THE DEPENDENCE OF ASYMMETRY OF SELF-REVERSED SPECTRAL LINES WITH THE QUADRATIC STARK-EFFECT ON THE ABSORPTION PARAMETER

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In this work we continue (see [1,2]) the analysis of asymmetry of self-reversed spectral lines in the emission influenced by the quadratic Stark-effect under the conditions of dense plasma when the broadening by charge particles predominates. In contrast to [1,2], the theoretical analyses based on computer calculations of an emission transfer equation have been carried out at enough rigorous analytical representation of normalized local broadening profile $P_\nu(r)$ (ν is the frequency, r is the spatial coordinate) in which the electron and ion broadening are taken into account simultaneously (see the approximation expressions in [3,4]). The rigorous representation of $P_\nu(r)$ allows us to investigate theoretically in detail the asymmetry of self-reversed lines on the various stages of self-reversal. The model of strongly inhomogeneous axially symmetric plasma described in [1,2,5] are used: emitting atoms are located in the emission zone with the radius R_o - their radial distribution is given through the parameter *m* of source function; the electron impact half-width is equal to the maximal value α_o at the centre at r=0-the radial drop of electron half-width is given through the parameter *b* (further the calculated data are presented at *m*=2 and *b*=2). In contrast to [1,2], the complicated radial variation $n_j(r)$ of absorbing atoms concentration is used: $n_j(r)/n_j(0)=[1+a_1g_1(r/R_o)^2]\exp[-g_1(r/R_o)^2]$ for $0\leq r/R_o\leq r_1/R_o$; $n_j(r)/n_j(0)=[1+a_1g_1(r_1/R_o)^2]\exp[-g_1(r_1/R_o)^2][1+a_2g_2(r/R_o-r_1/R_o)^2]\exp[-g_2(r/R_o-r_1/R_o)^2]$ for $r_1/R_o < r/R_o \leq r_o/R_o$ (r_o is the radius of the absorption zone); a_1, a_2, g_1, g_2 and r_1 are the parameters. At a_2=0, g_2=0 and $r_1=r_o$ (in this case a_1=a and g_1=g) the radial variation $n_j(r)$ turns out to be the variation $n_j(r)$ used in [1,2,5]. The calculations have been carried out at various values of the absorption parameter $p_o=A(N_j/\delta_o)$ where A is the constant for a given spectral line and $N_j=\int_0^{r_o} n_j(r)dr$ is the total number of absorption atoms.

Below some results obtained by as are presented Fig.1 shows the typical profile of asymmetric self-reversed line ($I(\nu)$ is the intensity; ν_o is the unperturbed frequency of line; η is the ratio of the electron shift to the electron half-width; α_o is the ionic broadening parameter at r=0) for the central line-of -sight in the plasma cross-section. The distance between the self-reversal maxima $2s=\Delta_s/\delta_e$ and the asymmetry parameters $I_{max1}/I_{max2}=I_{12}$ and $\chi_e=k_1-k_2=(u_1-u_2)/\delta_e$ are the principal profile parameters, where Δ_s, u_1 and u_2 are the measured distances in the frequency scale (or in the wavelength scale). Tables 1-3 show the dependence of 2s, I_{12} and χ_e on p_e for three various cases of the concentration variation $n_j(r)$ shown on Fig.2 (the model I - a=2, g=0.83; II - a_1=0, g_1=0, $r_1=R_o$, a_2=15, g=4; III - a=30, g=0.1). As p_e increases the value of I_{12} passes through the maximum. The particular importance of the parameter χ_e should be noted - the knowledge of χ_o permits one to determine the electron half-width δ_o using the measured values of u_1 and u_2 and the electron concentration n_{eo} using δ_e, and p_o and N_j using 2s. In [1,2], the equation $\chi_e =1.55|\eta| + 6.4\alpha_e$ (Eq.(1)) was proposed to estimate of χ_o as a first approximation. In table 4 the values of χ_o calculated using Eq.(1) at η=1.2 are presented. As seen from the tables the approximate Eq.(1) gives reasonable values of χ_o. However one can see from tables 1 and 2 that a refinement of χ_o is desirable. To this end even a rough estimate of p_e is sufficient.

