Rev. Mexicana Astron. Astrof., **14**, 431-434 (1987)

SPECTROSCOPIC STUDIES OF THE SOUTHERN CEPHEID β DOR

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ABSTRACT. Fine analysis of the southern Cepheid β Dor has been conducted at different phases with an aim to derive atmospheric parameters at those phases. Atmospheric abundances have been derived for Fe group elements and s-process elements. The derived parameters of β Dor are compared with earlier estimates.

Key words: SPECTROSCOPY -- STARS-ABUNDANCES -- STARS-CEPHEIDS

INTRODUCTION

Beta Doradus is a bright southern classical Cepheid with a period of 9.84 days. Broad band photometry of β Dor is done by Eggen, Gascoigne and Burr (1957), Irwin (1961), and Mitchell et al. (1964). Six-colour UBVGRI photometry was done by Parsons (1970) who derived temperatures, gravities and surface brightness at different phases. Walraven VBLUW photometry of β Dor was done by Pel (1976) who derived temperatures, gravities, bolometric light curve, radius variation and equilibrium values of these quantities (Pel 1978).

Differential curve of growth analysis of β Dor relative to the Sun was done by Rodgers and Bell (1964, hereinafter RB) using high dispersion (6 Å mm^{-1}) spectra taken at 9 different phases. RB have employed a very large number of lines in their investigation. However, differential curve of growth analysis with respect to the Sun is not justified due to the difference in luminosity class of the two stars considered. Besides, gf values used in the construction of solar curve of growth (Allen, 1953) which is used by RB are hopelessly outdated. The recent estimates of gf values, like those by Blackwell and Shallis, could attain a precision of 1% in their experiments where temperatures were very precisely maintained. It appears that gf values available two decades ago were quite uncertain and the accuracy was poorer for ionised lines. Consequently the temperatures derived by RB do not agree with the photometric estimates. They are systematically lower by $\sim$800 K compared to Parsons (1970) and $\sim$600 K lower compared to those of Pel (1978). Also, the analysis of RB includes very strong lines (Equivalent Width > 500 mÅ) of FeII and TiII which are likely to be affected by non-LTE effects.

The reasons mentioned above led us to believe that there is a need to reanalyse the line data of RB obtained at high dispersion and to derive the atmospheric abundances.

LINE EQUIVALENT WIDTHS AND gf VALUES

We have chosen relatively unblended and weaker lines from the line list of RB. The lines stronger than 450 mA equivalent widths were dropped due to the reasons mentioned above. The gf values were selected from various sources and will be listed elsewhere, but a good number of them were taken from Hearnshaw and Desikachary (1982). To estimate the accuracy of equivalent widths measured by RB, we have compared equivalent widths for δ CMa measured by Bell and Rodgers (1965) using the same observational set up as for β Dor, with those of Castley and Watson (1960). For lines common in the two investigations, we find no systematic difference between the measured equivalent widths.

ATMOSPHERIC PARAMETERS AND ABUNDANCES

We have used model atmospheres of Kurucz (1979) in the effective temperature range 5500 K - 6500 K and log g = 0.5 - 2.0. We have used single line version of spectrum synthesis code of Sneden (1974) to compute theoretical equivalent widths. We have modified the code to include the opacities due to CI, MgI, AlI, SiI and electron scattering. The classical representation of natural broadening is also included together with van der Waals broadening. Our method of deriving atmospheric parameters have been described in detail in Giridhar (1983). We have chosen a large number of FeI and FeII lines covering a good range in equivalent widths and in excitation potentials. The microturbulent velocity was derived by requiring lines of different strengths to lead to the same value of abundance. The temperature were derived such that lines of different excitation potentials gave the same value of abundance and gravities were obtained by requiring both FeI and FeII lines to give the same abundance. Figures 1 and 2 demonstrate the fact that for adopted atmospheric parameters there is no dependence of derived [Fe/H] on excitation potentials and equivalent widths of the lines. The figures deal with one particular phase but the same is true for other phases. The atmospheric parameters derived for four phases are listed in Table 1. Using these atmospheric parameters, we have derived atmospheric abundances for Fe-peak elements Ca, Sc, Ti, V, Cr, Co, Ni and Zn and s-process elements Y, Ba, La, and Ce. Derived atmospheric abundances of these elements at different phases and also their mean values are presented in Table 2.

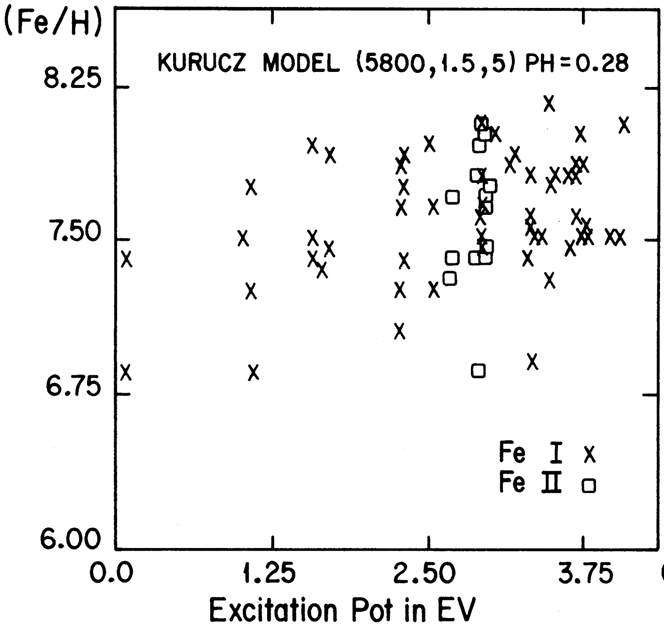

Fig.1.Derived [Fe/H] abundances as a function of excitation potentials of the lines.

