Publ. Astron. Obs. Belgrade No. 57 (1997), 101 – 104 *Contributed paper*

STARK PARAMETERS DEPENDENCE ON THE EMITTER REST CORE CHARGE WITHIN ION OFF- RESONANCES

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1. INTRODUCTION

In recently published paper (Puric, 1996) measured and calculated Stark widths and shifts data and their dependence on the upper level ionization potential χ were used to demonstrate the existence of the other kinds of regularities within similar spectra of different elements and their ionization stages. The aim of this contribution is to continue such investigation effort. The emphasis is (i) on the Stark parameter dependence on the rest core charge within a given transition of several ionisation stages of all elements; and (ii) the electron temperatures dependence of Stark broadening data for the lines from similar spectra on the quality of such investigations. The found relations connecting Stark broadening and shift parameters and upper level ionization potential, rest core charge and electron temperature can be used for a prediction of new Stark broadening data, avoiding much more complicated procedures. For opacity calculations and investigation of stellar atmosphere, when a large number of line broadening data was required, present investigation are useful in enlarging the number of required data. This field of research remains largely open to other demonstrations of regularities and similarities, as long as one can relate the same kind of spectroscopic transition. Also, the obtained dependencies can be used as additional criteria for checking accuracy of the particular theoretical and experimental data from different sources.

Stark widths dependencies on the upper level ionization potential within spectral lines originating from ns-np off-resonance transition ($n=n_0+1$, where n_0 is the main quantum number of ground energy level of a corresponding emitter) of several singly, doubly and triply charged ions have been found and discussed. After being well established and checked using existing theoretical data (Griem, 1974; Dimitrijevic, 1988) the dependencies can be used to predict additional Stark broadening data for the lines for which there is no either theoretical or experimental data so far, especially for multiply charged ion of resonances of heavy elements..

2. REGULARITIES

In order to investigate Stark parameters regularities an accurate set of theoretical and experimental data is needed for a multiple, suppermultiplet transition array, homologous, isoelectronic and isonuclear sequences or the same type of transition (for instance resonance or off-resonance) along the Periodical system of elements for different stages of ionisation under the same plasma conditions characterized by particular electron density and electron temperature. Therefore the Stark parameters dependencies on the electron density and electron temperature has to be well determined to make it possible to normalise the data given for different temperatures and densities to particular ones at which the other types of regularities have to be investigated. A number of published papers deals with Stark parameters dependences in the all above mentioned cases (Puric *et al.* 1991; Puric *et a.* 1993; Puric, 1996 and the references therein). The Stark parameters dependence on the electron density is well established and in the case of nonhydrogenic emitters is linear. However, Stark parameters dependence on the electron temperature, although weak, is of different kind from line to line in every spectrum. Therefore, the correction to temperature dependence has to be done with a great care for all data used in particular case of the verification of certain type of mentioned dependencies. For instance instead of usually used temperature dependence as $1/T^{1/2}$ one has to use the whole spectrum of the functions from line to line of the following form

$$w \propto f(T) = \alpha + \beta T^{-\delta} \qquad (1)$$

Different kinds of regularities within Stark parameters of the given spectra can be explained on the basis of their dependence on the upper level ionization potential (Puric *et al.* 1991; Puric *et al.* 1993; Puric 1996). A general form of that dependence in the case of the particular transition array along the Periodical table of the elements is

$$w = N_e\, f(T)\, z^c\, a \chi^{-b} \qquad (2)$$

where w is the line width in angular frequency units: χ is the corresponding upper level ionisation potential expressed in eV; z is the rest core charge of the emitter seeing by the electron undergoing transition. Coefficients a, b and c are independent of the temperature, ionization potential, and the electron density for a particular transition.

A comprehensive set of Stark broadening data (Griem 1974; Dimitrijevic 1988) of the investigated ion off-resonance spectral lines has been used here to demonstrate the existence of Stark widths data regularities within this group of spectral lines. Namely, Stark parameters dependencies on the upper level ionization potential of the investigated lines originating from ns-np off-resonance transition arrays of the following singly (Ne, F, O, Cl, Ar, P, Si and Al), doubly (Al, Ar, B, Be, C, Cl, F, N, Na, O, P, S, and Si) and triply (Ar, B, C, Cl, Mg, N, Ne, O, P, S and Si) charged ions have been found and discussed.

3. RESULTS AND DISCUSSION

It has been verified that the Eq.(2) is appropriate for all of the investigated ns-np transitions in the above -mentioned group of the ions at different temperatures and electron densities. Namely, it has been found that the best fit could be obtained if $f(T)$ is taken as given by Eq. (1) instead of $T^{-1/2}$.
As an example, the reduced Stark width

$$w^* = w\, z^{-C} = a\chi^{-b}, \tag{3}$$

as the function of the inverse value of the upper level ionization potential χ of the corresponding transition is given in Fig. 1, for an electron temperature T=20 000 K and electron density $N_e = 1 \times 10^{23} m^{-3}$.

