Experimental Stark Widths and Shifts for Spectral Lines of Neutral Atoms
(A Critical Review of Selected Data For the Period 1976 to 1982)

N. Konjević and M. S. Dimitrijević

Institute of Physics, 11001 Beograd, P.O. Box 57, Yugoslavia

and

W. L. Wiese

Center for Radiation Research, National Measurement Laboratory, National Bureau of Standards, Gaithersburg, MD 20899

A critical review of all experimental data on Stark widths and shifts of spectral lines of neutral elements published during the period 1976–1982 has been carried out. This work represents an extension and update of an earlier review which covered the period before 1976. Data tables containing the selected experimental Stark broadening parameters are presented together with estimated accuracies. Comparisons with comprehensive calculations based on the semiclassical theory are made whenever possible.

Key words: critically evaluated data; neutral atoms; Stark broadening parameters; Stark shifts; Stark widths

Contents

1. Introduction

This critical review is the extension of an earlier review on experimental Stark broadening data for spectral lines of non-hydrogenic atoms.[1] It covers the period from 1976 to the end of 1982, but some previously omitted papers of the earlier period are also included. As the main literature source for the period 1976 through June 1978, we have used the references listed in an NBS bibliography,[2] and for the more recent period we consulted the master file of the NBS Data Center on Line Shapes and Shifts. Also, for the entire period covered by this review, the authors maintained an independent literature search for additional references.

Theoretical data are used as a check on the consistency of the experimental results, including consistency among the various lines measured within each experiment as well as consistency between different experiments. To ensure uniform comparisons,

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only comprehensive calculations[3,4] were chosen, as in our previous review. Calculated data are now available for elements heavier than calcium,[4] and the results of the comparison with experimental data are included in the tables. For some atoms (Ge I, Cd I, Br I, and some results in Zn I) data from the preceding review[1] are reprinted, because they can now be compared with the new theoretical results.

2. Evaluation Procedure

The evaluation criteria have already been discussed in detail in the earlier review.[1] Since we follow these same criteria, we will state again only the main criteria for the selection of experimental work:

(a) An independent and accurate determination of the plasma electron density, N_e, must have been carried out.

(b) A reasonably accurate determination of the electron temperature must have been carried out.

(c) Other contributing line broadening mechanisms (Doppler, Van der Waals and instrumental broadening) and pertinent experimental problems (possible self-absorption effects, source inhomogeneities, etc.) must have been discussed and taken into account.

The two Stark broadening parameters that were taken from each experiment were the halfwidth, i.e., the *full width* of the spectral line at *half maximum* intensity (FWHM), and the shift of the line at peak intensity. The wavelength shift is considered positive when the measured peak-intensity wavelength is shifted to longer wavelengths (red shift), and negative when it is to shorter wavelengths (blue shift).

3. General Arrangement of the Tables

The data are presented in separate tables arranged according to chemical elements, and these are listed in alphabetical order. Associated with each element table is (a) a brief discussion of the experiments and a list of references, and (b) a table listing some key facts for each experiment. Also, when more than 15 transitions are listed, a finding list with lines ordered according to wavelengths is included.

The data tables contain four main items of information. In the first three columns, the transitions are identified spectroscopically by transition array, multiplet designation, and wavelength (given in Angstrom units). The wavelengths are usually taken from the tables of Reader *et al.*[5]; the multiplet numbers refer to the running numbers in the multiplet tables by Moore,[6] and the transitions are listed in order of increasing lower and upper quantum numbers. The second part of the table, comprising columns 4 and 5, lists the temperature and electron density values at which the Stark widths and shifts have been determined. In the third part of the table, the measured Stark halfwidths (FWHM), w_m, and shifts, d_m, and the ratios of measured-to-theoretical widths, w_m/w_{th}, and shifts d_m/d_{th}, are presented. In the final part of the table, we provide estimates of the accuracy of the data, and the references are identified. When Stark widths as well as shifts are measured, two accuracy estimates are given; the first refers to the halfwidth, while the second pertains to the shift. We have subdivided total uncertainties (due mainly to errors in the electron density and Stark width or shift measurements) into four ranges and coded these by letters, and we have made further differentiations by singling out slightly better data among similar ones by assigning plus signs (+) to indicate our first choices. The letters represent the following:

A = Uncertainties within 15 percent,
B = Uncertainties within 30 percent,
C = Uncertainties within 50 percent,
D = Uncertainties larger than 50 percent.

