A METHOD FOR DETERMINATION OF ELECTRON CONCENTRATION IN DENSE SPACE PLASMA

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A method for determination of the intensity distribution of the recombination emission on the Balmer series limit versus logarithm of the electronic concentration $\log n_e$ is presented. Both the Stark and Doppler effects are taken into account. The core of the correspond integral equation is tabulated in a compact form for the wide range of $\log n_e$ (from 9 to 15) and the most probable velocities of hydrogen atoms (from 0 to 3000 km/s).

The spectral range of the Balmer series limit is highly attractive to plasma diagnostics. Is was shown that observed distribution of intensity in the Balmer precontinuum provides an opportunity for determination of the electron concentration inhomogeneity [1]. The Balmer precontinuum intensity is meant to be an interpolated curve through points of minimum intensities between the high Balmer members. The method proposed by [1] is not quite correct and overestimates the values of the electron concentration by factor 3 [2]. In this paper the redetermine plasma diagnostics is presented.

One can obtain the differential distribution of the recombination emission at the Balmer series limit, $I_{c,2}$ with respect to logarithm of the electron concentration, $\log n_e$, solved numerically equation

$$I(\lambda) = \int \varphi(\lambda, \log n_e, \xi)\, I'_{c,2}\, d\log n_e, \tag{1}$$

where $I(\lambda)$ – observed precontinuum intensity, λ – the wavelength of electromagnetic radiation, ξ – the most probable velocity of hydrogen atoms, $\varphi(\lambda, \log n_e, \xi)$ – precontinuums calculated for fixed values of n_e. These precontinuums were calculated as a result of overlapping of the hydrogen line wings broaden by the Stark and Doppler effects. Since the Doppler effect is negligible in the line wings, the constant value of ξ is assumed for a whole object. ξ is determined from low members of Balmer series. The special choice of coordinates allows to tabulate the function $\varphi(\lambda, \log n_e, \xi)$ in a compact form.

Let us consider the precontinuum as a function of parameter $x = \log(\lambda - \lambda_{c,2})$, where $\lambda_{c,2}$ is the limit of the Balmer series (in Angstroms). Take the value $\bar{x}$ equal to x which satisfies the condition $I(\bar{x}) = I_{c,2}/2$, where the precontinuum intensity, $I(x)$, equals the half of intensity at the series limit. Then if spectral lines are broaden by the Doppler effect only

$$\bar{x}(\xi) = -3.1367 + 0.67 \log \xi, \tag{2}$$

where ξ is in cm/s.

Table 1: Profiles of precontinuums

$x-\bar{x}$	α					$x-\bar{x}$	α				
	0.5	0.2	0	−0.2	−0.5		0.5	0.2	0	−0.2	−0.5
−0.20	1.00	1.00	1.00	0.99	0.99	0.08	0.22	0.20	0.19	0.18	0.18
−0.16	1.00	1.00	0.99	0.97	0.96	0.12	0.15	0.13	0.11	0.09	0.09
−0.12	1.00	0.99	0.94	0.92	0.91	0.16	0.10	0.09	0.06	0.04	0.03
−0.08	0.95	0.89	0.84	0.82	0.81	0.20	0.07	0.06	0.04	0.02	0.01
−0.04	0.75	0.71	0.68	0.67	0.67	0.30	0.03	0.02	0.01	0.01	0.00
0	0.50	0.50	0.50	0.50	0.50	0.40	0.01	0.01	0.01	0.00	0.00
0.04	0.33	0.33	0.33	0.33	0.33	0.60	0.00	0.00	0.00	0.00	0.00

For the Stark effect

$$\bar{x}(n_e) = -1.827 + 0.265 \log n_e. \tag{3}$$

The precontinuum profiles depend on the parameter $\alpha = \bar{x}(n_e) - \bar{x}(\xi)$. We calculated these dependencies and presented them in Table 1.

The calculations including both the Stark and Doppler effects are presented in Table 2. To determine the value $\bar{x}(n_e, \xi)$ the dependence of $\beta = \bar{x}(n_e, \xi) - \bar{x}(\xi)$ on α is given in Table 2 as well.

Table 2: Dependence of parameter β on α

α	β	α	β	α	β	α	β
0.6	0.602	0.3	0.316	0.0	0.090	–0.3	0.011
0.5	0.504	0.2	0.229	–0.1	0.048	–0.4	0.005
0.4	0.409	0.1	0.152	–0.2	0.024	–0.5	0.002

Tables 1 and 2 together with Eqs. (2)–(3) allow to obtain the functions $\varphi(\lambda, \log n_e, \xi)$ for a numerical solution of Eq. (1) in wide the range of values n_e (from 10^9 up to 10^{15} cm^{-3}) and ξ (from 0 up to 3000 km/s).

REFERENCES

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