STARK WIDTH REGULARITIES WITHIN SPECTRAL SERIES OF NEUTRAL ALKALINE AND ALKALINE EARTH METALS

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Abstract

Stark width regularities within spectral series originating from neutral atoms of alkaline and alkaline earth metals homologous group were found and discussed. The emphasis is on: (i) the Stark width (w) simultaneous dependence on the upper level ionization potential (χ); and (ii) term structure influence on the found Stark parameter dependences. Stark widths published data are used to demonstrate the existence of these kinds of regularities for the electron impact contributions to the Stark widths within these homologous spectral series. The found relations for particular electron temperature and density were of the form $w=A\chi^{-B}$ where A, B are constants, for particular homologous spectral series. These functional dependences are different for singlet and triplet series. The obtained functions were used to predict Stark widths data for lines not calculated or measured so far within this group of elements. These data were compared with already published data.

1. INTRODUCTION

It was found that the most convenient way to study Stark broadening parameters regularities was expressing them as the function of the binding energy of the electron undergoing transition /1-4/. The binding energy or upper level ionization potential χ conveys the plasma electric micro-field influence on the electron undergoing transition. The effect of plasma electric micro-field on the Stark broadening of particular line is higher if the bounding energy is lower. This dependence was successfully used recently in a series of papers devoted to the study of regularities within spectral series of the alkaline metals (Li I, Na I, K I) and from alkaline earth metals (Mg I, Be I, and Ca I) where coefficients obtained suggested that the upper level ionization potential is an appropriate parameter for studying the Stark broadening behaviour within similar spectra. The aim of this paper is to analyse functional dependence of the electron and proton impact contribution to the Stark widths of spectral lines (FWHM) on the upper level ionization potential, within several spectral series of the investigated homologous groups of elements. Using the proposed simple model, based on the found Stark parameter dependences one can provide Stark broadening data for transitions that have not yet been calculated due to the lack of parameters

needed in more complicated models.

Stark broadening data used for the analysis presented in this paper was taken from /5/ and references therein. Necessary data for ionization potentials were taken from NIST database /6/. Singlet, triplet and doublet series were studied. The found similarities in the studied dependences were discussed.

2. THEORETICAL BACKGROUND

Similar behaviour of Stark broadening data and χ was found by Purić et al. /7/. This discovery was followed by investigation of analytic relation between Stark widths and χ in paper /8/. The quantum theoretical basics for this relation are given in /9/. The final form of Stark width dependence is given by:

$$\omega = a \cdot \chi^{-b} \tag{1}$$

In this equation, w is Stark width in rad/s, is the upper level ionization potential taken in eV; and a, b are the fitting coefficients independent of χ. In order to investigate this dependence one has to have an accurate database normalised to the same electron density and temperature as it is described elsewhere /1/.

3. RESULTS AND DISCUSSION

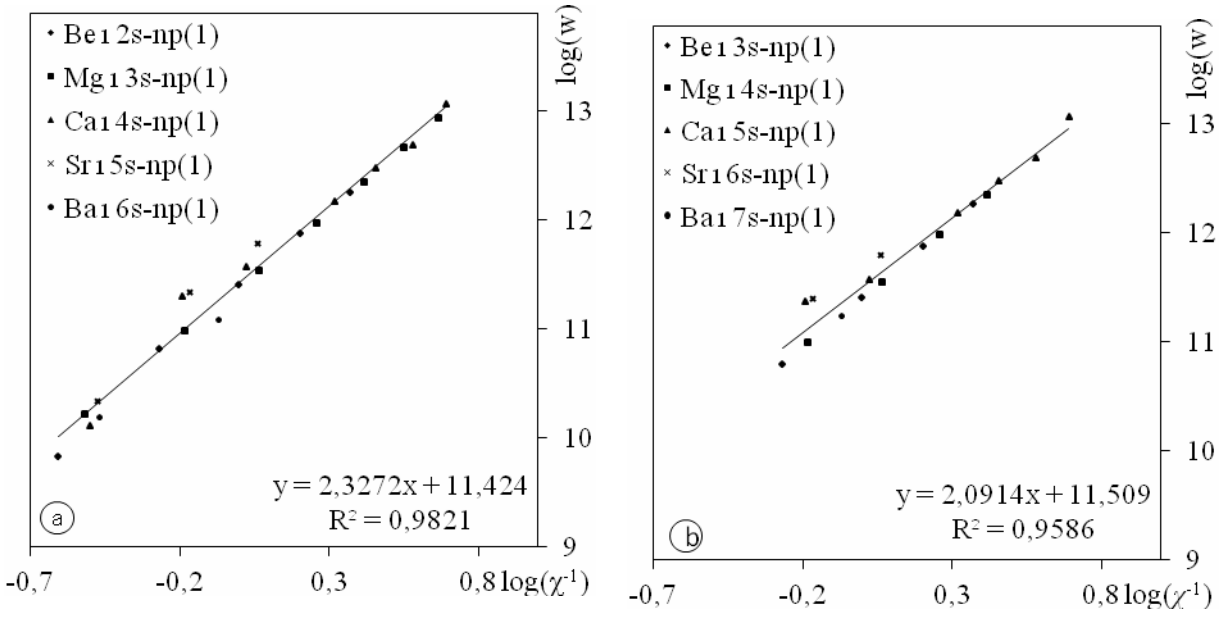

Figure 1 Stark widths (rad/s) vs χ (eV) for resonant (a) and off-resonant (b) spectral lines

