ABUNDANCE AND MAGNETIC FIELD GEOMETRIES OF HELIUM-STRONG AND HELIUM-WEAK STARS

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1. INTRODUCTION

The helium-weak and helium-strong stars are main sequence stars with anomalously weak and strong helium lines for their spectral types respectively. Many members of the two classes have strong, globally ordered magnetic fields (Thompson and Landstreet 1985; Bohlender et al. 1987) and are currently thought to represent high temperature extensions of the Ap stars. In collaboration with C. T. Bolton (U. of Toronto), we have obtained high S/N phase resolved spectra of several stars using the coudé reticon detector at CFHT. One of the principle goals of this work is to determine abundance and surface magnetic field geometries of several helium peculiar stars with large, well-determined effective fields. We employ a line synthesis program (Landstreet 1987) that incorporates the effects of surface magnetic fields and non-uniform abundances on the observed line profiles of a star. Since these stars are rapid rotators the surface magnetic field strength must be inferred from differential magnetic intensification of lines with different magnetic sensitivities. Of the few lines with suitable strengths in these hot stars we have decided that the Si III multiplet 2 lines are best suited for this aspect of our investigation. We have also modelled the unblended He I line λ4437, ignoring magnetic effects for the time being. Individual results are discussed below.

2. HD 64740

This star's effective field ranges from -900 at ϕ=0.0 to 500 G at ϕ=0.5. We find helium to be overabundant in two spots: one near the negative pole with radius 70° and ε_{He}=0.25 and one at the opposite pole with radius 60° and ε_{He}=0.20. The silicon profiles are reproduced by a band of silicon between colatitudes 40° and 70° from the positive

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G. Cayrel de Strobel and M. Spite (eds.), The Impact of Very High S/N Spectroscopy on Stellar Physics, 309–312.

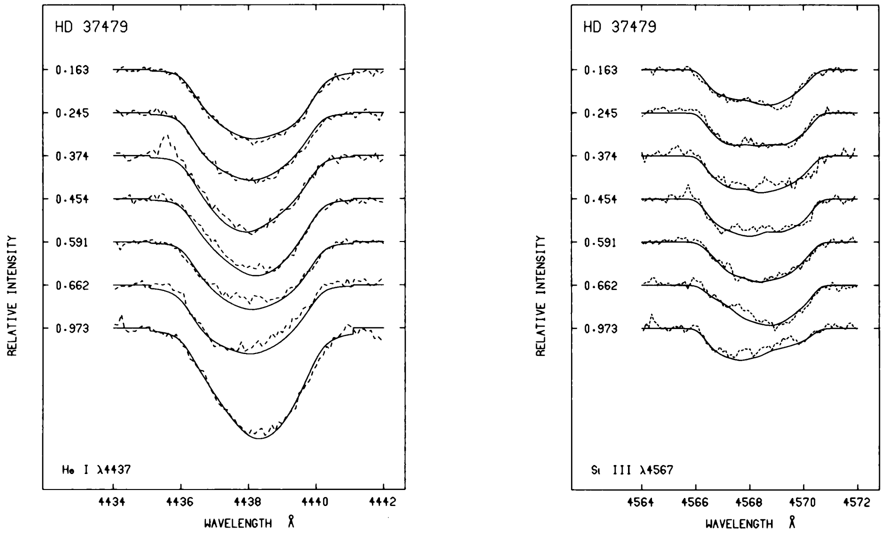

Figure 1. Observed (dashed line) and model (solid line) He and Si line profiles of HD 37479. We have employed a model atmosphere with T_{eff}=25000 K, i=58^{o}, β=64^{o} and a vsini of 150 km s^{-1}. The phases to the left of each spectrum are determined from the ephemeris 2442778.819 + 1.19081E. In each figure individual spectra are separated by 5% of the continuum intensity.