The word uncertainty is used here with the connotation "estimated extent of deviation from the true value," and our uncertainty estimates are based on the evaluation of random errors as well as our estimates of the maximum effects of possible systematic errors. Further comments on the choice of our uncertainty estimates are given elsewhere.[1,7]

4. Theoretical Comparisons

For comparisons of the tabulated experimental data with theory, two extensive tables of calculated data are applied, both based on the semiclassical impact approximation. Griem[3] published tables for the lighter elements up to Ca ($Z=20$) in 1974 based on a computer code developed by Benett and Griem,[8] and similar calculations were recently undertaken by two of the present authors (M. S. D. and N. K.) for those heavier elements for which experimental data are available. For the latter calculations, a computer code developed by Jones *et al.*[9] for singly ionized atoms was adapted to neutrals in accordance with Benett and Griem's[8] approximation of the semiclassical theory. Both approaches include not only the dominant electron impact contribution, which at a given temperature scales linearly with N_e, but also small ion broadening and shift terms, which scale with $N_e^{1/4}$. The numerical agreement between the two slightly different versions of the semiclassical theory should be very close, which is indeed the case, as seen in a typical example (Table 1).

5. Discussion and Conclusions

The experimental data on the Stark widths of isolated lines selected for this tabulation are generally

TABLE 1. Calculated Stark broadening parameters for Li I multiplet No. 1. w = full halfwidth, and d = shift in Angstrom units at $N_e = 1 \times 10^{17}$ cm^{-3} for several electron temperatures. Results with subscript BG were calculated by Benett and Griem[3,8]; results with subscript DK were calculated by Dimitrijević and Konjević.[4]

Transition	T (K)	w_{DK}	w_{BG}	d_{DK}	d_{BG}
Li I $2s\ ^2S - 2p\ ^2P^\circ$	5000	0.196	0.198	−0.0441	−0.0435
	10000	0.272	0.276	−0.0430	−0.0445
$\lambda = 6707.8$	20000	0.390	0.392	−0.0421	−0.0419
$\Delta S/S^* = -0.072$	40000	0.532	0.532	−0.0393	−0.0353
$N_e = 1 \times 10^{17}$					

*$\Delta S/S$ is measure of the failure in the fulfillment of sum rules for the squares of dipole matrix elements, S being the sum of the squares of these matrix elements with all perturbing levels (see Refs. 3 and 4).

found to be in agreement with each other within the estimated uncertainties. Important new developments are the recent high-accuracy Stark width and shift measurements for He I, N I, C I, and Fe I, with uncertainties estimated in the 15–20% range (A or B+). We recommend these data for plasma diagnostic purposes, particularly the He I lines at 5015.68 Å and 3888.65 Å, for which high-precision measurements with various plasma sources were reported and excellent mutual agreement has been found (see the He I tables and Ref. 1). However, we do not recommend that the compiled experimental results should be scaled to values significantly outside the experimental temperature and electron density ranges. Actually, some of the additional experimental work most needed at this time are investigations of the electron density and temperature dependence of Stark broadening parameters over as wide a range as possible, covering low electron temperatures ($T_e < 5000$ K) and very high electron densities ($N_e > 10^{18}$ cm^{-3}).

Generally, the agreement between experiments and semiclassical theory is fairly good. The differences in the widths usually do not exceed ±30%; however, for heavier elements the comparisons with the new theoretical results show larger disagreements in several cases. Our critical analysis indicates that in most of these cases the experimental data are not sufficiently accurate to allow definite conclusions. Therefore, new experimental data on the Stark broadening of isolated spectral lines for elements heavier than calcium are urgently needed.

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7. Data Tables

Aluminum

Al I

Ground State: $1s^22s^22p^63s^23p\ ^2P^\circ_{1/2}$

Ionization Energy: 5.986 eV = 48278.37 cm^{-1}

At the time of the publication of our preceding critical review[1] no experimental Stark parameters for Ar I lines were available; in the meantime, four experimental results for Stark widths and shifts of some prominent Al I lines were reported.[2-5] Generally, the agreement between experiments is well within the limits of the estimated uncertainties. The average agreement with semiclassical calculations[6] is within ±20%, which is considered typical for lines of neutral atoms (see, e.g., Refs. 1 and 6).

It may be of interest to note that in Ref. 3 an unexpectedly large difference (28%) was reported for the two Stark widths of multiplet No. 2. The authors unsuccessfully searched[3,7] for the cause and concluded "that the measured difference of the half-widths of the Al I resonance doublet must be an intrinsic plasma effect."[7]

The line at 3092.71 Å overlaps completely with a weaker line of the same multiplet at 3092.84 Å for the experimental conditions of Refs. 2 and 4. This fact is noted in Ref. 4, but the influence of the weaker line is neglected; it is probably not considered in Ref. 2 either.

