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PLASMA BROADENING OF SPECTRAL LINES ALONG ISOELECTRONIC SEQUENCES OF LITHIUM AND BORON

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Abstract. The Stark width dependence of the $3s^2S - 3p^2P^0$ transitions along lithium isoelectronic sequence (BIII, CIV, NV, OVI) and $3s^2S - 3p^2P^0$; $3p^2P^0 3d^2D$ transitions along boron isoelectronic sequence (NIII, OIV, FV) were studied theoretically using impact semiclassical method and experimentally observed in the plasma of a low pressure pulsed arc. Plasma electron densities were determined from the width of the HeII P_α line while the electron temperatures were measured from the relative line intensities. To estimate the influence of different ions to the width of lines, the evaluation of plasma composition data was performed and in conjunction with our theoretical results contribution of ion broadening was estimated. Furthermore in our theoretical calculations was taken into acount the influence of perturbing levels with different parent term to the width and shift of investigated OIV spectral lines for the first time.

1. THEORY

By using the semiclassical-perturbation formalism (Sahal-Brechot, 1969) we have calculated (Blagojević *et al.* 1994) electron-, proton-, and HeII-impact broadening parameters for OIV $3s^2S - 3p^2P^0$ and $3p^2P^0 - 3d^2D$ transitions previously. Energy levels needed for these calculations were taken from Bashkin and Stoner (1975). Oscillator strengths were calculated by using method Bates and Damgaard (1949), see also Oertel and Shomo (1968). For higher energy levels the method described in Van Regemorter (1979) was used. In the case of the considered transitions, several transitions with different parent term may significantly influence particularly on the results for the Stark broadening parameters in particular the shift values. The new calculations with the inclusion of such transitions were performed here. In order to assure consistency of the data set, all oscillator strengths (and not only those for added transitions with different parent term) were taken from the TOP base (the complete package of the opacity project (OP) data with database management system is usually referred to as TOP base) (Butler *et al.* 1993; Cunto *et al.* 1993). Beside electron impact line widths, Stark broadening parameters due to all relevant ion perturbers were calculated as well.

2. EXPERIMENT

The experimental apparatus and procedure are described in Blagojević *et al.* (1994) so only few details will be given here. The light source was a low pressure pulsed arc with a quartz discharge tube 10 mm internal diameter. The distance between aluminum electrodes was 161 mm, and 3 mm diameter holes were located at the center of both electrodes to allow end-on plasma observations. All plasma observations were performed with 1-m monochromator with inverse linear dispersion 8.33 Å/mm in the first order of the diffraction grating, equipped with the photomultiplier tube and a stepping motor. The discharge was driven by a 15.2 μF low inductance capacitor charged to 3-6 kV, pressure of the gas mixture p = 1.7-3 torr, continuous flow of the gas mixture, composition : 0.5 to 2% of investigated gas in He. The stepping motor and oscilloscope were controlled by a personal computer, which was also used for data acquisition. Recordings of spectral line shapes were performed shot-by-shot. At each wavelength position of the monochromator time evolution and decay of the plasma radiation were recorded by the oscilloscope. Eight such signals were averaged at each wavelength. To construct the line profiles these averaged signals at different wavelengths and at various times of the plasma existence were used to construct line profiles. Spectral line profiles were recorded with instrumental half widths of 0.165 Å. To determine the Stark half width from the measured profile, a standard deconvolution procedure for the Lorentzian (Stark) and Gaussian (instrumental+Doppler) profiles was used.

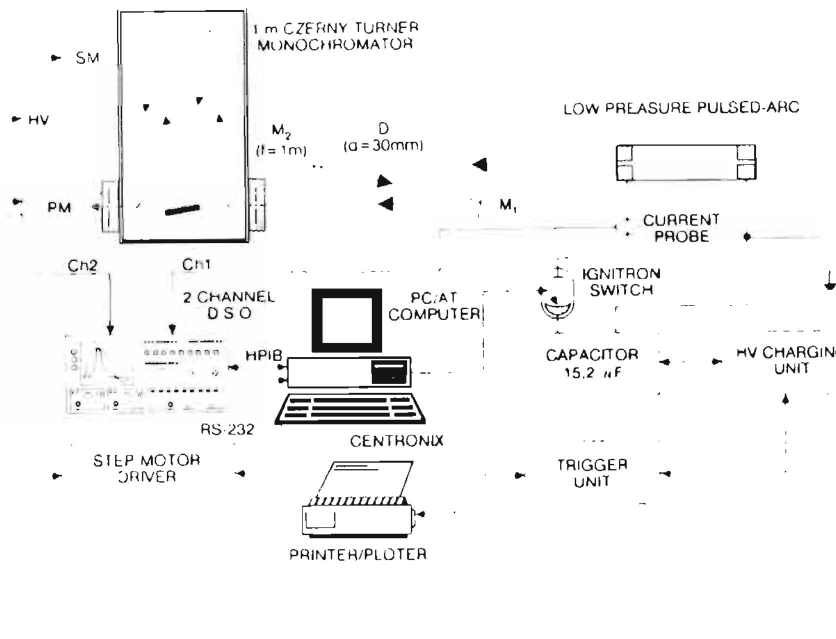

Fig. 1. The experimental setup.

