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STARK LINE BROADENING WITHIN SPECTRAL SERIES OF POTASSIUM ISOELECTRONIC SEQUENCE

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Abstract. Stark line broadening within potassium-like emitters was investigated, using regularity approach. Available Stark data for ns-np, np-ns, np-nd, nd-np and nd-nf spectral series within potassium isoelectronic sequence present input data for regularity analysis. Formulas expressing Stark widths dependence on the value of the upper-level ionization potential and the rest core charge of the emitter, for analyzed spectral series have been established and can be used for calculation of Stark widths for transitions within spectral series of any potassium-like emitter.

1. INTRODUCTION

In the presented paper Stark widths of transitions within ns-np, np-ns, np-nd, nd-np and nd-nf spectral series of potassium like emitters are investigated using regularity approach.

Stark broadening data for emitters within potassium isoelectronic sequence are of great interest for astrophysics and fusion physics. For example, potassium lines are important for investigation of chemical evolution of stars; Ca II lines are used for opacity research of young stellar object; Sc III lines are present in the spectra of Am Fm stars. Ti IV and V V Stark widths data are of interest for first-wall problem in fusion physics. Data for Cr, Mn and Fe are of interest for fusion physics, too.

The ground state of K I and Ca II has [Ar]4s electronic configuration, with term ^{2}S, while Sc III, Ti IV, V V, Cr VI, Mn VII, Fe VIII,… have [Ar]3d electronic configuration of ground state, with term ^{2}D. Except this difference in configuration of ground states, all members of potassium isoelectronic sequence have similar excited states, so regularity behavior of atomic parameters within spectral series are expected. In the present research, just one-electron transition processes have been analyzed.

2. THEORETICAL BACKGROUND

The regularity approach used in present investigation is based on equation (1) (Trklja et al. 2018).

$$\omega^* = \frac{\omega}{Z_e^c} = a \cdot \log \chi^{-b} \quad (1)$$

ω^* is the reduced Stark width, χ is the electron binding energy on the upper level of analyzed transition, Z_e is the rest core charge of the emitter; $a = const \cdot N_e \cdot f(T_e)$, b is a fitting coefficient. Parameter c can be found by analyzing the quality of the fit which is determined by factor R^2 (Dojčinović et al. 2019.).

Temperature normalization is done according to equation (2) (Purić et al. 1999).

$$\omega = A + B \cdot T^{-C} \quad (2)$$

Normalization of electron density is done using the approximation of linear dependence of Stark widths on electron density which has been found as appropriate.

3. RESULTS AND DISCUSSION

Regularity analysis within potassium like emitters include 148 spectral lines: K I (46), Ca II (56), Sc III (10), Ti IV (10), V V (26). Stark width data used in the present study are taken from Stark B data base (Sachal-Brechot et al. 2018). And complemented with available experimental data of Stark widths. χ values are taken from NIST atomic database (Kramida et al. 2018). Data were complemented with available experimental data of Stark widths.

Dependence of R^2 on c for the potassium isoelectronic sequence is presented in Fig. 1. Parameter c is approximately equal to 2.8.

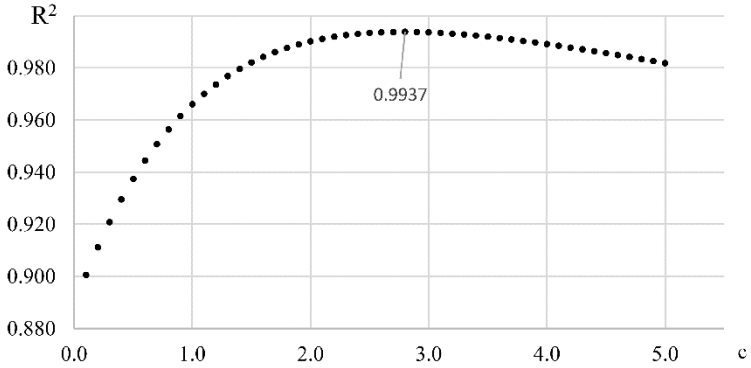

Figure 1: Determination of parameter c

All Stark widths used in the present investigation are normalized at electron density $N_e=10^{22}$ m^{-3} and temperature T=100000 K. Temperature normalization is done using parameters A, B and C (equation (2)) which are results of fitting process. Each transition has its own A, B and C parameters. As example of fitting procedure, dependence of Stark width on temperature has been presented for 4s-4p transition within K I (Fig. 2).