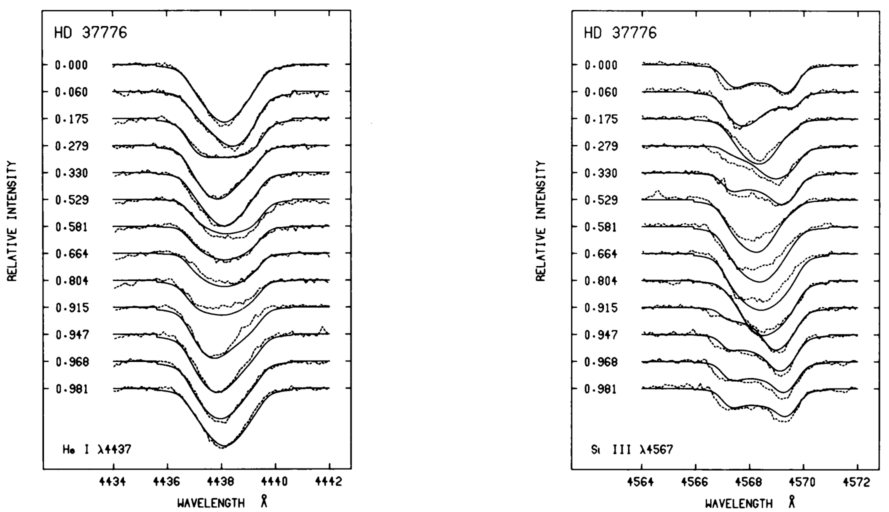

Figure 2. Observed and model He and Si line profiles of HD 37776. Here, T_{eff}=22500, i=β=90^{o}, and vsini=100 km s^{-1}. Phases are given by the ephemeris 2445724.669 + 1.53869E.

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pole with $\log(N_{Si})=-4.0$. The remainder of the surface has $\log(N_{Si})=-4.7$. Unfortunately, the magnetic field is not strong enough to enable us to uniquely define the surface field, and therefore the inclinations of the rotation and magnetic axes, i and β.

3. HD 37479 (σ Ori E)

The prototypical helium strong star has an effective magnetic field that varies from +2800 to -1500 G. Fits for the helium and silicon line profiles are illustrated in figure 1. Two patches of helium give a reasonable fit to the observed profiles: one with radius 40° and $\varepsilon_{He}=0.70$, 70° from the positive pole, and the other on the opposite side of the star with radius 30° and $\varepsilon_{He}=0.40$. Helium is slightly over-abundant elsewhere. Silicon has solar abundance in a band between 30° and 90° from the negative magnetic pole and in a 50° radius spot 45° from the positive pole, but is underabundant elsewhere by a factor of ten.

4. HD 37776

This may well be the most interesting of the entire class of helium peculiar objects. Its unique magnetic field variation has been discussed by Thompson and Landstreet (1985), and can be reproduced with a superposition of colinear dipole, quadrupole, and octupole components. Model profiles for He I λ4437 and Si III are given in figure 2. These models do not include a magnetic field, but lend some support for the above field model in that the He and Si abundance geometries are approximately axisymmetric with respect to the location of the proposed magnetic pole ($\phi=0.175$). The helium line variations are reproduced with a band of helium with width varying between 40° and 60° and with $\varepsilon_{He}=0.30$. The band crosses the sub-solar point at phases 0.0 and 0.330. Helium is slightly underabundant elsewhere, with $\varepsilon_{He}=0.07$. The preliminary silicon geometry consists of two patches of silicon centered at phases 0.175 and 0.675. In these spots $\log(N_{Si})=-2.7$. The abundance is normal on the rest of the surface.

5. Other Objects

High quality CFHT spectra have also been obtained for several other stars, including the helium weak star HD 175362, the helium variable HD 125823, and the peculiar Si star HD 32633. Analysis of these data is in a very early stage.

REFERENCES

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DISCUSSION

PRADERIE What model atmosphere and source function do you use for each of your lines at each phase ?

BOHLENDER We use Kurucz's (1979) LTE blanketed model atmospheres. We assume the lines are formed in LTE. At each phase the star is divided into 60 equal area elements, and for each area the local abundance and line-to-continuum opacity ratio is determined for each Zeeman component of the line. The local field strength determine the extent of the line splitting for each area element. A disk integration is then performed and a series of line profiles for the four Stokes parameters and for various v sin i is the final result.

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