MAGNETOSPHERES AND WINDS IN THE HELIUM WEAK STARS: OBSERVATIONS OF C IV IN UPPER MAIN SEQUENCE CP STARS

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ABSTRACT

We present a sample of eleven helium weak and Si stars, observed at high dispersion. These are HD 5737, 21699, 28843, 34452, 125823, 131120, 142301, 142990, 144334, 175362 and 215441. The stars span the range B2.5 to B6 and include both magnetic and nonmagnetic as well as rapid and slow rotators. In the two stars designated "sn" by Abt, the C IV profile is strong (HD 5737 and 21699) while all of the other stars can be explained by numerous blended lines of Fe III and similar ions. Most of the stars have been observed several times, and only HD 21699 appears to show large amplitude spectral variations.

INTRODUCTION

This paper represents a continuation of our study of magnetospheres and winds in the helium rich stars (Shore and Adelman 1981, Barker et al. 1982a, 1982b), and continues down the main sequence from that survey. The fact that even the coolest of the helium rich stars display spectral variations at CIV 1548,1550 which are suggestive of nonisotropic distributions of low density gas about these (magnetic) stars, leads to the question: at what effective temperature do the winds in the CP stars turn on? The problem is naturally parallel to that posed by normal main sequence stars, and can be viewed as ancillary to any such study. Since many of the helium weak stars have strong (or detectable) magnetic fields, and appear to obey the oblique rotator model well, we have chosen a sample of well studied He weak and Si stars to see whether there is in fact some place on the main sequence at which the presence of a chemical anomaly and/or magnetic field plays any role in the mass loss by the star.

OBSERVATIONS AND RESULTS

Most of the stars in our sample have been observed by Borra, Landstreet and Thompson (1983, BLT) using Zeeman polarimetry. In the case of HD 21699, additional observations have been obtained in 1983. The stars are listed below and illustrated in figures 1. All observations have been obtained at high dispersion with the SWP camera of IUE. HD 21699, 28843, 142301, 142990, 144334 and 175362 have been observed during 1983. All other spectra

are archival. The data have been reduced at the RDAF at Goddard Space Flight Center using standard programs. A discussion, in the companion papers, of the low dispersion SWP data and of the time-dependent variations of HD 21699, supplement this discussion. All quoted magnetic measurements are from BLT except for HD 21699.

HD 5737 (Vsini = 10 km s^{-1} , B5): CIV 1548,1550 very strong (residual inten. of about 15%. Sharp FeIII 1558,1559 well resolved, as is blend at 1550. Two archival spectra at about the same phase, no variations detected.

HD 21699 (Vsini= 40 km s^{-1} , B5): CIV variable (!), going from about as strong as HD 5737 to invisibility. Total of seven spectra, taken in one week, suggest periodic variations of the CIV component of the line. The Fe lines do not vary, nor do the SiIV 1400 lines. The star has a detected field of about 1 kG (see paper, this session).

HD 28843 (No Vsini published, B5): CIV extremely weak, if present. Only Fe III lines appear to dominate the 1540 to 1560 A region. Four spectra, at three different phases, do not show variations. The 1548, 1550 lines are about the median strength for the helium weak stars. Possible that the rotational velocity is 60 - 100 km s^{-1} on the basis of the Fe lines. Upper limit for B_{eff} is 250 G. North (1984, preprint) gives a period of 1.37 days.

HD 34452 (Vsini=60 km s^{-1}, B6): Only archival spectra available. FeIII 1550 and 1559 strong; no evidence for CIV. Spectral variations probably due to Fe variations. The star has a weak, variable magnetic field (430 G) and a period of about 2.5 days. The Si is extremely strong in this star (see accompanying paper).

HD 125823 (17 km s^{-1}, B3): This star has been extensively discussed by Fahey (1981 and references therein). We have used archival images taken subsequent to his study for comparison. No CIV is present, and the numerous sharp absorption lines in the region compare quite well with model calculations. The B_{eff} is 500 G, and reverses symmetrically with a period of about 8.8 days. This star serves as a "standard" for comparison with the models.

HD 131120 (90 km s^{-1}, B2.5): The profile is dominated by FeIII absorption. The 1548, 1550 blend is about as strong as FeIII 1558, 1559. Only one spectrum was obtained, but the profile is "normal" for the helium weak stars. No period is known, and only an upper limit of 170 G is given by BLT. The star is quite similar to HD 142990 at CIV; no CIV indicated.

HD 142301 (50 km s^{-1}, B3.5): Two spectra available at essentially the same phase. No CIV detected and the FeIII 1558,1559 agrees with the Vsini. The 1550 line is boxlike, with the 1550,1551 iron lines visible and about the same strength as 1548. The profile is a good match for the intermediate strength in HD 21699, and for HD 175362. The r.m.s. field is 2.1 kG and a period is given by North of 1.46 days.

HD 142990 (150 km s^{-1}(:), B3): This star is the most rapid rotator in our sample, being comparable with the helium rich stars. The 1548,1550 lines are probably entirely FeIII. The spectrum compares well with the model calculations. All suggested periods for this star are less than one day. The r.m.s. field is 1.4 kG. Only one SWP spectrum obtained.

HD 144334 (45 km s^{-1}, B4): Two phases have been observed (one archival). CIV is very weak if present at all. The available spectrum fits the

mean profile of HD 175362 quite well. BLT give an r.m.s. field of 780 G with a period of 3.61 days; North finds a period of 1.49 d.

HD 175362 (28 km s^{-1}, B2.5): We have, including archival spectra, six SWP spectra at five phases. No marked variations are observed, although the period is well covered. No CIV appears present beneath the 1548, 1550 Fe lines. Some weak variability of the metallic lines may be happening. The line strengths are consistent with those of HD 125823 with some slight rotational broadening. The measured field is 3.9 kG variable with He on a 3.67 d period.

HD 215441 ($<$ 5 km s^{-1}, B4): Two archival spectra are available for this star at different phases. Numerous sharp absorption lines make specification of the continuum level a problem, but there appears to be no CIV in either spectrum. The lines are stronger (FeIII) than in HD 125823. The measured field is the strongest of any of the He peculiar stars, 10 kG, and the period the longest, 9.49 d, of any of the stars in our sample.

DISCUSSION AND MODELS

We have computed a series of rotationally broadened spectra, using the OSU version of ATLAS 6, for T_{eff} from 17000 to 25000 (log g = 4.0) and a virial parameter of 0.5 (an equatorial velocity of about 200 km s^{-1}). The models have a von Zeipel gravity darkening and normal He/H ratio (we have also computed models with X = 0.53, Y = 0.47 but these do not differ by more than 5% on any of the lines). No CIV is visible until about 25000 K, and then the residual intensity for a normal model is 50 percent. We here show (figs.2) the model for 17000 K, with i = 0° and 30°. The match with most of the He weak stars is, in our judgement, good. Only the "sn" stars in our sample, HD 5737 and 21699, appear to show enhanced absorption due to CIV. In fact, the profiles in these stars are as strong as we see in any of the helium rich stars. All other stars can be described by broadened and blended Fe III and other metallic ion lines blanketing the 1540-1560 spectral region. A more complete discussion is in preparation.

In conclusion, although at present only a tentative statement can be made, we find that only the "sn" stars among the helium weak class show any evidence for stellar winds.

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