3. EXPERIMENTAL RESULTS AND DISCUSSION

The experimental results for Stark widths and comparisons with theoretical results are given for $3s^2S - 3p^2P^0$ transitions of lithium isoelectronic sequence (Fig.2) and $3s^2S - 3p^2P^0$; $3p^2P^0 - 3d^2D$ transitions for boron isoelectronic sequence (Fig.3; Fig.4). The best agreement was achieved with our semiclassical calculations.

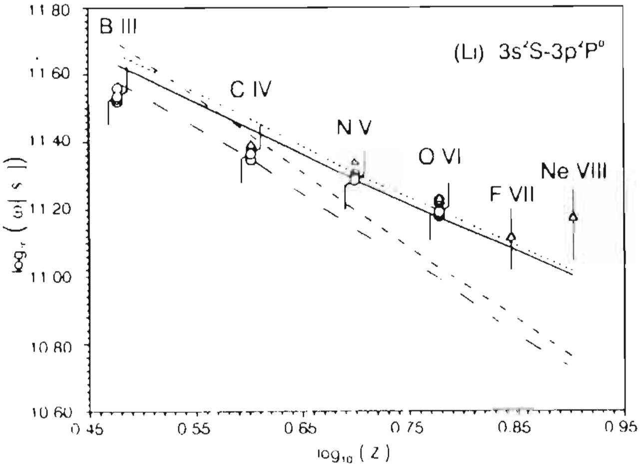

Fig. 2. Stark widths Li-like spectral lines (in angular frequency units) as function of $\log_{10} Z$ for $3s^2S - 3p^2P^0$ multiplets. Theory : • • ••, semiclassical electrons + ions impact widths, ——— semiclassical electrons only; _ _ _, semiclassical approximation (Eq.(526) taken from Griem, 1974); — — —, modified semiempirical formula (Dimitrijević and Konjević, 1980). Experiment : O, our data, Δ, Glenzer et al (1992, 1993).

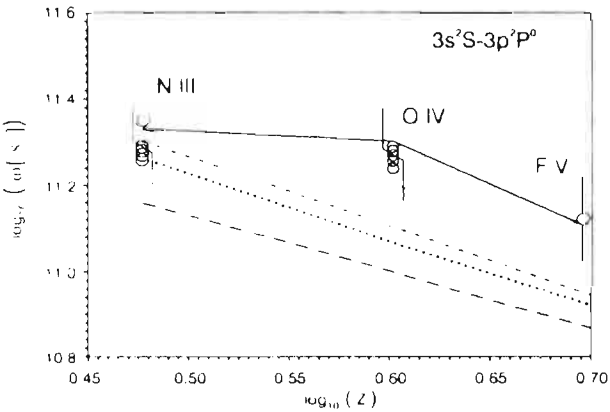

Fig. 3. Stark widths B-like spectral lines (in angular frequency units) as function of $\log_{10} Z$ for $3s^2S - 3p^2P^0$ multiplets. Theory : • • ••, semiclassical electrons + ions impact widths, ——— semiclassical electrons only; _ _ _, semiclassical approximation (Eq.(526) taken from Griem, 1974); — — —, modified semiempirical formula (Dimitrijević and Konjević, 1980). Experiment : O, our data, D, Glenzer *et al.* (1994).

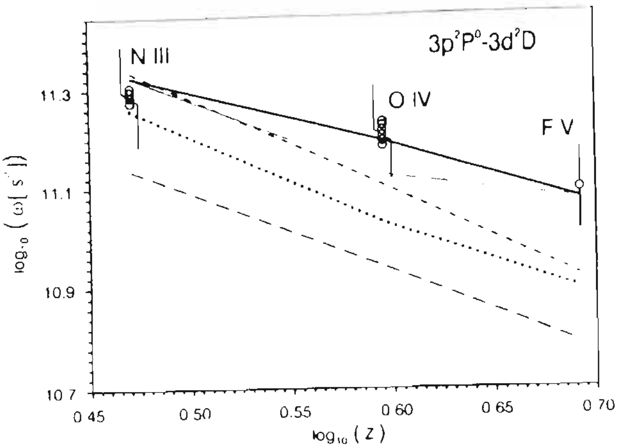

Fig. 4. Same as for figure 3 but for $3p^2P^0 - 3d^2D$ multiplets.

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