The estimation of p_e using 2s was considered by us in [2] (here the knowledge of δ_o and model parameters is necessary). In this work for the first time we emphasize that one can preliminary estimate p_o using the dependence of I_{max1}/I_{max2} on 2s (Fig. 3) and of dependence of $2s/\chi_o= \Delta_s/(u_1-u_2)$ (to determine this ratio the knowledge of δ_o is not necessary) on p_o (Fig. 4). At present the detailed theoretical and experimental study of these and similar dependences (using also absorption line parameters) is under way. Here we present only one example of using of dependences given in Figs. 3 and 4. Under the conditions of a low-voltage impulse discharge [6] we have obtained for the AlI 396.1 nm self-reversed resonance line at the axial values of temperature T_e=13600 K and $n_{eo}=3.6\cdot10^{17}cm^{-3}$ (measured by the H_α line width of hydrogen): I_{max1}/I_{max2}=3.6, Δs=1.5 Å and u_1-u_2=2.1 Å in the wavelength scale, χ_e=2.5 by the Eq.(1) at η=1.2 and α_o=0.1 [7]. As a first approximation we have δ_e=0.85 Å and 2s=1.75. These data are presented in Fig.3 as the dot (x)- the location of this dot shows that the asymmetry of given aluminium line is close to the maximal one (for the case of definition of $n_j(r)$ variation by the model II - this variation of $n_j(r)$ we have obtained from the transverse picture of absorption profiles using technique described in [2]). From the dependence of $2s/\chi_e$ on p_e for the model II at α_o=0.1 we have p_o=3.1 and as a second approximation χ_e=2.95 and 2s=2.2 (see table 2). These data are presented in Fig.3 as the dot (o). In the present case the approximate Eq.(1) underestimates χ_e and overestimates δ_o approximately by 20%. The similar correction of χ_e, δ_e and n_{eo} may be carried out for the data presented in [1].

