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STARK PARAMETER GENERAL REGULARITIES FOR THE ION LINES

J. PURIĆ[1] and M. ŠĆEPANOVIĆ[2]

[1] *Faculty of Physics, University of Belgrade, P. O .Box 368, 11001 Belgrade, Yugoslavia*
[2] **Faculty of Sciences and Mathematics, University of Montenegro, P. O.Box 211, 81000 Podgorica, Yugoslavia*

1. INTRODUCTION

Stark widths and shifts published data (Griem, 1974; Dimitrijević, 1998, 1993.a,b; Dimitrijević and Sahal-Bréchot,1992. a,b,c,d, 1993.a,b,c,d, 1996; Dimitrijević *et al.* 1994, 1996, Popović and Dimitrijević 1996; Popović *et al.* 1993.) and their dependence on the upper level ionization potential (Purć, 1996; Purć *et al.* 1993.) χ are used here to demonstrate the existence of the other kinds of regularities within similar spectra of different elements and their ionization stages. The emphasis is on the Stark parameter dependence on the rest core charge and the electron temperatures for the lines from similar spectra. The found relations connecting Stark broadening and shift parameters and upper level ionization potential, rest core charge and electron temperature were 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 needed 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 an additional criterion for checking accuracy of the particular theoretical and experimental data from different sources.

Stark widths dependencies on the rest core charge and electron temperatures within spectral lines originating from 2p-nd (n=3,4,5); 2s-np (n=2,3); 2p-3s; 3d-np (n=4,5); 3d-4f; 3p-nd (n=3,4,5); 3p-ns (n=4,5); 3s-np (n=3,4,5); 4s-np (n=4,5); 4p-nd (n=4,5); 4p-5s; 5p-5d; 5s-5p under the same plasma conditions have been found and discussed here. After being well established and checked using existing theoretical (Purć 1996) data the dependencies can be used to predict additional Stark broadening data for the lines for which there is neither theoretical nor experimental data so far.

2. REGULARITIES

In order to investigate Stark parameters regularities an accurate set of theoretical and experimental data is needed for a multiplet, supermultiplet transition array, homologous, isoelectronic and isonuclear sequences or the same type of transition along

the Periodical system of elements for different stages of ionization 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 normalize data given for different temperatures and densities to particular ones at which the other types of regularities have to be investigated. Of special interest are dependencies on the rest core charge of the emitter within isoelectronic or isonuclear sequences or on the nuclear charge number within particular transition of homologous group of atoms or ions and on the upper level ionization potential in all the above mentioned cases.

The Stark parameter dependence on the electron density is well established and in the case of nonhydrogenic emitters is linear. However, Stark paramter dependence on the electron temperature 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 dependencies as $T^{-1/2}$ for ion lines, one has to use the whole spectrum of the functions from line to line of the form:

$$W = f(T) = A + BT^{-C} \tag{1}$$

Different kinds of regularities within Stark parameters of the given spectra can be explained on the bases of their dependencies on the upper level ionization potential (Purć 1996; Purć *et al.* and Refs. therein). A general form of that dependence in the case of the particular transition array along the Periodical table of the elements is:

$$W = N_E f(T) z^c a \chi^{-b} \tag{2}$$

where w is line width in angular frequency units; χ is the corresponding upper level ionization 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.

The procedure for Stark broadening data predictions was described elsewhere (Purć 1996; Purć *et al.* and Refs. therein). A comprehensive set of Stark broadening data of the investigated ions has been used here to demonstrate the existence of Stark width data regularities within this group of spectral lines.

3. RESULTS AND DISCUSION

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

$$W^* = w f(T) z^{-c/a} \chi^{-b} \tag{3}$$

as the function of the inverse value of the upper level ionization potential χ of the corresponding transition is given in Fig. 1 for all of that transitions.

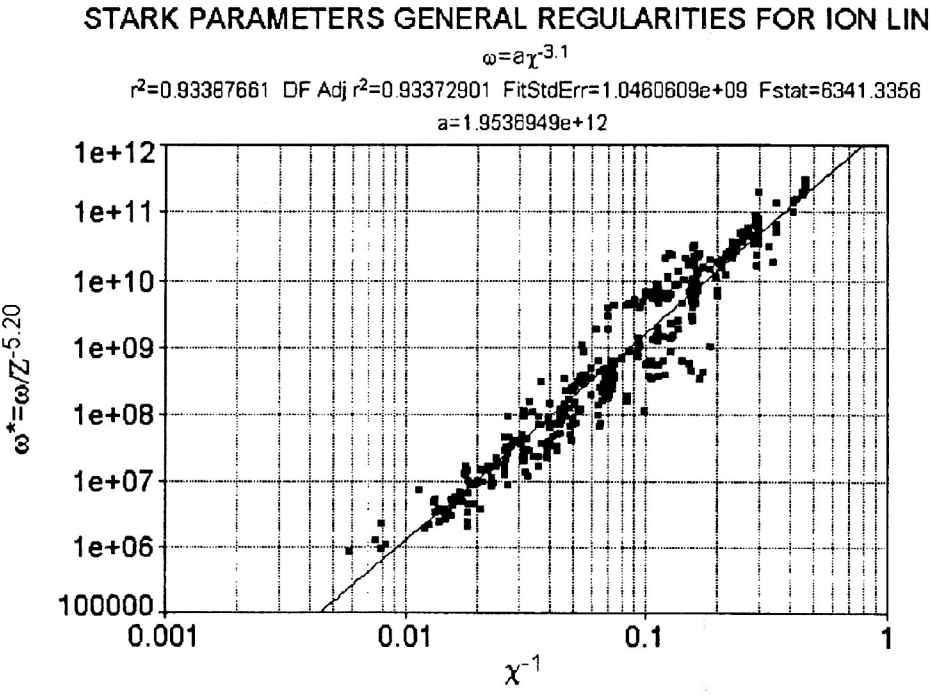

Fig. 1

By a comparison of the above described regularities and those presented elsewhere (Dimitrijević 1993a). one can conclude that the method used here differs in the choice of the variable conveying atomic structure information. Prior work (Purć *et al.* 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 (Teller 1937) is taken into account, predicting merging with continuum when the plasma environment causes a line's upper state ionization potential to approach zero; and (iii) the ω dependence on χ is theoretically expected (Purć 1996).

The corresponding correlation's factor was almost equal to unity. Less then 17% of all our data correspond to values that are twice bigger than prediction values. Therefore, the Eq. (3) can be used to calculate Stark widths of the multiply charged ion from this transition 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 is at an electron density $N_e = 1 \times 10^{23}$ m^{-3} for different temperatures being normalised using the Eq. (1) at $T = 10^5$ K.

4. CONCLUSION

Stark parameters dependence on the upper level ionization potential, after being well established within particular transition array can be used for prediction of the parameters for the corresponding ion 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 lines of heavier elements from this types of transitions one has to find the upper level ionisation potential for that lines and substitute it in the Eq. (3) using the coefficient as anb b obtained from Fig. 1 and taking that the coefficient c=5.20. This method used here is computationally simple, involving each line's upper level ioniation potential and one multiplicative and one exponential fitting parameter per the investigated group of spectral lines originating from all of the investigated transition arrays, for the given emitter, temperatures and electron densities. Such method is conductive to the method's incorporation into mathematical simulations of stellar atmosphere opacities.

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