A PRELIMINARY ANALYSIS OF THE PULSATING EXTREME HELIUM STAR V652 HER (BD+13°3224)

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ABSTRACT. A preliminary fine analysis of the atmosphere of the pulsating extreme star V652 Her (=BD+13°3224) is reported. The mean effective temperature and temperature variation have been determined from the ionisation equilibria of Si and N. Both of these elements are strongly overabundant, whilst C appears to be underabundant.

1. INTRODUCTION

The extreme helium star V652 Her (=BD+13°3224) discovered by Berger and Greenstein (1963) was found to be variable by Landolt (1975). Radial velocity studies confirmed that the variations were due to radial pulsations (Hill et al 1980; Paper I) and enabled a pulsation mass to be derived. Absolute flux measurements and new velocity data enabled Lynas-Gray et al. (1984; Paper II) to improve the mass determination to $0.7^{+0.3}_{-0.2}$ $M_{\odot}$, the major uncertainty being the surface gravity. The high surface gravity ($\log g=3.7\pm0.2$) and the period decrease found by Kilkenny & Lynas-Gray (1982, 1984) led to the proposal (Paper II & Jeffery 1984) that V652 Her is unlike the extreme helium stars discussed by Hunger (1975), but that it is contracting onto the helium main-sequence. As such, V652 Her occupies a unique position in the Hertzsprung-Russell diagram. An abundance analysis is required to understand the origin of the star.

2. OBSERVATIONS

High-resolution spectroscopic data obtained with the IPCS and the Anglo-Australian Telescope in 1979, 1980, 1982 and 1984 in the wavelength range 3400-4600Å has been described in Papers I and II and by Jeffery & Hill (1986, Paper III). In addition to the integrated spectrum obtained from the sum of all spectra used in radial velocity measurements, we chose two phase bins of width 0.2 cycles centred at

K. Hunger et al. (eds.), Hydrogen Deficient Stars and Related Objects, 101–105.

phases 0.68 and 0.02, corresponding to the minimum and maximum of the T_{eff} curve determined in Paper II. All unnormalised spectra obtained within these phase bins (as determined by Kilkenny & Lynas-Gray's 1984 cubic ephemeris) were added. Rectification and normalisation were carried out as the final stage of data reduction.

3. ANALYSIS

We have begun an analysis of these spectra based on LTE model atmospheres. Here we report preliminary results for calculations of the ionisation equilibria of silicon (SiII/III/IV) and nitrogen (NII/III) and hydrogen line profiles.

3.1. Model Atmospheres

LTE model atmospheres have been constructed with a code specially designed for helium-star atmospheres. Details can be found in Heber and Schönberner (1981) and references therein. It is important to note here that line blanketing is not taken into account. Models have been calculated with gravities of log g=3.5 and log g=4.0, which bracket the paper II result (log g=3.7), and a few effective temperatures. Hydrogen, nitrogen and silicon line profiles have been calculated with the code of Schönberner (1973). Atomic data are the same as those used by Heber (1983). We have assumed a fixed microturbulent velocity of 5 km s^{-1} throughout.

3.2. Ionisation Equilibria.

3.2.1. Effective temperature and abundances. Equivalent widths of as many lines of NII, NIII, SiII, SiIII, SiIV as possible were measured for the integrated spectrum and for each of the two phase-binned spectra; these are given in Table I. Only the lines SiII 4128Å and SiIV 4116Å are sufficiently free of blends to be representative of these species in an equilibrium analysis, but several lines of SiIII are available. Equivalent width variations in the NII and SiIII lines were less than 10%. The run of the ionisation equilibria of NII/III, SiII/III and SiII/IV in the (T_{eff}, log g)-plane is shown in Fig. 1. Since the gravity is known we can read off the effective temperature of the model, obtaining T_{eff}=28100±1100 K. Simultaneously the nitrogen and silicon abundances are determined from the ionisation eqilibria. Both elements are strongly overabundant with respect to the Sun. Silicon is enhanced by 0.9±0.1 dex and nitrogen by an even larger factor (1.6±0.1 dex).

TABLE I

Ion/ Multiplet		λ(Å)	W_λ (mÅ)		
			<T>	Tmax	Tmin
NII	5	4601.5	235		
	5	4607.2	230		
	12	3995.0	341		
	15	4447.0	174		
	33	4227.7	159		
	38	4082.3	124		
	39	4056.9	100		
	48	4241.8	357		
	48	4236.9	196		
	55	4442.0	110		
NIII	1	4097.3	173	212	149
	1	4103.4	133	157	103
SiII	3	4128.1	58	48	83
SiIII	2	4567.9	323		
	2	4574.8	232		
	2	4552.7	372		
SiIV	1	4116.0	142	186	128