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Key data on experiments

Ref.	Plasma source	Method of measurement		Remarks
		Electron density	Temperature	
2	Plasma jet	H_α and H_β Stark widths	Plasma composition data	
3	Gas-driven shock tube	Laser interferometry at 3.39 μm	Plasma composition data	Photographic technique
4	Wall-stabilized arc	Width of Ar I 3949 Å line	Plasma composition data	
5	Wall-stabilized pulsed discharge	H_α Stark width	Absolute intensity of maximum of self-absorbed line[8]	Photographic technique; numerous theoretical assumptions made in order to derive Stark widths from experimental line shape measurements

Numerical results for Al

No.	Transition array	Multiplet (No.)	Wavelength (Å)	Temperature (K)	Electron density (10^{17} cm^{-3})	w_m (Å)	w_m/w_{th}	d_m (Å)	d_m/d_{th}	Acc.	Ref.
1.	$3p$–$3d$	$^2P^o - ^2D$ (3)	3082.15	13200	1.28	0.51	0.60	0.19	0.53	B,C	2
				10000–12000	0.1	0.045*	0.78			B	4
			3092.71	13200	1.28	0.51	0.60	0.19	0.53	B,C	2
				10000–12000	0.1	0.049	0.77			B	4
2.	$3p$–$4s$	$^2P^o - ^2S$ (1)	3961.52	13200	1.28	0.54	1.02	0.31	1.13	B,C	1
				9670	1.42	0.628	1.28	0.14	0.44	C,C	3
				10000–12000	0.1	0.038*	1.09			B	4
				13600	4.5	1.30	0.76	0.86	0.69	D+,C	5
			3944.01	13200	1.28	0.54	1.02	0.31	1.13	B,C	2
				9670	1.42	0.465	0.95	0.14	0.44	C,C	3
				10000–12000	0.1	0.037*	1.06			B	4
				13600	4.5	1.40	0.82	0.93	0.73	D+,C	5

*Results taken in electron density range (0.15–0.60) × 10^{17} cm^{-3}.

Argon

Ar I

Ground State: $1s^2 2s^2 2p^6 3s^2 3p^6\ {}^1S_0$

Ionization Energy: 15.759 eV = 127109.9 cm^{-1}

Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.
3948.98	3	4272.17	1	5882.62	14	6059.37	8
4044.42	4	4300.10	2	5888.58	15	6105.64	12
4158.59	1	4510.73	6	5912.09	8	6145.44	12
4164.18	1	5650.70	9	6032.13	10	6384.72	13
4181.88	5	5834.26	11	6043.22	10	6416.31	13
4259.36	5	5860.31	14	6052.72	7		

Four experimental papers dealing with the Stark broadening of Ar I lines have been selected.[1-4] In Ref. 2, measurements were carried out over a wide electron density range and a linear dependence of Stark width and shift on electron density N_e was found. The results were therefore normalized to $N_e = 1 \times 10^{17}$ cm^{-3}. In Ref. 3 no temperature measurements were reported. Since the Stark width measurements were performed in a wall-stabilized arc at atmospheric pressure in argon, one may—on the basis of another, similar experiment[5]—estimate that the temperature was in the range 10000–13000 K.

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Key data on experiments

Ref.	Plasma source	Method of measurement: Electron density	Method of measurement: Temperature	Remarks
1	Wall-stabilized arc	H_β Stark width	Absolute intensity of Ar I 4259.4, 4272.2 and 4300.1 Å lines and H_β	No self-absorption check reported
2	Gas-driven shock tube	Two-wavelength laser interferometry at 6328 Å and 1.15 μm	Plasma composition data	Self-absorption checked via ratio of line center to continuous background
3	Wall-stabilized arc	H_β Stark width		Measurement of electron temperature is not reported
4	Wall-stabilized arc	H_β Stark width and absolute intensity of continuum	Absolute intensity of Ar I lines	Photographic technique

Numerical results for Ar

No.	Transition array	Multiplet (No.)	Wavelength (Å)	Temperature (K)	Electron density (10^{17} cm^{-3})	w_m (Å)	w_m/w_{th}	d_m (Å)	d_m/d_{th}	Acc.	Ref.
1.	4*s*–5*p*	$[3/2]^{\circ}-[3/2]$	4164.18	10550	0.26	0.596				C+	1
			4158.59	11700–12500	0.60–0.92	1.105–1.902				C+	1
			4272.17	10550–12500	0.26–0.92	0.644–1.666	1.15–0.78			C+	1
2.		$[3/2]^{\circ}-[5/2]$	4300.10	10550–12500	0.26–0.92	0.594–1.596				C+	1
				12200–10400	1	2.24*		0.95		C,C	2
3.	4*s*–5*p*′	$[3/2]^{\circ}-[1/2]$	3948.98		0.17–0.53	0.3–1.1				C+	1
4.		$[3/2]^{\circ}-[3/2]$	4044.42	10550–11700	0.26–0.60	0.572–1.112				C+	1
5.	4*s*′–5*p*′	$[1/2]^{\circ}-[1/2]$	4181.88	10550	0.26	0.948				C+	1
				11700–10600	1	2.28*		0.92		C,C+	2
			4259.36	10550–12500	0.26–0.92	0.764–1.985	1.01–0.75			C+	1
				11600–10500	1	2.44*	0.81**	1.00	0.61**	C,C	2
6.	4*s*′–5*p*	$[1/2]^{\circ}-[1/2]$	4510.73	10550–11700	0.26–0.60	0.927–1.930	0.91–0.79			C+	1
7.	4*p*–4*d*′	$[1/2]-[5/2]^{\circ}$	6052.72	10000	0.16	0.986		0.276		C+,B	4
8.		$[1/2]-[3/2]^{\circ}$	6059.37	10000	0.16	1.19		0.399		C+,B	4
			5912.09	10000	0.16	1.36				C+	4
9.	4*p*–5*d*	$[1/2]-[1/2]^{\circ}$	5650.70	10000	0.16	1.40				C+	4
10.		$[5/2]-[7/2]^{\circ}$	6032.13	10000	0.16	2.47	0.66	0.644	0.55	C+,B	4
			6043.22	10000	0.16	3.65		0.679		C+,B	4
11.	4*p*–5*d*′	$[3/2]-[3/2]^{\circ}$	5834.26	10000	0.16	1.90				C+	4
12.	4*p*′–5*d*′	$[3/2]-[5/2]^{\circ}$	6105.64	10000	0.16	2.90	0.73	0.560	0.44	C+,B	4
			6145.44	10000	0.16	3.20		0.658		C+,B	4

