

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; Cardenoso and Gigogos, 1989) and for experimenters (Kellecher and Wiese, 1973; Helbig and Nick, 1981). In plasmas of moderate densities ($N_e \geq 10^{22} \text{ m}^{-3}$) 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 around $1 \times 10^{23} \text{ m}^{-3}$. 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 $3.5 \times 10^{22} \text{ m}^{-3}$ for electron density and $11 \times 10^3 \text{ K}$ 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 stepping 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 monochromator 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. Underlying 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.

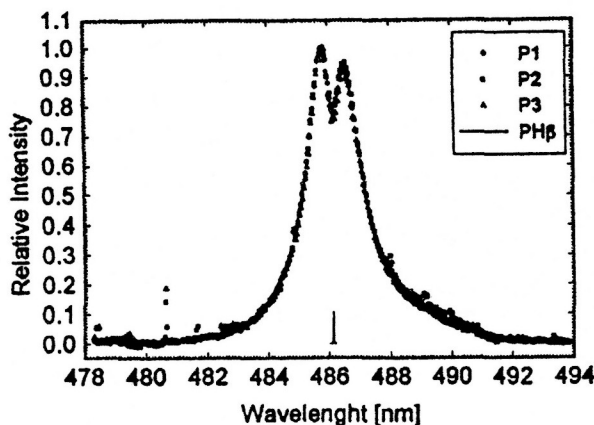


Figure 1.

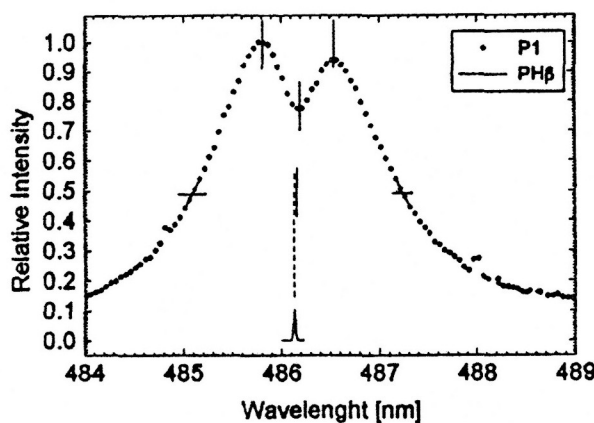


Figure 2.

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 ($\frac{1}{2}I$, $I = \frac{1}{2}(I_B + I_R)$ 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 $\frac{1}{2}I$. 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 $3.6 \times 10^{22} \text{ m}^{-3}$ and temperature $11 \times 10^3 \text{ K}$. Line center λ_C at half (average) intensity maximum is increased with respect to low pressure $H\beta$ line for 0.04 nm. The blue maximum differs from λ_C for $\Delta\lambda_{BP} = -0.36 \text{ nm}$, while red maximum for $\Delta\lambda_{RP} = 0.37 \text{ nm}$. 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.

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