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MEASUREMENTS OF STARK BROADENING OF SOME SINGLY IONIZED ARGON LINES

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Half-widths of Stark-broadened argon II lines at 4806 Å ($4s\ ^4P$-$4p\ ^4P^\circ$), 4736 Å ($4s\ ^4P$-$4p\ ^4P^\circ$), and 4426 Å ($4s\ ^4P$-$4p\ ^4D^\circ$) have been measured[1] in a helium-argon plasma behind the reflected shock wave in an electromagnetic T tube with backstrap.[2-8] The leg of the 19-mm-o.d., 16-mm-i.d. Pyrex T tube is inserted into an aluminum block which contains a reflector and observation and pumping ports. Intensity measurements are made through two holes of 2-mm diam for observing the plasma (a) across the diameter of the tube and (b) across a chord near the wall. All measurements are made 1 mm in front of the adjustable reflector. The distance from the electrodes in the arms of the T to the reflector is 12.5 cm. An energy-storage capacitor with 600 J at 40 kV (ringing at 300 kc/sec) is used to power the driver discharge. The circuit is critically damped to prevent the generation of multiple shock waves.

The vacuum system (base pressure 1×10^{-6} Torr) is filled to a pressure of 1 Torr with a mixture of 97% helium and 3% argon.

Three 0.5-m monochromators with photomultipliers (Fig. 1) are employed to (a) scan the line profile shot by shot[4]; (b) monitor the total intensity of the 4806-Å line of argon II; and (c) monitor a 33-Å-wide continuum band centered at 5100 Å. The first (scanning) monochromator has a nearly Gaussian apparatus function with a (full) half-width of 0.2 Å. All data are rejected unless the two monitored intensities are reproduced within ±10%.

The electron density is determined independently from a measurement of the half-width of the 5876-Å line of helium I as observed at the two positions. The (full) half-widths agree well within experimental error limits, and indicate an electron density of 1.03×10^{17} cm^{-3} (±10%) uniformly throughout the plasma. The ratio of the integrated intensity of the 5876-Å helium-I line to a 100-Å-wide band of the underlying continuum yields a temperature of 18 000°K (±20%) at both locations and indicates that the temperature is likewise uniform.

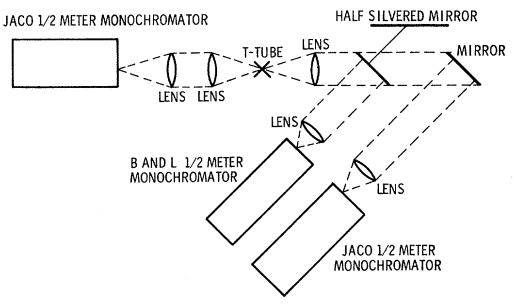

FIG. 1. Optical arrangement.

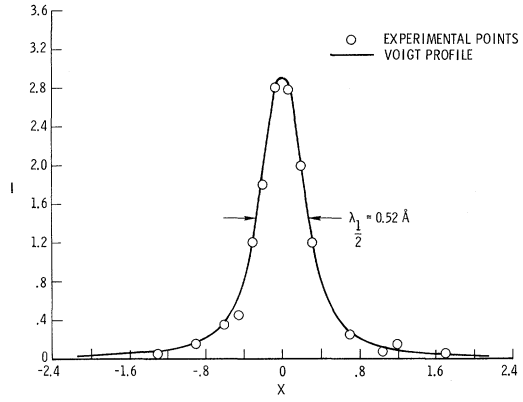

FIG. 2. Experimental profile—4806-Å Ar II.

The profile of the 4806-Å line in the multiplet $4s\ ^4P\text{-}4p\ ^4P^\circ$ of argon II was also measured at both locations. The (full) half-widths again agree well within experimental error limits. After corrections for the underlying continuum[3] (Fig. 2) and instrumental broadening,[9] the (full) half-width was determined to be 0.39 Å (±10%) which is larger than the value predicted by Griem[10] by a factor $r = 2.6$. The profile of the 4736-Å line in the same multiplet of argon II was consistent with that of the 4806-Å line.

Under the same conditions the 4426-Å line in multiplet $4s\ ^4P\text{-}4p\ ^4D^\circ$ of argon II has a (full) half-width of 0.3 to 0.4 Å which is larger than the predicted value by $r = 2.5$ to 3.3. The large error limit on this particular line was due to a weak argon-II line distorting the continuum measurement. This line is listed in the tables published by Minnhagen,[11] but was not listed in other available tables.

Preliminary results of measurements at higher electron density (about 5×10^{17} cm^{-3}) show that the broadening of the 3729-Å line in another multiplet ($4s\ ^4P\text{-}4p\ ^4S^\circ$) of argon II is consistent with that of the 4806-Å line, i.e., it also exhibits more broadening than predicted with $r = 2.6$.

Popenoe and Shumaker[12] find $r = 2.55$ for the 4806-Å line in a high-temperature arc at lower electron density (6×10^{16} cm^{-3} to 1×10^{17} cm^{-3}), while $r = 2.5$ is indicated for the same line at higher electron density (several times 10^{17} cm^{-3}) by Burgess and Roberts.[13] Powell[14] finds $r = 2.34$ for the 4806-Å line and $r = 3.6$ for the 4426-Å line.

The consistency of the ratio r between experimental and theoretical half-widths for three multiplets with identical lower levels may be noted, although r may be slightly larger for multiplet 7 where the error limits are wider (Table I). The validity of a number of approximations inherent in the numerical calculations is being investigated, including the neglect of lower state perturbations, the classical path approximation with dipole interaction excluding "back reaction," etc. Additional experimental evidence including other multiplets is being sought which may shed more light on the possible causes of the theoretical difficulties.

Table I. Summary of results.

λ (Å)	Multiplet	$\lambda_{1/2}$(theor) (Å)	$\lambda_{1/2}$(meas) (Å)	Ratio, r
4806	$4s\ ^4P\text{-}4p\ ^4P^\circ$	0.15	0.39[a]	2.6
4736	$4s\ ^4P\text{-}4p\ ^4P^\circ$	0.15	0.39[a]	2.6
4426	$4s\ ^4P\text{-}4p\ ^4D^\circ$	0.12	0.30-0.40	2.5-3.3
3729	$4s\ ^4P\text{-}4p\ ^4S^\circ$	0.42	1.1	≈2.6

[a]Probable error ±10%.

*This work is part of a thesis to be submitted to the Physics Department, College of William and Mary, Williamsburg, Virginia, in partial fulfillment of the requirements for the degree of Master of Arts.

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