Numerical results for Ar—continued

No.	Transition array	Multiplet (No.)	Wavelength (Å)	Temperature (K)	Electron density (10^{17} cm^{-3})	w_m (Å)	w_m/w_{th}	d_m (Å)	d_m/d_{th}	Acc.	Ref.
13.	$4p$–$6s$	$[\frac{1}{2}]-[\frac{3}{2}]^\circ$	6416.31	10000	0.16	1.40		0.730		C+,B+	4
			6384.72	10000	0.16	1.20		0.684		C+,B+	4
14.	$4p$–$6s'$	$[\frac{1}{2}]-[\frac{1}{2}]^\circ$	5882.62	10000	0.16	0.83				C+	4
			5860.31	10000	0.16	1.20				C+	4
15.	$4p$–$7s$	$[\frac{5}{2}]-[\frac{3}{2}]^\circ$	5888.58	10000	0.16	3.40	0.77			C+	4

*Data taken in the electron density range (0.4–1.0) × 10^{17} cm^{-3}.
**Ratios taken at 11000 K.

Bromine

Br I

Ground State: $1s^22s^22p^63s^23p^63d^{10}4s^24p^5\ {}^2\mathrm{P}^\circ_{3/2}$

Ionization Energy: 11.814 eV = 95284.8 cm^{-1}

We present again the results for the Stark widths of two Br I lines,[1] obtained with a gas-driven shock tube and normalized to an electron density of 1.0×10^{17} cm^{-3}. These data were already listed in the earlier review[2] but are now (for the 4441.74 Å transition) compared with semiclassical theoretical results.[3] The experimental width is almost an order of magnitude larger than the theoretical result. It should be pointed out that a significant number of the energy levels necessary for Br I Stark width calculations are not known, and the available data tables are quite incomplete. To illustrate this we quote[3] the ratio $\Delta S/S = -0.63$ for the multiplet $^4\mathrm{P}-{}^4\mathrm{D}^\circ$ (see Br I table). $\Delta S/S$ is a measure of the failure of the fulfillment of sum rules for the squares of dipole matrix elements, S being the sum of the squares of these elements.[4] On the basis of other, similar cases, however, we estimate that the incompleteness of the knowledge of perturbing energy levels can explain only a part of the large discrepancy between theory and experiment. The transition at 4525.59 Å is listed again, because it was identified incorrectly.[2]

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[4] H. R. Griem, *Spectral Line Broadening by Plasmas*, Academic Press, New York (1974).

Key data on experiments

Ref	Plasma source	Method of measurement		Remarks
		Electron density	Temperature	
1	Gas-driven shock tube	H_β Stark width	Absolute intensity of Ne I 5852 Å line and H_β, also line reversal technique applied to H_α	Photographic technique

Numerical results for Br

No.	Transition array	Multiplet (No.)	Wavelength (Å)	Temperature (K)	Electron density (10^{17} cm^{-3})	w_m (Å)	w_m/w_{th}	d_m (Å)	d_m/d_{th}	Acc.	Ref.
1.	$4p^45s$–$4p^4(^3P)6p$	^4P - $^4D°$	4441.74	11000	1.0	10.4	7.89			D	1
2.		^4P - $^4P°$	4525.59	11000	1.0	9.9				D	1

Cadmium

Cd I

Ground State: $1s^22s^22p^63s^23p^63d^{10}4s^24p^64d^{10}5s^2\ ^1S_0$

Ionization Energy: 8.993 eV = 72538.8 cm^{-1}

The results of the only available experiment[1] have already been tabulated in the earlier critical review,[2] but now experiment/theory ratios can be added. The measurements were carried out with a pulsed discharge, and the results were normalized to $N_e = 1.0 \times 10^{17}$ cm^{-3} and $T = 11100$ K. Large variations of halfwidths within multiplets, and especially the fact that the weakest lines have the smallest halfwidths, seem to indicate that self-absorption was a problem which has not been corrected properly. Not unexpectedly, for most lines the agreement with the semiclassical results[3] is not good at all.