The existing data for the spectral lines of all emitters from this these groups of elements were used to demonstrate the upper mentioned Stark widths dependences on the upper level ionisation potential (χ). Figure 1(a) and 1(b) shows the Stark widths vs χ at the 10000K temperature for all resonant and off-resonant singlets spectral respectively for alkaline earth metals. A remarkable consistence is observed in broadening of resonances and off-resonances spectral lines of Be I, Mg I, Ca I, Sr I and Ba I. Thus a linear fit has been drawn through Be I, Mg I, Ca I, Sr I and Ba I resulting in coefficient of determination of R^2=0.9821.

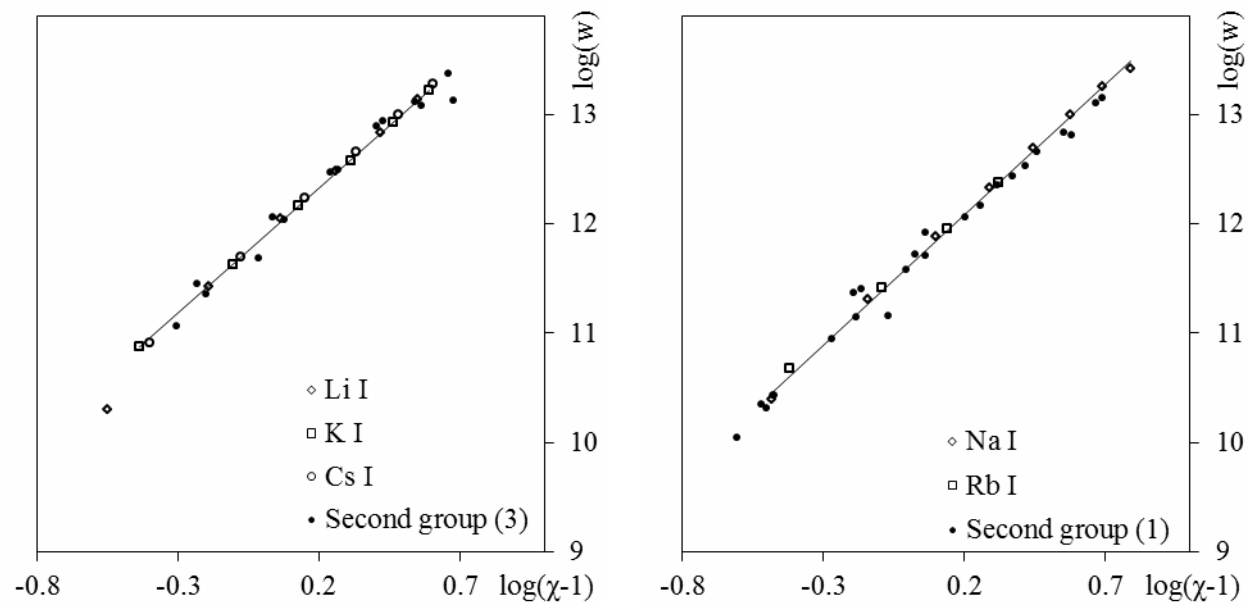

Figure 2 Stark widths (rad/s) vs χ (eV) of dublet and triplet (a); and singlet and dublet (b) of alkaline and alkaline earth metals studied spectral series.

Figure 2 a and b shows the Stark widths vs χ at the 10000K temperature together for doublet (Li I, K I, Cs I) and triplets (Be I, Mg I, Ca I, Sr I, Ba I) spectral lines (Figure 2a) and from singlets (Na I, Rb I) and doublets (Be I, Mg I, Ca I, Sr I, Ba I) of the investigated elements from these two homologous groups, respectively. Singlet, doublet and triplet spectral lines generally have different Stark widths dependences vs χ and must be treated separately. However, the same dependences are observed in behaviour within doublet and triplet spectral series (Figure 2a) as within singlet and doublet spectral series for the chosen group of elements respectively. The found regularities can be used for predicting for the mist spectral lines from these series.

4. CONCLUSION

Searching for different types of regularities and systematic trends which can simplify complicated theoretical calculations is of great interest. In this work the existence of the common Stark widths functional dependences on the upper level ionization potential was shown for the lines originating from the alkaline and alkaline earth metals. These dependences were obtained and found to be of the form given by equation 1 for the same electron temperature and density for both electron and proton impact contribution to Stark width. They can be used to evaluate the results of Stark broadening data that is already measured or calculated or for prediction of the Stark widths values for the lines not measured or theoretically calculated until now but belonging to the investigated series.

The best precision can be obtained using the same equation for any particular series separately. However, in the case of thise two homologous groups of elements the studying the regularities within particular groups of spectral series can improve the accuracy of data prediction based on larger sets of existing data.

Acknowledgements

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