By a comparison of the above described regularities and those presented elsewhere (Dimitrijevic and Sahal-Brechot 1992) one can conclude that the method used here differs in the choice of the variable conveying atomic structure information. Previous work (see Puric et all 1993 and Refs. therein) was based on the hydrogenic model. Consequently, it used integer principal quantum numbers instead of the upper level ionization potential. Although both parameters take into account the density of states perturbing the emitting state, the advantages of the present method are: (i) χ based trend analyses achieve better fits; (ii) in χ values the lowering of the ionization potential (Inglis and Teller 1939) is taken into account, predicting merging with continuum when the plasma environment causes a line's upper state ionisation potential to approach zero; and (iii) the ω dependence on χ is theoretically expected (Puric *et al.* 1991, Puric *et al.* 1993, Puric 1996).

Using the existing Stark parameters data for the investigated lines originating from different ions the corresponding coefficient *a,b* and *c* from Eq. (2) are found as $a = 6.9 \times 10^{11}$, $b = 2.50$ and $c = 5.20$. The corresponding correlation factors were almost equal to unity. Therefore, the Eq. (3) can be used to calculate Stark widths of the multiply charged ion off-resonance's of different elements along the Periodic table of the elements not calculate so far taking T and χ in K and eV, respectively. All data used in the course of the data presentation in Fig.1. were normalized at an electron density $N_e = 1 \times 10^{23} m^{-3}$ for different temperatures being normalized to an electron temperaature of T=20 000 K using the Eq. (1).

4. CONCLUSION

The influence of Stark broadening parameters on the quality of the investigated dependence on the different atomic parameters is of great importance. Stark parameters dependence on the upper level ionization potential and rest core charge of the emitters, after being well established within ns-np off-resonance transition

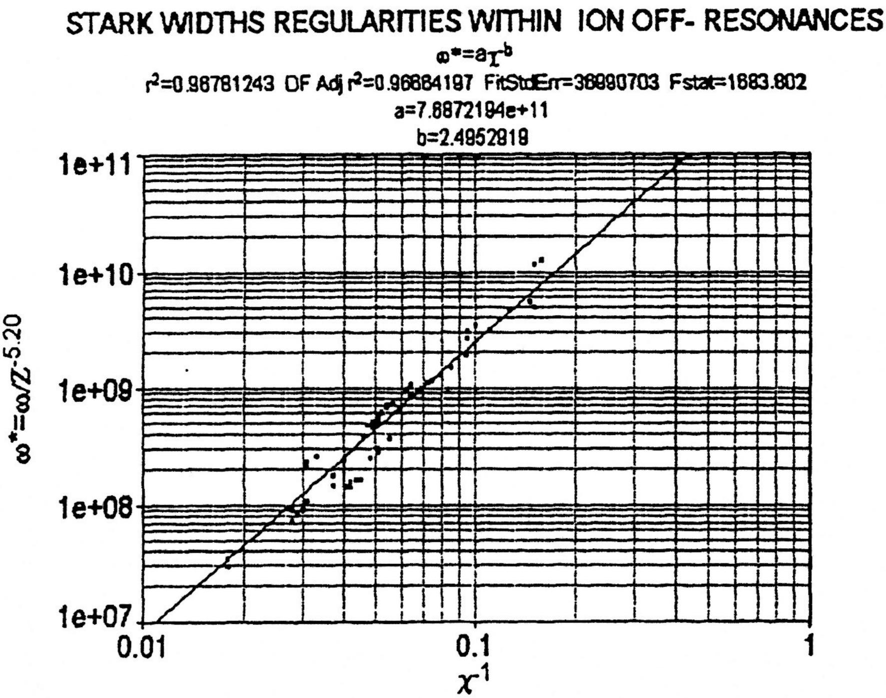

Fig.1.

array can be used for prediction of the parameters for the corresponding ion off-resonance of heavier elements where not available so far. The electron-impact widths predicted by intratransition arrays regressions analyses are of the same accuracy as the accuracy of the results used in the course of the calculation of coefficients *a*, *b* and *c* from Eq.(2) in order to generate widths for heavier elements ion off-resonance's. This method is computationally simple, involving each line' s upper level ionization potential and one multiplicative and one exponential fitting parameter per investigated group of spectral lines originating from ns-np off-resonance transition arrays for the given emitter temperatures and electron densities. Such method can be applied onto mathematical simulations of stellar atmosphere opacities.

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