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Key data on experiments

Ref.	Plasma source	Method of measurement: Electron density	Method of measurement: Temperature	Remarks
1	Pulsed discharge	H_β Stark width	Plasma composition data	Photographic technique

Numerical results for Cd

No.	Transition array	Multiplet (No.)	Wavelength (Å)	Temperature (K)	Electron density (10^{17} cm^{-3})	w_m (Å)	w_m/w_{th}	d_m (Å)	d_m/d_{th}	Acc.	Ref.
1.	$5s5p$–$5s6s$	$^3P°$ - ^3S	5085.82	11100	1.0	3.67	6.34			D	1
		(2)	4799.91	11100	1.0	3.84	6.63			D	1
			4678.15	11100	1.0	1.74	3.00			D	1
2.	$5s5p$–$5s5d$	$^3P°$ - ^3D	3610.51	11100	1.0	1.84	1.97			D	1
			3466.20	11100	1.0	1.63	1.74			D	1
			3403.65	11100	1.0	0.94	1.01			D	1

Carbon

C I

Ground State: $1s^22s^22p^2\ ^3P_0$

Ionization Energy: 11.260 eV = 90820.42 cm^{-1}

Four recent experiments, all performed with wall-stabilized arcs, have been selected.[1-4] In Ref. 1, only the overall profiles of multiplet No. 6 are reported (this multiplet is not listed in this tabulation, since the widths are not given), and the measured profiles are compared with semiclassical theoretical results by Griem.[5] The authors[1] attempted to determine the ion broadening parameter by arbitrarily varying this quantity until the best agreement between theory and experiment was obtained. Remaining discrepancies between theory and experiment could not be explained by the estimated experimental errors.

In Ref. 2 detailed results for two C I lines are given. Although the data for the 5052 Å line agree well with other experiments[6,7] and the estimated accuracy for line width measurements is 25%,[2] we estimate a lower accuracy for the following reason: An analysis of the experimental profiles using the Davies and Vaughan tables[8] shows that the contribution of the Gaussian part is very large (between 50% and 60% of the total width, as seen especially from Figs. 5–7 of Ref. 2), while the author claims that "the experimental profiles are approximately Lorentzian."

In Ref. 3, the Stark width and shift parameters of several UV and VUV lines were studied. The lines were measured under approximately optically thin conditions. The experimental values agree well (i.e., within the uncertainties of the experiment and the theory) with semiclassical results,[9] with the exception of the shift data for the 1751.9 Å line, where better agreement is obtained with the calculations by Wilson and Nicolet.[10]

The curve-of-growth method was used in Ref. 4 to determine the Stark widths of several VUV lines. An attempt was also made to determine the ion broadening parameters for all measured lines. The agreement of these Stark width measurements with the results of Ref. 3 is well within the mutually estimated error limits. The only exception is multiplet No. 2 UV, where the discrepancy amounts to a factor of two.

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Key data on experiments

Ref.	Plasma source	Method of measurement		Remarks
		Electron density	Temperature	
2	Wall-stabilized arc	Plasma composition data	Absolute intensities of Ar I 4158 Å, C I 4932 Å, and O I 4368 Å lines	Photographic technique; no corrections for Doppler and instrumental broadening reported
3	Wall-stabilized arc	Plasma composition data	Absolute intensity of Ar II 4806 Å line	
4	Wall-stabilized arc	H_β Stark width	Plasma composition data	Curve-of-growth method is used to determine Stark widths

