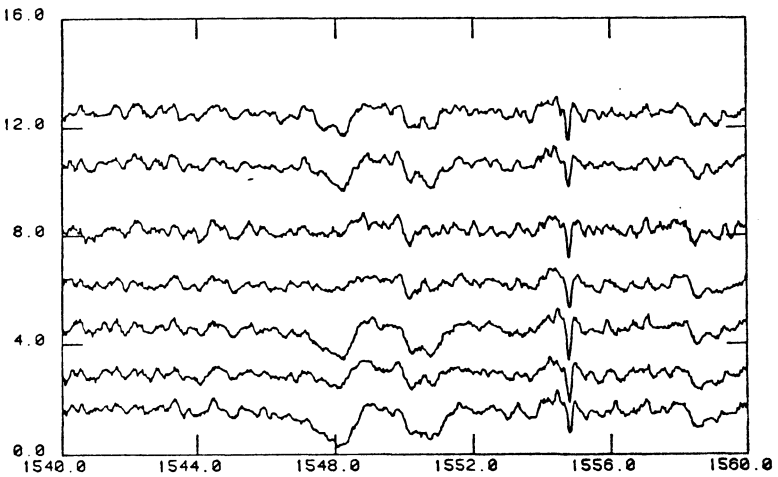

Fig.1.Gallery of CIV Profiles. Bottom to top: SWP 21081, 21096, 21110 21118, 21123, 21127, 21133. A three point filter has been applied.

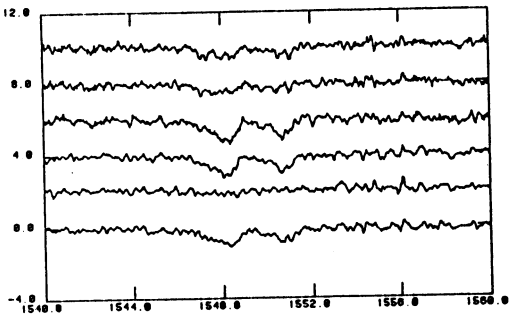

Fig. 2. Differenced profiles for C IV region. Taken relative to SWP 21081. Three point filtering. The order is the same as figure 1.

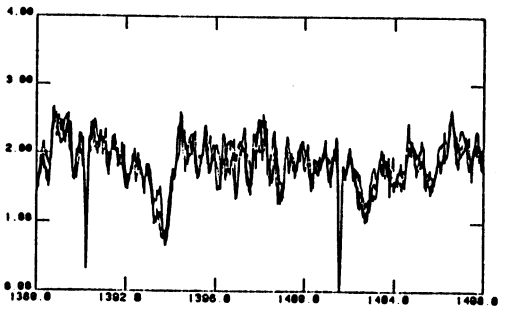

Fig. 3. Three extreme phases of HD 21699, plotted at Si IV 1400. SWP 21081, 21096, 21110 with a three point filter applied.

Figure 4 (below). Magnetic curve for HD 21699, based on Zeeman polarimetry. ϕ_0 = 0.0512. Ephemeris is: JD (SWP21081 ϕ = 0P) = 2445595.778 + 2^d.4819 E (magnetic best fit period).