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STARK BROADENING IN THE Ne II 3s ^{4}P–3p ^{4}D^0 MULTIPLET

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Abstract. Stark widths of three Ne II spectral lines (336.063, 333.487 and 332.716 nm) belonging to the $3s^4P - 3p^4D^0$ transition have been measured in the linear, low pressure, pulsed arc plasma at 31 000 K and 34 500 K electron temperatures and corresponding electron densities of 0.95 10^{23} m^{-3} and 1.83 10^{23} m^{-3}, respectively. Our experimental Stark widths data have been compared to the existing experimental and theoretical Stark width values.

1. INTRODUCTION

In the paper published by Uzelac et al. (1993) evident discrepancies between existing calculated Stark width values were found in the case of the Ne II $3s^4P - 3p^4D^0$ transition. Thus, the results of the classical-path approximation (HB) (Hey & Breger 1980; Uzelac et al. 1993) provide very small dependence on the electron temperature (T). In contrast to this, predictions made by modified semiempirical method (SEM) (Dimitrijević & Konjević 1980; Uzelac et al. 1993) show perceptible dependence on the electron temperature. Griem's (1974) (G) values calculated on the basis of the semiclassical theory lie above both other group of the mentioned theoretical predictions. Existing experimental Stark width data between 27 000 K and 40 000 K electron temperatures show acceptable agreement with G and HB values, but the latest measurements (Uzelac et al. 1993) give Stark widths which at about 80 000 K electron temperature agree well with SEM values.

The aim of this work is contribution to the clarification of the above explained problem. In this order Stark FWHM (full-width at half intensity maximum, W) have been measured in two discharge conditions in neon plasma. Beside, for the first time, estimations of the researched W values (based on the Stark width regularities) have been included, also, in the comparison between measured and calculated Stark width values.

2. EXPERIMENT AND RESULTS

The modified version of the linear low pressure pulsed arc (Djeniže et al. 1991,1998) has been used as a plasma source. A pulsed discharge was driven in a quartz discharge tube of 5 mm inner diameter and effective plasma length of 7.2 cm (Fig. 1 in Djeniže et al. (1991,1998)). The tube has end-on quartz windows. The working gas was neon at 130 Pa filling pressure in constant flux flowing regime. A capacitor of 14 μF was charged up to 1.5 kV and 2.5 kV, respectively. Spectroscopic observation of isolated spectral lines were made end-on along the axis of the discharge tube. The line profiles were recorded using a step-by-step technique, described in our earlier publications. The spectrograph exit slit (10 μm) with the calibrated photomultiplier was micrometrically traversed along the spectral plane in small wavelength steps (0.0073 nm). The averaged photomultiplier signal (five shots in each position) was digitized using an oscilloscope, interfaced to a computer.

Plasma reproducibility was monitored by the Ne II and Ne III lines radiation and, also, by the discharge current (it was found to be within 5%). Recorded line profiles can be fitted to the Voigt function as a superposition of the Gauss (instrumental and Doppler broadening) and Lorentz (Stark broadening) functions. The standard deconvolution procedure (Davies & Vaughan 1963) was computerized using the least square algorithm. Stark widths have been obtained with $\pm$ 10% accuracy at given T and N. Great care was taken to minimize the influence of self-absorption on Stark width determinations. The opacity was checked by measuring line-intensity ratios within multiplet. The values obtained were compared with calculated ratios of the products of the spontaneous emission probabilities and the corresponding statistical weight of the upper levels of the lines. These ratios differed by less than $\pm$9%, testifying to the absence of the self-absorption. The necessary atomic data were taken from Wiese et al. (1966).

The plasma parameters were determined using standard diagnostic methods (Rompe & Steenbeck 1967). Thus, the electron temperature (T) was determined from the Boltzman-slope on 14 Ne II lines (331.98, 336.06, 337.18, 341.48, 341.69, 341.77, 350.36, 356.83, 366.41, 369.42, 429.04, 439.19, 440.93 and 441.32 nm) with a corresponding upper-level energy interval of 7.52 eV with an estimated error of $\pm$ 7%, assuming the existence of LTE, according to criterion from Griem (1974). All necessary atomic data were taken from Wiese et al. (1966).The electron density (N) decay was measured using a well known single laser interferometry technique for the 632.8 nm He-Ne laser wavelength with an estimated error of $\pm$7%. The electron density and temperature decays are presented in Fig. 1 (for the 1.5 kV bank energy). Our experimental W data are given in Table 1.