Numerical results for C

No.	Transition array	Multiplet (No.)	Wavelength (Å)	Temperature (K)	Electron density (10^{17} cm^{-3})	w_m (Å)	w_m/w_{th}	d_m (Å)	d_m/d_{th}	Acc.	Ref.
1.	$2s^22p^2$–$2s2p^3$	^3P - $^3D^\circ$ (3 UV)	1561.0*	12500	1	0.0015				B	4
2.	$2p^2$–$2p3s$	^3P - $^3P^\circ$ (2 UV)	1656.27	12800–15500	1.1 -2.2	0.050–0.070	1.23–0.80	0.012**–0.044	0.87**–0.86	B,B	3
			1657.91	12800–15200	1.1 -2.1	0.045–0.075	1.11–0.94	0.014***–0.037	0.72***–0.70	B,B	3
			1658.12	12800–15500	1.1 -2.2	0.045–0.075	1.11–0.86	0.024****–0.041	0.85****–0.77	B,B	3
			1657.0*	12500	1	0.0165	0.43			C+	4
3.		^1D - $^1P^\circ$ (33 UV)	1930.91	11700–15500	0.6 -2.2	0.030–0.112	0.99–1.03	0.017–0.057	0.92–0.84	B,B+	3
				12500	1	0.045	0.92			B	4
4.		^1S - $^1P^\circ$ (61 UV)	2478.56	11700–15300	0.6 -1.2	0.061–0.193	1.23–1.08	0.030–0.109	1.04–0.99	B+,B+	3
5.	$2p^2$–$2p3d$	^1D - $^1D^\circ$ (34 UV)	1481.76	12500	1	0.042	0.54			D+	4
6.		^1D - $^1F^\circ$ (37 UV)	1463.34	12500	1	0.045	0.52			C+	4
7.		^1D - $^1P^\circ$ (38 UV)	1459.03	12500	1	0.100	1.13			C+	4
8.		^1S - $^1P^\circ$ (62 UV)	1751.83	11700–15300	0.6 -2.1	0.096–0.388	0.73–1.33	0.071–0.194	2.27–1.64	B+,B	3
				12500	1	0.147	1.16			B	4
9.	$2p^2$–$2p4s$	^1D - $^1P^\circ$ (36 UV)	1467.40	12500	1	0.123	0.73			B	4
10.	$2p3s$–$2p4p$	$^1P^\circ$ - ^1D (12)	5052.17	9300–11100	0.20–0.61	0.62–1.77	0.83–0.75			D+	2
11.		$^1P^\circ$ - ^1S (13)	4932.05	9100–11150	0.15–0.64	0.91–2.0	1.03–0.49			D+	2

*Average wavelength for the multiplet.

**Taken at $N_e = 0.6 \times 10^{17}$ cm^{-3} and $T \approx 11700$ K.

***Taken at $N_e = 0.8 \times 10^{17}$ cm^{-3} and $T \approx 12000$ K

****Taken at $N_e = 1.2 \times 10^{17}$ cm^{-3} and $T \approx 13000$ K.

Cesium

Cs I

Ground State: $1s^22s^22p^63s^23p^63d^{10}4s^24p^64d^{10}5s^25p^66s\ ^2S_{1/2}$

Ionization Energy: 3.894 eV = 31406.432 cm^{-1}

The Stark width and shift of the $6s\ ^2S_{1/2}$ - $6p\ ^2P^\circ_{3/2}$ resonance line at 8521.12 Å has been measured with an electromagnetic shock tube (T-tube).[1] The electron density was determined by laser interferometry and the temperature was determined by a Boltzmann plot of Ar II line intensities and from ratios of Si I to Si II line intensities. Stark width and shift data were obtained over a large electron density range from 0.4 × 10^{17} cm^{-3}

to 2.2×10^{17} cm^{-3} and for several temperatures from 15000 to 26000 K. The results were normalized to an electron density of 10^{17} cm^{-3} and, for the low and high temperatures, are as follows: The full width at half maximum intensity is 2.42 Å at 15000 K and 2.60 Å at 26000 K, and the corresponding shifts are 0.88 Å and 0.75 Å, respectively. A "C+" accuracy is estimated for the widths, and "B" for the shifts. The agreement with semiclassical theory[2] is very good, as the experiment/theory ratios show: $w_m/w_{th} = 0.93$–0.91 and $d_m/d_{th} = 0.83$–0.84 for the above-cited temperatures.

References

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Fluorine

F I

Ground State: $1s^2 2s^2 2p^5\ ^2P^\circ_{3/2}$

Ionization Energy: 17.422 eV = 140524.5 cm^{-1}

Stark broadening and shift parameters for nine F I lines were measured in a T-tube plasma.[1] In this paper several of the important experimental factors (self-absorption, contributions of other broadening mechanisms, and instrumental broadening) are not discussed, which makes it difficult to estimate the accuracy of the reported data.

The experimental results agree well with the theoretical data listed in the F I table, with the exception of the shift results for multiplet No. 1. But since the discrepancy with another set of data[2,3] is large, an experiment was performed by one of us[4] to search for the causes of this disagreement. It was found that in Ref. 2 a systematic error in the electron density measurements was made. Mode interference in the He-Ne laser used for the interferometric density measurements produced an electron density which was always larger by about a factor of two. If this is corrected, the agreement with Ref. 1 is within the estimated errors of both experiments, and also the apparent discrepancy between Ref. 2 and the semiclassical theory is resolved.

