Publ. Astron. Obs. Belgrade No. 57 (1997), 113 – 116 *Contributed paper*

SHIFTS OF THE CENTRAL PARTS OF H_β LINE

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1. INTRODUCTION

Parameters of Balmer H_β line are a well-known tool for plasma diagnostics purposes. Thus the knowledge about the dependence of line half-width, $\Delta\lambda_{1/2}$, and parameters of the central part of the line, on plasma parameters T and N_e is of the great interest for theoretical calculations (Kudrin and Sholin, 1966; Seidel, 1977; Cardeñoso and Gigogos, 1989) and for experimenters (Kellecher and Wiese, 1973; Helbig and Nick, 1981). In plasmas of moderate densities ($N_e \geq 10^{22}\,\mathrm{m^{-3}}$) the discrepancy between the calculated and measured values of H_β parameters is of the order of several percent for $\Delta\lambda_{1/2}$ and considerably larger for parameters of the central part of the line. The basic reason for the discrepancy between the calculated and the measured values, especially for the central part of the line, is the negligence of influence of ion motion in the calculations. Thus the central structure of the line has become more attractive for theoretical and experimental investigations.

During the last decade or so, the ion-dynamics effect gave satisfactory explanation for the line shift. At the same time a few measurements of the line central structures have been performed (Wiese, 1974). The most reliable experiments were performed using wall-stabilized arc as light source (Helbig and Nick, 1981; Wiese, 1974; Djurović, *et al.*, 1988) reaching the electron densities up to arround $1 \times 10^{23}\,\mathrm{m^{-3}}$. For higher electron densities a pulsed plasma source should be used (Hey, 1974; Savić *et al.*, 1996). In the cited papers only the relative magnitudes, such as dip, asymmetry and peak separation (relative to the halfwidths of the line) were reported. In this paper rather precise absolute measurements concerning the central structure of H_β line are reported. The hereby presented results refer to $3.5\times10^{22}\,\mathrm{m^{-3}}$ for electron density and 11×10^3 K for electron temperature.

2. EXPERIMENTAL

A wall stabilized arc (Djurović *et al.*, 1997) operating at atmospheric pressure was used as the plasma source. The current of 30 A was supplied to arc by a circuit-stabilized power supply with stability of 0.3%. The mixture containing 90% of argon and 10% of hydrogen was introduced into the central part of the arc with flow rate of 0.03 ℓ/min. The flow rate of the working gas-argon was 3 ℓ/min, so the percentage of H_2 in the arc was approximately 0.16 %.

Profiles of the H_β line were scanned by 1 m monochromator equipped with a 1200 g/mm grating and strepping motor with 36000 step/rev. Signals from photomultiplier were led to the digitizing oscilloscope working in averaging mode (32 samples over 200 ms for each sample).

The light from the arc plasma (observed end-on) and from reference source (low pressure hydrogen discharge tube) is focused onto the entrance slit of the monchromator alternatively by using light chopper. The personal computer was used for control the stepping motor, light chopper, and oscilloscope and also for data acquisition. Back reflection mirror method for the line self-absorption testing was applied.

We have analyzed three independently obtained profiles (P_1, P_2, and P_3) of H_β. Relative intensities of all profiles were normalized to 1 for the maximum measured values. Underlaying continuum was taken to be equal to the lowest measured intensity at far wings (over 3 full halfwidths of the profile) and subtracted from the profiles shown in Figs 1 and 2. All three profiles are presented together in Fig. 1 illustrating excellent reproducibility. Referent wavelength is determined by fitting the Gauss profile on the experimental profile obtained from the reference source.

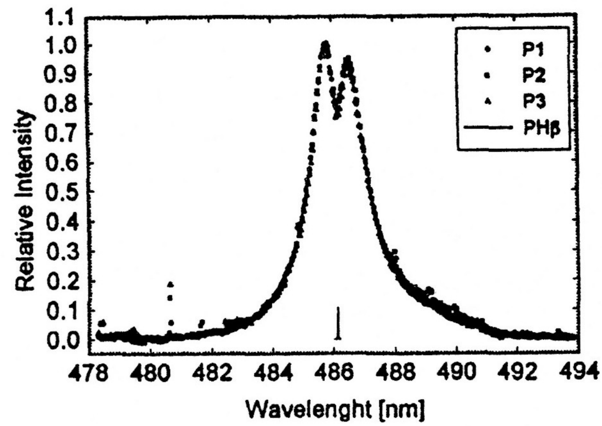

Figure 1.

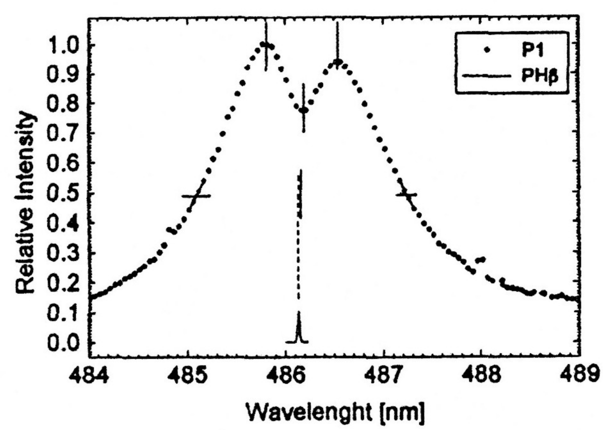

Figure 2.

