Publ. Obs. Astron. Belgrade No. 50 (1995), 69 – 71

THE INTERDEPENDENCE BETWEEN THE PARAMETERS OF STARK BROADENING AND ASYMMETRY OF SELF-REVERSED SPECTRAL LINES WITH THE QUADRATIC STARK EFFECT

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There is ample literature (see for example Griem, 1964; Griem, 1974; Dimitrijević, 1991) on the theoretical and experimental investigations of Stark broadening by charged particles (electrons and ions) of spectral lines with the quadratic Stark effect. The important parameters are here the electron impact half-width d, electron impact shift h or shift parameter $t = h/d$ and ionic broadening parameter A. The knowledge of these parameters gives the possibility to construct the broadening profile $P(v)$ normalized to unit area over a frequency scale v. The experimental investigations of $P(v)$ profiles are carried out ordinarily by using spectral lines free from the self-absorption. It is often difficult to get spectral lines free from the self-absorption under the conditions of dense plasmas with the predominant broadening by charged particles (the plasmas of pulsing discharges, exploding wires, sparks, plasma jets, laser produced plasmas etc.). The atom resonace spectral lines tend particularly to the self-absorption. The self-absorption causes here usually the formation of strongly asymmetric self-reversed spectral lines. The theoretical and experimental investigations of asymmetric self-reversed lines carried out by us (Fishman *et al.*, 1981; Salakhov *et al.*, 1981; Fishman *et al.*, 1991) show that the interesting information about Stark broadening parameters may be received by the parameters of self-reversed lines.

The theoretical analysis of self-reversed profiles has been carried out on the basis of computer calculation of an emission transfer equation for different lines of sight of strongly inhomogeneous axially symmetric plasma described in Il'in *et al.* (1976). The source function $f(r)$ (r is the geometric coordinate) characterizing the relative distribution of emission atoms concentration relative to distribution of absorption atoms concentration was set at $0 < r < D$ (D is radius of emission zone) as

$$f(r) = f(0)[1 - F(r)]$$

where $F(r)$ is r/D to power m (m is the inhomogeneity parameter) and $f(r) = 0$ at $r > D$. The radial concentration variation of absorption atoms $n(r)$ on the lower level

of spectral transition was set as

$$n(r) = n(0)[1 + agG(r)]\exp(-gG(r))$$

where $G(r)$ is r/D to power 2 (a and g are the parameters). The local broadening profile $P(v, r)$ was represented in terms of Stark profile $j(x, A(r), R)$ (Griem, 1974) (x is related with v; R is the Debay shielding parameter) with the electron impact half-width

$$d(r) = d(0)\exp(-bG(r))$$

at $0 < r < D$ and

$$d(r) = d(0)\exp(-b)$$

at $r > D$ (b is the parameter) and electron impact shift $h(r) = td(r)$. For the computer calculation of emission transfer equation the central part of the profile $j(x, A(r), R)$ given in tabulated form in Griem (1974) was represented in accordance with Preobrazhenskii (1971) in form of two Student distributions with different parameters dependent on the local ionic broadening parameter

$$A(r) = A(0)q(r)$$

where $q(r)$ is $d(r)/d(0)$ to power 1/4 as a first approximation. For the wings of the profile $j(x, A(r), R)$ the asymptotic formulae (Griem, 1974) are used. The procedure of $P(v)$ construction is described in detail in Il'in and Konovalova (1995).

The calculated data have permitted to investigate in detail the influence of the parameters m, a, g, b, t, $A(0)$, R and the value of absorption (through the absorption parameter p) on the principal parameters of asymmetry of self-reversed lines - the ratio of intensity I_1/I_2 (I_1 is the maximal intensity of big intensity peak; I_2 is the maximal intensity of small intensity peak) and the wings asymmetry parameter

$$w = \frac{u_1 - u_2}{d(0)}$$

(u_1 and u_2 are the wing extents at a certain intensity height calculated from the unperturbed frequency V in the direction of big and small intensity peaks respectively). With the increase of p the ratio I_1/I_2 for the central line of sight in the plasma cross-section passes through the maximum (for the comparison of experimental and calculated data the graphs of dependence I_1/I_2 on $2s = M/d(0)$ are very useful where M is the distance between maxima of intensity). The main influence on I_1/I_2 the parameters t, a and g give : At $t = 1$, $a = 2$ and $g = 0.83$ (the main part of absorption atoms placed in the emission zone) $I_1/I_2 = 1.5 - 2.0$. At $t = 1$, $a = 30$ and g=0.1 (the main part of absorption atoms placed out of the emission zone) I_1/I_2=3.0-4.0. The parameter w is sensible mainly to the Stark broadening paramerters t and $A(0)$ and may be calculated by the equation $w = 1.55|t| + 6.4 \cdot A(0)$ (Fishman *et al.*, 1991) as a first approximation. This circumstance gives the possibility simple enough to determine $d(0)$ and then the plasma electron concentration by the measured u_1 and u_2.

For the comparison of experimental and calculated data the *Al I* 394.4 nm and *Al I* 396.1 nm resonance lines for which the Stark broadening parameters are given in Griem (1974) are convenient. In accordance with Griem (1974) for these lines we have t=-(1.0-1.2) in the frequency scale and $A(0)$=0.1 under the conditions of low-voltage pulse discharges (Fishman *et al.*, 1981; Sarandaev *et al.*, 1988). For the experimental self-reversed profiles I_1/I_2=3.5-4.0, $u_1 - u_2$=(0.14-0.2) nm in the wavelength scale. These values of $u_1 - u_2$ give the electron concentration values differing by no more than (10-15) % of the electron concentration values obtained by the H_α line of hydrogen. The large experimental values of I_1/I_2, on the one hand, show on the big a and small g for aluminium atoms (such $n(r)$ distribution is confirmed by absorption spectra (Fishman *et al.*, 1991)) and, on the other hand, show on the large value of t of the order of 1. These results confirme for the given resonance aluminium lines the theoretical values of t, A and d (Griem, 1974).

The interesting results have been obtained for the *Cu* I 324.7 nm and *Cu* I 327.4 nm resonance self-reversed lines. For these lines there are no data in literature about the shift parameter t. The small values of $u_1 - u_2$= (0.02-0.04) nm under the conditions of low-voltage pulse discharge (Sarandaev *et al.*, 1988) show that the *Cu* I 324.7 nm and *Cu* I 327.4 nm lines have a small Stark shift (t no more than 0.1-0.2). The small shift of copper resonance lines is well in accord with the small theoretical Stark shift of *Cu* I 510.5 nm, *Cu* I 570 nm and *Cu* I 578.2 nm lines (Konjević and Konjević, 1986).

These examples show that the asymmetry of self-reversed spectral lines may be used both for the test of theoretical Stark broadening parameters and for the estimation of Stark shift of spectral lines for which there are no data in literature.

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