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Key data on experiments

Ref.	Plasma source	Method of measurement: Electron density	Method of measurement: Temperature	Remarks
1	T-tube	Laser interferometric technique	Boltzmann plot of Ar II line intensities	No self-absorption check reported; no correction for Doppler and instrumental broadening reported

Numerical results for F

No.	Transition array	Multiplet (No.)	Wavelength (Å)	Temperature (K)	Electron density (10^{17} cm^{-3})	w_m (Å)	w_m/w_{th}	d_m (Å)	d_m/d_{th}	Acc.	Ref.
1.	$2p^4 3s$–$2p^4(^3P)3p$	^4P - $^4P^\circ$ (1)	7331.96	17500–26000	1	0.64–0.64	0.97–0.78	0.20–0.20	7.50–8.99	C,C+	1
			7398.69	17500–26000	1	0.58–0.74	0.88–0.90	0.20–0.21	7.50–9.43	C,C+	1
			7425.65	26000	1	0.72	0.88	0.19	8.54	C,C+	1

Numerical results for F—continued

No.	Transition array	Multiplet (No.)	Wavelength (Å)	Temperature (K)	Electron density (10^{17} cm^{-3})	w_m (Å)	w_m/w_{th}	d_m (Å)	d_m/d_{th}	Acc.	Ref.
2.		^{4}P - ^{4}D° (2)	6856.03	17500-26000	1	0.72-0.86	1.17-1.13	0.20-0.23	1.18-1.42	C,C+	1
			6870.22	17500	1	0.70	1.14	0.18	1.07	C,C+	1
			6902.48	17500- 26000	1	0.52-0.64	0.85-0.84	0.20-0.21	1.18-1.30	C,C+	1
3.		^{4}P - ^{4}S° (3)	6239.65	17500- 26000	1	0.56-0.60	0.89-0.84	0.29-0.32	1.06-1.16	C,C+	1
			6413.65	26000	1	0.60	0.84	0.29	1.05	C,C+	1
4.		^{2}P - ^{2}D° (4)	7754.70	26000	1	0.96	0.92	0.16	1.13	C,C+	1

Germanium

Ge I

Ground State: $1s^22s^22p^63s^23p^63d^{10}4s^24p^2\ ^3P_0$

Ionization Energy: 7.899 eV = 63715 cm^{-1}

The only experimental investigation on the Stark broadening of germanium was carried out with a gas-driven shock tube.[1] The Stark widths are normalized to $N_e = 1.0 \times 10^{17}$ cm^{-3} and $T = 11000$ K. Theory[2] and experiment differ drastically for the 4226.56 Å transition.

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Key data on experiments

Ref.	Plasma source	Method of measurement: Electron density	Method of measurement: Temperature	Remarks
1	Gas-driven shock tube	H_β Stark width	Line reversal applied to H_α, absolute intensity of H_β and 5853 Å Ne lines	Photographic technique

Numerical results for Ge

No.	Transition array	Multiplet (No.)	Wavelength (Å)	Temperature (K)	Electron density (10^{17} cm^{-3})	w_m (Å)	w_m/w_{th}	d_m (Å)	d_m/d_{th}	Acc.	Ref.
1.	$4p^2$–$4p5s$	^{1}S - ^{3}P°	4685.83	11000	1.0	0.35				C	1
2.		^{1}S - ^{1}P°	4226.56	11000	1.0	3.18	7.20			C	1

Helium

He I

Ground State: $1s^2\ ^1S_0$

Ionization Energy: 24.587 eV = 198310.76 cm^{-1}

For He I a total of 45 papers were reviewed. Only 6 papers dealing with optically allowed helium transitions unblended with other allowed or forbidden transitions were selected,[1-6] and, with the exception of the results of Ref. 1, all data are given in the He I table. The authors of Ref. 1 have chosen an unusual approach to present their results; they calculated line profiles from theoretical broadening parameters[7,8] as a function of the radial distribution of the electron density and temperature in their plasma jet. These profiles, which include Doppler broadening, were superposed to obtain theoretically predicted line profiles as emitted along a diameter of their source. The resulting profiles were then compared with measured ones and an average agreement within 10% was found for the line widths, while the discrepancies for the shift data were larger, but still within 25%.

The most comprehensive measurements of He I Stark widths and shifts were performed with a wall-stabilized arc[5] at electron densities from 0.02×10^{17} cm^{-3} to 0.13×10^{17} cm^{-3}, and electron temperatures from 10000 K to 20000 K. Stark broadening theory[7,9] for all measured isolated neutral He lines was found to be in excellent agreement with the experimental results. The average electron density determined from both the widths and shifts of these lines was about 10% below the value obtained from the Stark width of the hydrogen Balmer line H_β (which is often utilized to determine the electron density), and this result was also within the approximately 12% uncertainty of the density measurements.[5] It is important to note that in Refs. 5 and 6 the influence of Debye shielding[9] is taken into account for the evaluation of the theoretical Stark shifts, which improves the agreement with the experiment. (In Ref. 6, ion-ion correlation effects are also taken into account.) The theoretical results in the He I table, in column d_m/d_{th}, do not include Debye shielding, and therefore the differences with experiment are larger by about 10%. It is very encouraging that the agreement between the theory and the experiments (with the exception of Ref. 6) performed with various plasma sources is very good, well within 10% for the line widths. This is especially the case with the He I lines at 5015.68 Å and 3888.65 Å. The scatter in the electron densities determined from the shifts of He I lines is about twice as large as for the widths (see He I table). Therefore, the He I lines, and in particular the two abovementioned ones, are recommended for plasma diagnostic measurements. The electron densities deduced from their Stark widths in conjunction with semiclassical data[7,9] should be accurate to within ±10% (see also Ref. 10). This statement is valid for electron densities below a few times 10^{17} cm^{-3}. For higher electron densities data are given only in Ref. 6 and the agreement with the theory becomes much worse. Since only a few results are available at high electron densities, no quantitative conclusions can be drawn and the applicability of neutral helium lines for plasma diagnostic purposes in this range remains to be checked.

