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REGULARITIES IN THE STARK WIDTHS OF *ns-n'p* AND *np-n's* SPECTRAL LINES FOR A SERIES OF NEUTRAL ATOMS

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In [1-4] the dependences have been obtained which allow one to estimate the Stark parameters of lines within an atom (ion). However there are general considerations on the base of which one may try to use the similar dependences to estimate the widths and shifts of lines within several atoms (ions).

In the adiabatic approximation the width of the atom level under consideration in frequency units is determined by the expression

$$\Delta E_i = CN_e T^{-1/2}\left[\sum_{i\neq k}\left(f_{ik}/E_{ik}^2\right)\right]^{2/3} \qquad (1)$$

where E_{ik} are the distances to the perturbing levels, f_{ik} are the oscillators strengths for the transitions between the level under consideration and the perturbing levels, N_e is the electron concentration, T is the temperature, C is a constant. One can see that the level width depends on E_{ik} to a greater extent than on f_{ik}, and the nearest upper and lower perturbing levels provide the principal contribution. From the analysis of energy level diagrams of many atoms and ions one can note a similar arrangement of s and p levels. Therefore, from (1) one can suppose that some difference in the values of f_{ik} will have a little effect on the level widths and with a certain error the widths of s levels of such elements will be described the same dependence. Taking into account the arrangement of d levels the same may be said about the widths of p levels of these elements.

In order to check these assumptions and to construct these dependences the widths of s and p levels have been determined from the corresponding line widths using technique developed earlier [1] for the following elements: I group (LiI [5], NaI [6], KI [7], RbI [8]), II group (BeI [9], MgI [10], SrI [11]), III group (AlI [12]) and VI group (SeI [13]). The choice of elements is determined firstly by the presence of a large set of data about the Stark parameters of lines for each atom and secondly by using a unique semiclassical approximation in the calculations. For at $N_e=10^{17}cm^{-3}$ and T=20000K the dependences of the widths of s levels

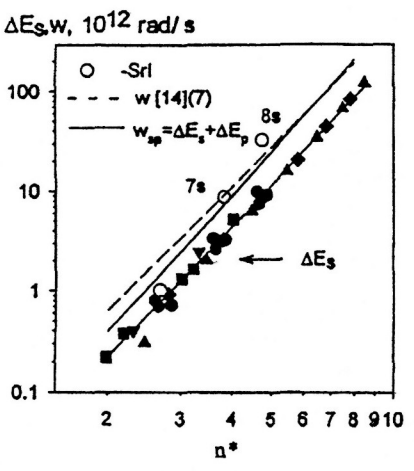

Fig.1.

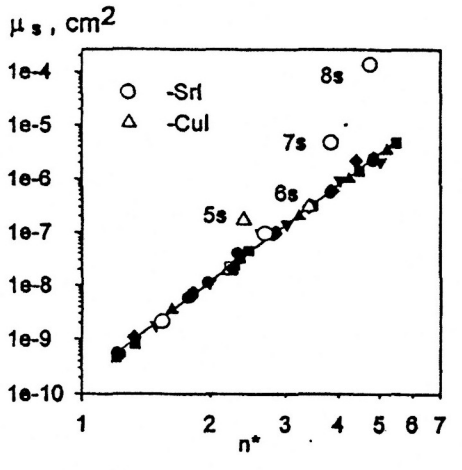

Fig.2.

(Fig.1) and p levels on the effective principal quantum number have been plotted in the logarithmic scale. The level widths practically of all atoms are well described by the linear dependences which have been approximated by the following relationships (the correlation coefficients (R) not less than 0.99)

$$\Delta E_s = 10.68 \cdot 10^9 (n^*)^{4.33} \quad \text{(rad/s)} \qquad (2)$$

$$\Delta E_p = 6.61 \cdot 10^9 (n^*)^{4.72} \quad \text{(rad/s)}, \qquad (3)$$

where n* is the effective principal quantum number. Note that the line width (w_{ik}) according to [1] is determined as the sum of widths of the upper (i) and lower (k) levels: $w_{ik}=\Delta E_i+\Delta E_k$.

Consider the widths which are not described by relationships (2) and (3) (Fig.1). The widths of 7s and 8s levels of SrI deviate appreciably from the straight line. This may be expected since the level diagram of strontium shows that for these levels the regularity in the level arrangement characteristic for other atoms dose not hold. That is, for the 7s level the nearest perturbing 7p level is placed not typically close while for 8s level the 5p' level is placed very close.

In order to have an objective criterion of applicability of these dependences to calculate the widths of s and p levels of an atom the attempt has been made to introduce a parameter (μ) which may be easily estimated using only the energies of corresponding levels.

Since the level width depends on E_{ik} to a greater extent than on f_{ik} (1), in the first approximation the following value may be chosen as such parameter

$$\mu_i = \sum_{i \neq k} \left(1 / E_{ik}^2\right) (\mathrm{cm}^2). \qquad (4)$$

The μ_i value depends on the energy of the considering level (i), and good accuracy in the μ_i estimation may be obtained taking into account only the nearest perturbing levels (k).

In Fig.2, the dependence of the parameter μ_s on the effective principal quantum numbers of levels under consideration is shown as an example. To calculate μ_s two nearest p levels have been taken into account as the perturbing levels-the upper and lower ones while to calculate μ_p two s levels (the nearest upper and lower ones) and two similar d levels have been taken into account. To construct of these dependences a more wide set of atoms has been used which includes the light atoms and the heavy atoms (ZnI, CuI, CdI, HgI). One can see μ depends on n* practically linearly. The dependences obtained have been approximated by the following relationships

$$\mu_s = 1.78 \cdot 10^{-10} (n^*)^{6.04} \ (\mathrm{cm}^2) \qquad (5)$$

$$\mu_p = 2.15 \cdot 10^{-10} (n^*)^{6.43} \ (\mathrm{cm}^2). \qquad (6)$$

As seen from Fig. 2, the dependence of parameter μ_s on n* for the 7s and 8s levels of SrI deviates strongly from the straight line confirming aforesaid about the widths of these levels.

It is interesting to compare the dependences obtained with the ones earlier established for the spectral line widths of definite serial transitions of atoms and ions [14]. Fig.2 shows that the common dependence (for the $(n_o+1)s$-$(n_o+1)p$ transitions of ions) reduced to given coordinates for $z=1$ and T=20000K ($w=3.63 \cdot 10^{10} (n^*)^{4.12}$)-the dotted line) agrees very well with our dependence $w_{sp}=\Delta E_s+\Delta E_p$.- the solid line) which represents the sum of two dependences (2) and (3). However in contrast to [14], the dependences (2) and (3) we propose are correct not only for the $(n_o+1)s$-$(n_o+1)p$ transition but for many ns-np' and np-ns' transitions which satisfy the criteria μ represented above.

As a demonstration of using of these dependences the comparison has been made also for two transitions of copper for which literature theoretical calculations are absent. For the transition 4p-6s of CuI, our estimations (0.241 nm and 0.246 nm) agree with the data of [15] (0.240 nm and 0.221 nm) while the parameter μ has the characteristic values for the both levels. However for the 5s level the value of μ_s is a bit overestimated therefore for the lines of

4p-5s transition there is the difference of about 50-60% between our estimations (0.197 nm and 0.205 nm) and the data of [15] (0.320 nm and 0.293 nm).

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