MASS LOSS, MAGNETIC FIELD AND CHEMICAL INHOMOGENEITIES IN THE HE-WEAK STAR HD 21699

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1. Introduction

HD 21699 is a He-weak star whose longitudinal magnetic field ranges from −1.3 to +1.1 kG (Brown et al. 1985). Its effective temperature, T_{eff} = 15 900 K, and its gravity, $\log g = 4.0$, were determined by Wolff (1990) from photometry of the Balmer discontinuity and from measurements of the Hγ line. HD 21699 was reported to exhibit remarkable variations in the C IV ultraviolet resonance lines at 1548 and 1551 Å (Shore et al. 1987). These variations occur with the same period, $2^{\mathrm{d}}.49$ (Percy 1985), as the magnetic variations and the photometric variations in the optical region. Similar UV line variations could be found only in two other He-weak stars, HD 5737 and HD 79158. They were interpreted as an evidence of the occurrence of outflowing winds controlled by the magnetic field. Furthermore, Shore et al. emphasized that no lines in IUE spectra other than C IV, and possibly Si IV, show any statistically significant variation. Recently, irregular brightening of a few hundredths of magnitude, superimposed over the periodic variations, were observed in the U photometric band (Vetö 1993); their origin is currently unknown.

Unfortunately, there are few optical spectroscopic studies of HD 21699 in the literature, and no information about the variability of the lines of helium and of iron-group elements. To decide whether the behaviour of HD 21699 is distinct from that of other typical He-weak stars, we looked in optical spectra for line profile changes which might be caused by inhomogeneous distribution of chemical elements on the stellar surface.

2. Observational results

HD 21699 was observed during 5 nights in March 1992 with the coudé spectrograph of the 2.2 m telescope of the Calar Alto Observatory. The detector

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used was a GEC CCD with 1152×770 pixels of $22.5\times22.5\ \mu m^2$. Spectra were taken in several wavelength ranges between 4610 and 5330 Å, at a reciprocal linear dispersion of 2.2 Å mm^{-1}, corresponding to resolving powers of $4\,10^4$ to $5\,10^4$. These spectra were reduced with MIDAS. To determine the radial velocities, the wavelengths of the line centres of gravity were measured by direct integration.

The observations are well distributed over the variation period. HD 21699 turns out to be a striking helium and silicon variable. The changes in the line profiles with rotational phase imply that these chemical elements are inhomogeneously distributed on the stellar surface. Our measurements of radial velocities as well as of equivalent widths suggest that helium is less abundant near the positive magnetic pole whereas silicon minimum coincides approximately with the negative longitudinal field extremum. Though they do not exhibit clear equivalent width variations, the lines of Cr II and of Fe II change markedly with rotation phase too. Their measured radial velocities vary between -8 and $+9$ km s^{-1}. At phase 0.57, splitting of these lines is definitely seen in our spectra. Such splitting is observable in some magnetic stars at rotational phases when the regions of enhanced element concentration appear at opposite stellar limbs.

Admittedly, with only observations at five different phases, we are unable to draw definite conclusions concerning the surface distribution of Fe, Cr, Si and He on HD 21699. More effort should be made to obtain a more detailed picture of the stellar surface. Such a study should rely on time series of high signal-to-noise, high resolution CCD spectra. From these data, magnetic and abundance maps for the inhomogeneously distributed elements should be derived simultaneously using a synthetic spectrum approach, taking into account the differential Zeeman effect affecting lines with different Landé factors. HD 21699 should lend itself well to this purpose, as its $v \sin i$, which we estimate of the order of 35 km s^{-1}, is sufficiently large so that Doppler effect on the line profiles can be exploited to extract geometrical information.

Comparison of abundance and magnetic maps with the inferred wind geometry is the most efficient way to investigate the effect of anisotropic mass outflows on the photospheric abundances of different chemical elements.

References

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