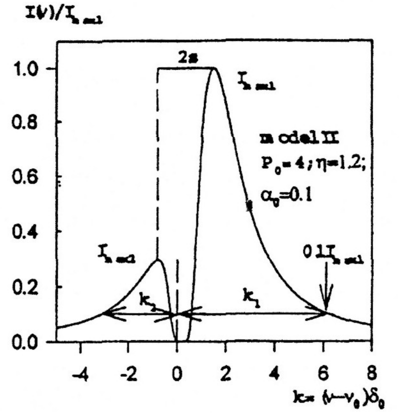

Fig.1

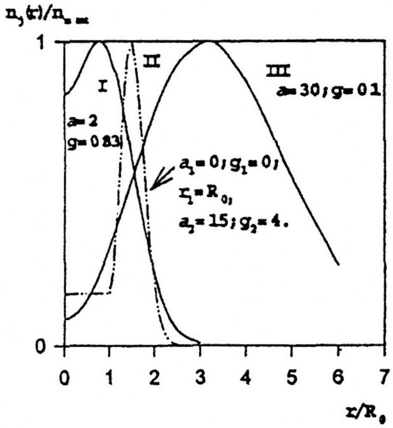

Fig.2

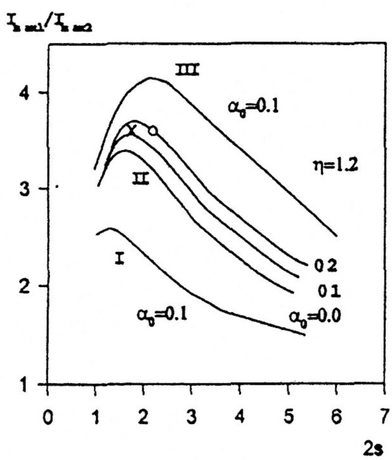

Fig.3

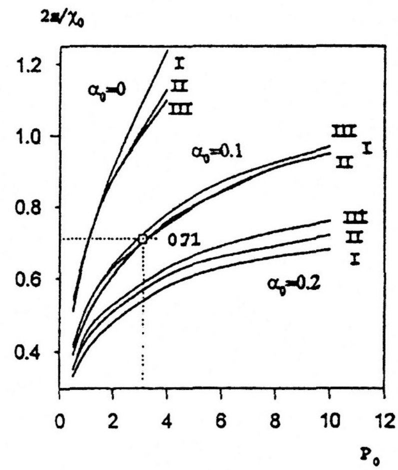

Fig.4

Table 1. η=1.2; a=2; g=0.83 (model I). $I_{12}=I_{max1}/I_{max2}$.

P_0	α_0=0.0				α_0=0.1				α_0=0.2			
	2s	I_{12}	χ_0	2s/χ_0	2s	I_{12}	χ_0	2s/χ_0	2s	I_{12}	χ_0	2s/χ_0
0.5	0.95	2.42	1.87	0.51	1.01	2.52	2.61	0.39	1.07	2.61	3.28	0.33
1.0	1.28	2.45	1.89	0.68	1.34	2.58	2.73	0.49	1.39	2.69	3.48	0.40
2.0	1.73	2.29	1.90	0.91	1.8	2.42	2.94	0.61	1.85	2.54	3.83	0.48
4.0	2.37	2.00	1.91	1.24	2.47	2.12	3.26	0.76	2.58	2.22	4.44	0.58
10.0	3.64	1.63	1.92	1.90	3.82	1.71	4.02	0.95	4.00	1.78	5.91	0.68

Table 2. η=1.2; a_1=0; g_1=0; $r_1=R_0$; a_2=30; g_2=4 (model II). $I_{12}=I_{max1}/I_{max2}$.

P_0	α_0=0.0				α_0=0.1				α_0=0.2			
	2s	I_{12}	χ_0	2s/χ_0	2s	I_{12}	χ_0	2s/χ_0	2s	I_{12}	χ_0	2s/χ_0
0.5	1.05	3.03	1.91	0.55	1.15	3.15	2.62	0.42	1.18	3.24	3.28	0.35
1.0	1.33	3.31	1.92	0.69	1.40	3.45	2.70	0.52	1.47	3.57	3.41	0.43
2.0	1.70	3.39	1.94	0.88	1.78	3.56	2.84	0.63	1.85	3.70	3.64	0.51
4.0	2.21	3.19	1.96	1.13	2.31	3..7	3.06	0.75	2.42	3.51	4.00	0.61
10.0	3.22	2.59	1.97	1.63	3.39	2.75	3.55	0.95	3.55	2.88	4.95	0.72
20.0	4.38	2.12	1.97	2.22	4.64	2.25	4.22	1.10	4.86	2.35	6.25	0.78

Table 3. η=1.2; a_1=30; g_1=0.1; (model III). $I_{12}=I_{max1}/I_{max2}$.

P_0	α_0=0.0				α_0=0.1				α_0=0.2			
	2s	I_{12}	χ_0	2s/χ_0	2s	I_{12}	χ_0	2s/χ_0	2s	I_{12}	χ_0	2s/χ_0
0.5	0.93	3.12	1.73	0.54	0.97	3.20	2.35	0.41	1.02	3.26	2.92	0.35
1.0	1.20	3.53	1.76	0.68	1.27	3.62	2.43	0.52	1.32	3.71	2.95	0.45
2.0	1.57	3.83	1.79	0.88	1.64	3.98	2.55	0.64	1.71	4.07	3.24	0.53
4.0	2.01	4.03	1.82	1.10	2.11	4.15	2.71	0.78	2.20	4.23	3.51	0.63
10.0	2.83	3.76	1.85	1.53	2.96	3.89	3.05	0.97	3.13	3.97	4.12	0.76

Table 4. η=1.2. χ_0 is calculated using Eq. (1).

α_0	0.0	0.1	0.2
χ_0	1.86	2.50	3.14

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