3. THE RESULTS

Wavelengths λ_B of the blue maximum, λ_D of the central dip, λ_R of the red maximum as well as halfwidth $\Delta\lambda_{1/2}$ were determined from the profiles illustrated in Fig. 2. The error of the wavelength determination is less than 0.02 nm. The halfwidths were determined at half of the mean maxima $\left(\frac{1}{2}\bar{I}, \bar{I} = \frac{1}{2}(I_B + I_R)\right.$ and I_B and I_R being intensities of the blue and red maxima respectively). Wavelength of the line center λ_C was determined as the mean value of the blue and red side profile at $\frac{1}{2}\bar{I}$. The wavelengths (all given in nm) read from the three profiles P_1, P_2 and P_3 are given in Table 1.

Table 1

	P_1	P_2	P_3
λ_B	485.81	485.78	485.81
λ_R	486.54	486.54	486.54
λ_D	486.18	486.20	486.17
λ_C	486.16	486.17	486.17
$\Delta\lambda_{1/2}$	2.16	2.16	2.13

The shifts of blue maxima $\Delta\lambda_B$, red maxima $\Delta\lambda_R$, dips $\Delta\lambda_D$, line centers $\Delta\lambda_C$, with respect to unperturbed line position $\lambda_{H\beta}$, defined as: $\Delta\lambda_B = \lambda_B - \lambda_{H\beta}$; , $\Delta\lambda_R = \lambda_R - \lambda_{H\beta}$; , $\Delta\lambda_D = \lambda_D - \lambda_{H\beta}$; and $\Delta\lambda_C = \lambda_C - \lambda_{H\beta}$ are given in Table 2, in nm.

The shifts of blue maxima $\Delta\lambda_B$, red maxima $\Delta\lambda_R$, dips $\Delta\lambda_D$, line centers $\Delta\lambda_C$, with respect to profile center λ_C, defined as: $\Delta\lambda_{BP} = \lambda_B - \lambda_C$; , $\Delta\lambda_{RP} = \lambda_R - \lambda_C$; , and $\Delta\lambda_{DP} = \lambda_D - \lambda_C$ are given in Table 3, also in nm

Table 2

	P_1	P_2	P_3
$\Delta\lambda_B$	-0.32	-0.35	-0.32
$\Delta\lambda_R$	0.41	0.41	0.41
$\Delta\lambda_D$	0.05	0.07	0.04
$\Delta\lambda_C$	0.03	0.04	0.04

Table 3

	P_1	P_2	P_3
$\Delta\lambda_{BP}$	-0.35	-0.39	-0.36
$\Delta\lambda_{RP}$	0.37	0.37	0.37
$\Delta\lambda_{DP}$	0.02	0.03	0.00

4. CONCLUSIONS

Relatively precise wavelength measurements of H$_\beta$ line central structure show the total red shift about 0.04 nm at electron density of $3.6 \times 10^{22}\,\mathrm{m}^{-3}$ and temperature 11×10^3 K. Line center λ_C at half (average) intensity maximum is increased with respect to low pressure H_β line for 0.04 nm. The blue maximum differs from λ_C for $\Delta\lambda_{BP} = -0.36$ nm, while red maximum foı $\Delta\lambda_{RP} = 0.37$ nm. It seems that λ_D is shifted for some 0.01 nm with respect to λ_C in which case the maxima are located symmetrically with respect to λ_D rather than to λ_C (the errors of λ_B, λ_R and λ_D are within 0.02 nm). Relative value of the dip (D), relative peak separation (S) as well as line asymmetry at its central part (Djurović *et al.*, 1988) agree well with the numerous earlier measurements.

REFERENCES

Cardeñoso, V. and Gigosos, M. : 1989, *Phys. Rev. A*, **39**, 5258

Djurović, S. , Mijatović, Z. and Kobilarov, R. : 1988, *Contrib. Plasma Phys.* , **28**, 220

Djurović, S. , Mijatović, Z. , Kobilarov, R. and Konjević, N. : 1997, *J. Quant. Spectrosc. Radiat. Transfer*, **57**, 695

Helbig, V. and Nick, K. P. : 1981, *J. Phys. B, At. Mol. Phys.* , **14**, 3573

Hey, J. D. : 1974, *Ph. D. Thesis, Univ. of Maryland*

Kelleher, D. E. and Wiese, W. L. : 1973, *Phys. Rev. Lett.* , **31**, 1431

Kudrin, J. P. and Sholin, G. V. : 1966, *Sov. Fiz. Dokl.* , **7**, 1015

Savić, I. , Vujičić, B. , Djurović, S. and Pavlov, M. : 1996, *SPIG 96 Contributed papers*, p. 290, p. 294

Seidel, J. : 1977, *Z. Naturforsch.* , **32.a**, 1195 and 1207

Wiese, W. L. : 1974, *7th SPIG*, Dubrovnik 1974, p. 637-673.