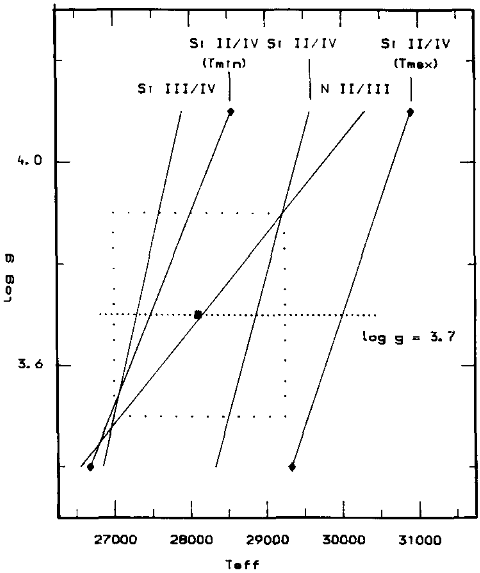

Figure 1. The ionisation equilibria of SiII/III, SiII/IV and NII/NIII calculated from the integrated spectrum of V652 Her. The variation of the SiII/IV equilibrium between minimum and maximum effective temperature is also shown.

3.2.2. Temperature variations. The SiII/SiIV line ratios are very sensitive to the effective temperature. We can use these line ratios to investigate temperature change during a pulsation cycle. The SiII/SiIV equlibria were calculated for the spectra near T_{min} and T_{max} and are also shown in Fig. 1. The amplitude of the T_{eff} variation is 2400±500 K for log g=3.7.

3.3. The Hydrogen Line Profiles

Paper I reported that the the Hγ/HeI4471 equivalent-width ratio gives an abundance ratio n_H/n_{He}=0.02, whereas the adopted model has n_H/n_{He}=0.01. In the current data two hydrogen lines (Hγ, Hδ) are available, Hε can also be identified. It has proved impossible to fit both line profiles simultaneously with the current models. in both cases the best result was obtained with T_{eff}=25000K and log g=3.5. However to fit Hγ, n_H/n_{He}=0.02 is required, whilst Hδ requires n_H/n_{He}=0.01.

4. DISCUSSION

Paper II determined the mean effective temperature of V652 Her and its variation from observations of the total flux emitted by the star, based mainly on the ultraviolet flux distributions. We have to compare our spectroscopic results with those of Paper II. The latter derived T_{eff}=23450±1320 K and the amplitude of the T_{eff} variation was 2850±110 K when the mean observations obtained within ±0.1 cycles of T_{min} and T_{max}, respectively, were considered.

While our results for the temperature variation are in good agreement (the difference is only about 350 K) the effective temperature of our model is considerably larger than the empirical T_{eff} of paper II (ΔT_{eff}=4600 K). This discrepancy can be explained (at least partially) by the fact that our model does not account for line blanketing. The observed ultraviolet spectrum, however, displays strong line blocking in the wavelength region 1200-2000Å, as can be seen in Fig. 3 of Paper II. Including the UV line blocking in the models would result in backwarming of the deeper layers. Consequently, a lower model T_{eff} has to be assigned to fit the ionisation equilibria.

5. CONCLUSIONS

We have presented preliminary results of an analysis of visual spectra of V652 Her. We derived T_{eff} and T_{eff} variations in reasonable agreement with previous investigations of the ultraviolet flux distribution.

The abundances of hydrogen, nitrogen and silicon have also been determined. The hydrogen deficiency is probably due to CN burning, since we find nitrogen strongly enriched while the carbon lines are weak. Only CII 4267Å can be identified (W_λ=158mÅ) in our spectra. The silicon enrichment (by ~1 dex) with respect to the Sun cannot be explained by nuclear processing in the stellar interior.

ACKNOWLEDGMENTS.

We are grateful to Dr.J.P.Kaufmann for preliminary calculations suggesting that both Silicon ionisation equilibria should be observable. This paper is based on observations made with the Anglo-Australian Telescope. The project is supported by the UK Science and Engineering Research Council.

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DISCUSSION

LYNAS-GRAY: What is the reason for the discrepancy between IUE and ionization equilibrium mean T_{eff} variations?

JEFFERY: It is the model atmosphere which we used. Yours is from a line blanketed model atmosphere. These ones are from continuum model atmosphere. The mean effective temperature derived from the IUE fluxes is an empirical one, i.e. essentially independent of the model. The T_{eff} derived from the ionization equilibrium is a model T_{eff}. The model does not take into account line blanketing. Since the UV line blocking is extra-ordinarily large, it can explain the difference between the two effective temperatures derived. The large UV line blocking might be related to the over abundances we find.

TUTUKOV: What is the time scale for the change of the pulsation period?

JEFFERY: It is roughly 10^{-10} days/cycle.

SAIO: Did you get the oxygen abundances?

JEFFEREY: We have not measured the oxygen abundances yet.