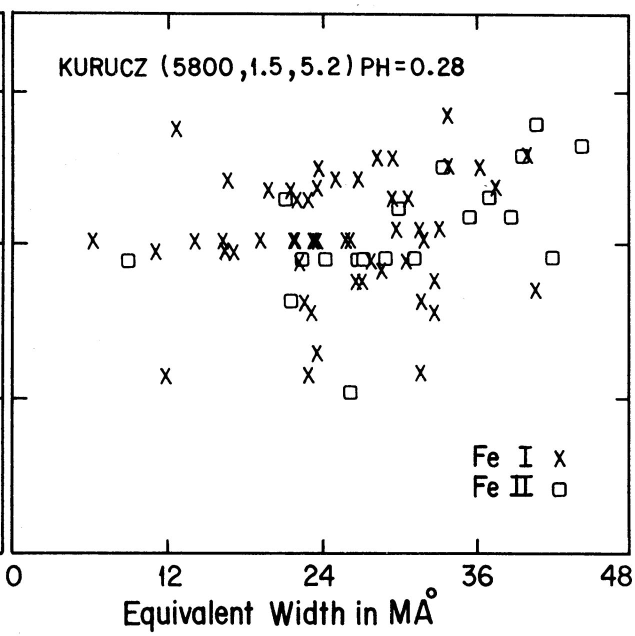

Fig. 2. Derived [Fe/H] abundances as a function of equivalent widths of the lines.

Table 1. Derived atmospheric parameters for different phases of β Dor

Phase	T_{eff}	Log g	ξ_T	No. of Lines	12+log [Fe/H]
0.18	6000	2.0	5.2	74	7.58
0.28	5800	1.5	5.0	75	7.65
0.38	5500	0.75	4.8	77	7.49

Table 2. Abundances of different elements with respect to their solar values

Element	No. of Lines	ϕ 0.18	ϕ 0.28	ϕ 0.38	$\bar{Z}$
CI	1	-0.20	-0.16	-0.20	-0.19
Ca I	8	+0.12	+0.12	+0.03	+0.09
Sc II	7	+0.25	-0.10	-0.13	+0.01
Ti I	12	+0.15	-0.02	0.00	+0.03
Ti II	20	+0.28	+0.20	+0.11	+0.20
V I	5	+0.12	+0.30	+0.18	+0.20
VII	4	+0.20	+0.38	+0.20	+0.29
Cr I	9	-0.07	+0.00	-0.20	-0.09
Cr II	9	+0.17	+0.15	-0.06	+0.03
Mn I	5	+0.35	+0.15	+0.20	+0.20
Co I	2	-0.30	-0.30	-0.30	-0.30
Ni I	8	-0.26	-0.20	-0.29	-0.25
Ni II	2	-0.25	-0.22	-0.03	-0.17
Zn I	2	-0.05	+0.15	-0.03	+0.02
Sr II	3		-0.20	-0.40	-0.30
Y II	4	-0.18	-0.20	-0.20	-0.19
Zr II	4	+0.16	-0.10	-0.14	-0.02
Ba II	2	+0.30	+0.33	+0.10	+0.24
La II	3	+0.40	+0.30	+0.15	+0.28
Ce II	4	+0.20	+0.20	+0.10	+0.18

RESULTS AND DISCUSSION

As in the case of other classical Cepheids, Fe/H for β Dor is very close to the solar value. Carbon is a little underabundant. Elements Ca, Sc, Ti and Cr have almost solar abundances, whereas V and Mn are slightly enriched. Elements Co and Ni, and S-process elements Sr and Y appear to be underabundant. Other s-process elements Ba, La, and Ce exhibit marginal enrichment. Enrichment of La in Cepheids of period range 7-10 days is also reported by Luck and Lambert (1981). However, the number of lines measured for these s-process elements are very small and therefore, prevents us from making a definite suggestion.

Compared to the analysis of RB, we do not observe strong deficiencies in V, Ni, Mn and Sr. Also the abundance presented here does not vary drastically with phase. The drastic variation of abundances reported by RB is mostly due to the choice of improper temperature scale which would also affect the ionization equilibrium. The atmospheric parameters derived by us are in good agreement with photometric estimates of Parsons (1970) and Pel (1976). Our analysis uses spectrum synthesis method and more precise gf values. Therefore, the abundances derived are naturally more accurate.

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