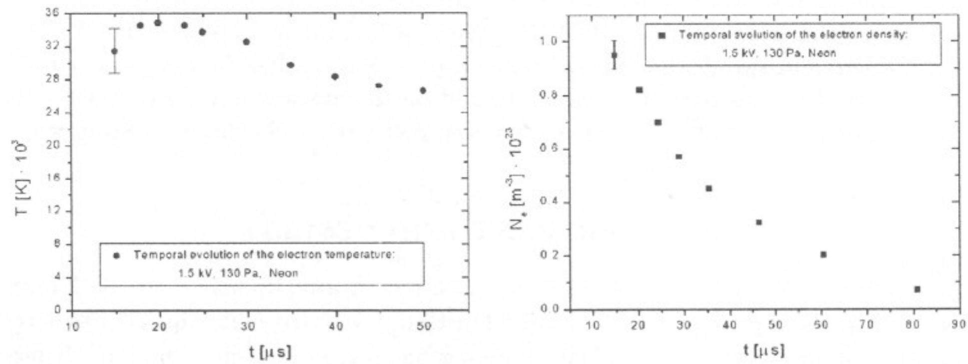

Fig. 1. Electron temperature (T) and density (N) decay at 1.5 kV bank energy.

Table 1. Measured W values with various plasma parameters.

λ (nm)	W (nm)	
	T=31 000 K $N = 0.95\ 10^{23}\ m^{-3}$	T=34 500 K $N = 1.83\ 10^{23}\ m^{-3}$
336.063	0.01252	0.02183
333.487	0.01330	0.02073
332.716	0.01400	0.02199

3. DISCUSSION AND CONCLUSION

In order to allow easy comparison among measured and calculated Stark width values, we report in Fig. 2. variations of W (FWHM) with the electron temperatures for a given electron density equal to $10^{23}\ m^{-3}$. Theoretical predictions are calculated on the basis of the modified semiempirical formulae (SEM), classical path -approximation (HB) and semiclassical theory (G). INS denote estimated W values calculated on the basis of Eq. (2) taken from Purić et al. (1988) and Djeniže & Labat (1996) which was obtained for the neon isonuclear sequence (see also Djeniže , 2000). The explicit form of this equation is given (for z=2) as:

$$W(m) = 1.97\ 10^{-9}\ \ T^{-1/2} \tag{1}$$

at an $N = 10^{23} m^{-3}$ electron density and T expressed in K. All necessary atomic data in determination of Eq. (1) were taken from Wiese et. al. (1966).

One can conclude that our new experimental data confirm the earlier observed experimental W values at about 30 000 K electron temperature and gravity to the G and HB theoretical values. It should be pointed out that the estimated INS values agree satisfactorily with experimental data including, also, those from Uzelac et al. (1993) at about T=80 000 K. INS and SEM predictions have similar course among electron temperatures. Explaining of these behaviours requires new steps in theory of the Stark widths predictions.

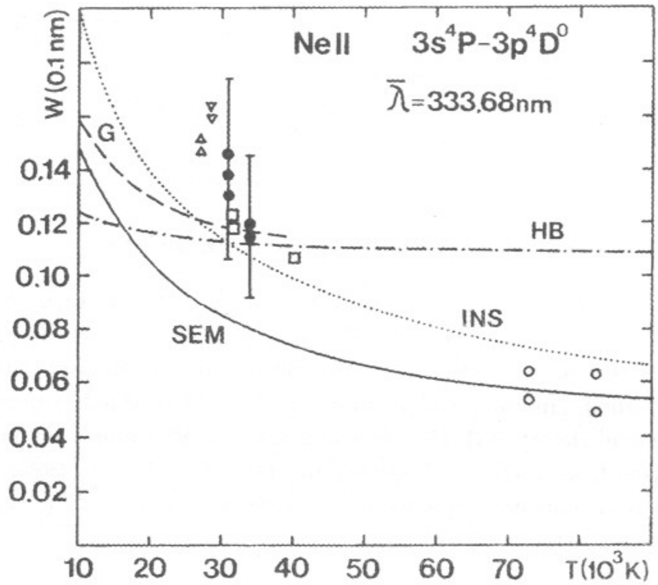

Fig. 2. Stark FWHM values vs. electron temperature at an 10^{23} m^{-3} electron density. •, this work; ∇, Platiša et al. (1978); △, Konjević & Pittman (1987); , Purić et al. (1987); ∘, Uzelac et al. (1993). G,Griem (1974); SEM, Uzelac et al. (1993), HB, Uzelac et al. (1993), INS, Djeniže & Labat (1996). Error bars include uncertainty estimates in width (±10%) and electron density (±7 %) measurements. $\overline{\lambda}$ is the mean wavelength in multiplet.

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