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Stark broadening of spectral lines of multicharged ions of astrophysical interest

XXII. K VIII and K IX spectral lines*

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Abstract. By using the semiclassical-perturbation formalism, we have calculated electron-, proton-, and He III-impact line widths and shifts for 4 K VIII and 30 K IX multiplets, of interest for analysis, investigation and modeling of different plasmas in solar and stellar subphotospheric layers research and plasma physics. The obtained results are presented as a function of temperature and perturber density. Results are compared with other theoretical estimates, based on regularities and systematic trends.

Key words: lines: profile-atomic data

1. Introduction

Potassium lines are present in Solar (Moore et al. 1966) and stellar spectra (Merrill 1956). For example potassium has been found in SN 1987 A ejecta (Trimble 1991). Potassium is a product of alpha processes - neutron capture on slow time scale, and the data on the spectral line broadening parameters of potassium in various ionization stages are of interest for modelling subphotospheric layers (Seaton 1987). Such data are as well of interest for the fusion plasmas and laser-produced plasmas research and for the investigation of soft X-ray lasers (see e.g. Griem & Moreno 1990; Fill & Schöning 1994).

This paper is the twenty second of a series devoted to the research of Stark broadening parameters of spectral lines of multicharged ions (see Dimitrijević & Sahal–Bréchot 1995 and references therein, as well as Dimitrijević & Sahal–Bréchot 1996a,b, 1997, 1998a-f). In accordance with our project (see e.g. Dimitrijević 1996) to make available to astrophysicists and physicists an as large as possible set of reliable semiclassical Stark broadening data needed for the investigation, diagnostics and modeling of various plasmas in astrophysics, physics and technology (see e.g. Dimitrijević & Sahal–Bréchot 1998f), we have calculated within the semiclassical-perturbation formalism (Sahal–Bréchot 1969a,b), electron-, proton-, and He III-impact line widths and shifts for 4 K VIII and 30 K IX multiplets.

2. Results and discussion

For the consideration of Stark broadening of K VIII and K IX spectral lines and the determination of the corresponding broadening parameters (the full line width at half maximum - W and the line shift - d), the semiclassical perturbation formalism has been used. This formalism, as well as the corresponding computer code (Sahal–Bréchot 1969a,b), have been updated and optimized several times (Sahal–Bréchot 1974; Fleurier et al. 1977; Dimitrijević & Sahal–Bréchot 1984; Dimitrijević et al. 1991; Dimitrijević & Sahal–Bréchot 1996b). The calculation procedure, with the discussion of updatings and validity criteria, has been briefly reviewed e.g. in Dimitrijević & Sahal–Bréchot (1996c) and Dimitrijević (1996). Atomic energy levels needed for calculations have been taken from Bashkin & Stoner (1978). The oscillator strengths have been calculated within the Coulomb approximation (Bates & Damgaard 1949, and the tables of Oertel & Shomo 1968). For higher levels, the method of Van Regemorter et al. (1979) has been used.

Our results for electron−, proton−, and He III−impact line widths and shifts for 4 K VIII and 30 K IX

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* Tables 1–2 are only available in electronic form at the CDS via anonymous ftp to cdsarc.u-strasbg.fr (130.79.128.5) or via http://cdsweb.u-strasbg.fr/Abstract.html

multiplets are shown in Tables 1 and 2 (accessibles only in electronic form), for K VIII (Table 1) for temperatures from 200 000 K up to 3 000 000 K and perturber densities 10^{18} cm^{-3} – 10^{22} cm^{-3}, and for K IX (Table 2) for temperatures from 200 000 K up to 5 000 000 K and perturber densities 10^{18} cm^{-3} – 10^{22} cm^{-3}.

Stark broadening data for densities lower than for tabulated data, are proportional to the perturber density. Moreover, we present in Tables 1–2 as well, a parameter c (Dimitrijević & Sahal–Bréchot 1984), which gives an estimate for the maximum perturber density for which the line may be treated as isolated, when it is divided by the corresponding full width at half maximum. For each value given in Tables 1–2, the collision volume (V) multiplied by the perturber density (N) is much less than one and the impact approximation is valid (Sahal–Bréchot 1969a,b). Values for $NV > 0.5$ are not given and values for $0.1 < NV \leq 0.5$ are denoted by an asterisk. When the impact approximation is not valid, the ion broadening contribution may be estimated by using the quasistatic approach (Sahal–Bréchot 1991 or Griem 1974). In the region between where neither of these two approximations is valid, a unified type theory should be used. For example in Barnard et al. (1974), a simple analytical formula for such a case is given. The accuracy of the results obtained decreases when broadening by ion interactions becomes important.

There is no experimental data concerning the Stark broadening of K VIII and K IX spectral lines. It exists however, a prediction for K IX $4s^2S{-}4p^2P^\circ$ Stark width (Djeniže & Labat 1996), obtained with the help of established regularities of the Stark widths along Na isoelectronic sequence. For $T = 500\,000$ K and an electron density of 10^{17} cm^{-3}, Djeniže & Labat (1996) obtained for the Stark full width (FWHM) the value of 0.0057 ± 25% Å, while the present result is 0.0099 Å. We hope that the presented data will be of interest for some problems in stellar and laboratory plasma research, especially for subphotospheric layers consideration, investigation and modeling of fusion and laser-produced plasmas, and of soft X-ray lasers, as well as for the checking and development of the Stark broadening theory for multicharged ion line shapes, as e.g. for investigations of systematic trends along isoelectronic sequences.

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