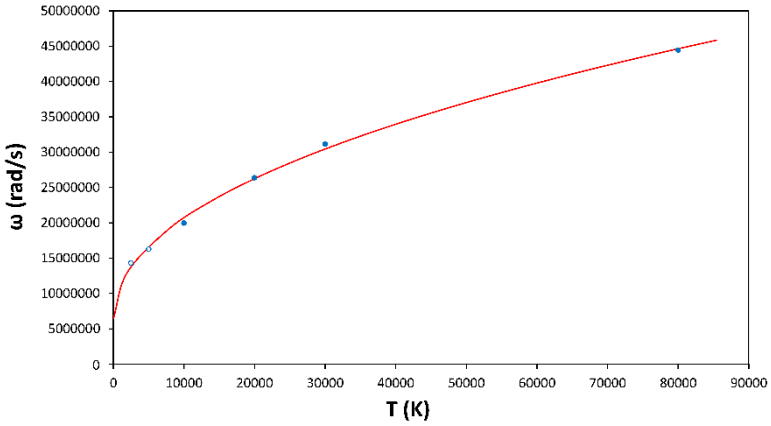

Figure 2: Stark width dependence on temperature for 4s-4p transition within K I

Fig. 3. represents dependence of the reduced Stark width on ionization potential of the upper level of transition, for np-nd spectral series of the potassium isoelectronic sequence, fitted according to equation (1).

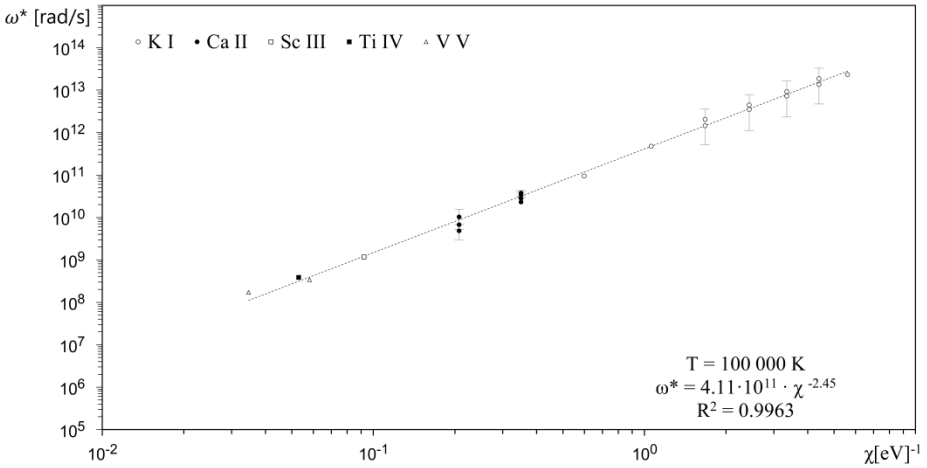

Figure 2: Dependence of ω^* on χ for the np-nd transition within potassium isoelectronic sequence ($N_e=10^{22}$ m^{-3}, T=100000 K)

According to fitting parameters, Stark widths for any transition within ns-np, np-ns, np-nd, nd-np and nd-nf spectral series of potassium isoelectronic sequence can be calculated using formula (3):

$$\Delta\lambda = p \cdot 10^{-20} \cdot \frac{Z_e^{2.8} N_e}{\chi^q} \lambda^2 \qquad (3)$$

Values of parameters p and q are given in Table 1. In equation (3) λ and Δλ are expressed in [m], N_e is expressed in [m^{-3}] and χ is expressed in [eV].

Spectral Series	p	q
ns-np	2.00	2.39
np-ns	1.87	2.39
np-nd	4.11	2.45
nd-np	3.87	2.34
nd-nf	3.61	2.54

Table 1: Values of parameters p and q in equation (3) for analyzed spectral series

4. CONCLUSIONS

Results of presented regularity analysis enable calculation of Stark widths for any transitions within ns-np, np-ns, np-nd, nd-np and nd-nf spectral series of the potassium isoelectronic sequence. Calculation of Stark widths of potassium-like ions is of interest for astrophysics and plasma physics.

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