The first observation of ion-dynamic effects in neutral isolated lines was reported in Ref. 5. In the case of isolated He I lines "the measured ion-dynamic effects are reasonably consistent with calculations based on an adiabatic unified theory for the ion perturbers."[5]

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Key data on experiments

Ref.	Plasma source	Method of measurement		Remarks
		Electron density	Temperature	
1	Plasma jet at atmospheric pressure	H_β Stark width	Plasma composition data	
2	Low-pressure pulsed arc	Absolute intensity of the He continuum radiation at 5300 Å	Absolute intensity of He I 5016 Å and He II 4686 Å lines	
3	T-tube	Michelson-type interferometer at 6328 Å	Ratio H_β line-to-continuum	
4	Low-pressure pulsed discharge	Michelson-type interferometer at 5145 Å and 6471 Å	Absolute intensity of He II 3203 Å and 4686 Å lines	
5	Wall-stabilized arc	H_β Stark width	Absolute intensity of He I lines	
6	CO_2-laser-produced plasma	He I 3889 Å Stark line width	Absolute intensity of He I 3889 Å and 6678 Å lines	

Numerical results for He

No.	Transition array	Multiplet (No.)	Wavelength (Å)	Temperature (K)	Electron density (10^{17} cm^{-3})	w_m (Å)	w_m/w_{th}	d_m (Å)	d_m/d_{th}	Acc.	Ref.
1.	$1s2s-1s3p$	$^1S-{}^1P^\circ$ (4)	5015.68	38000	0.26–0.36	2.1–2.9	0.99–0.97			B	2
				17400	1.05	9.6	1.01			A	3
					1.26	10.2	0.88			A	3
				20000	0.67	5.4	0.91			B	4
					0.77	6.6	0.96			B	4
				20900	0.103	0.854	1.01	–0.283	1.17	B+,B	5
2.	$1s2s-1s4p$	$^1S-{}^1P^\circ$ (5)	3964.73	20900	0.103	2.306	0.91	–0.771	0.96	B+,B	5
3.	$1s2p-1s3s$	$^1P^\circ-{}^1S$ (45)	7281.35	20900	0.103	0.878	0.96	0.473	1.19	B+,B	5
4.	$1s2p-1s4s$	$^1P^\circ-{}^1S$ (47)	5047.74	20900	0.103	1.674	0.92	0.891	1.20	B+,B	5
5.	$1s2p-1s3d$	$^1P^\circ-{}^1D$ (46)	6678.15	20900	0.103	0.982	1.11	0.355	1.22	B+,B	5
				20000	1 –16	9.6–81.6	1.01–0.48	0.9–5.2*	0.56–0.58	C,C	6
6.	$1s2s-1s3p$	$^3S-{}^3P^\circ$ (2)	3888.65	20000	0.67–1.14	1.7–3.3	0.96–1.08			B	4
				20900	0.103	0.242	0.92	0.080	1.37	B+,B	5
				20000	1 –16			0.4–4.0	1.69–0.90	C	6
7.	$1s2s-1s4p$	$^3S-{}^3P^\circ$ (3)	3187.74	20000	0.67–1.14	5.3–9.5	0.92–0.95			B	4
				20900	0.103	0.778	0.94	0.258	1.28	B+,B	5
8.	$1s2s-1s5p$	$^3S-{}^3P^\circ$ (11 UV)	2945.11	20900	0.103	2.002	0.89	0.683	1.17	B+,B	5

Numerical results for He—continued

No.	Transition array	Multiplet (No.)	Wavelength (Å)	Temperature (K)	Electron density (10^{17} cm^{-3})	w_m (Å)	w_m/w_{th}	d_m (Å)	d_m/d_{th}	Acc.	Ref.
9.	1*s*2*p*–1*s*3*s*	$^3P^\circ - {}^3S$ (10)	7065.19	20900	0.103	0.470	0.90	0.302	1.22	B+,B	5
10.	1*s*2*p*–1*s*4*s*	$^3P^\circ - {}^3S$ (12)	4713.15	20900	0.103	0.956	0.93	0.538	1.18	B+,B	5
11.	1*s*2*p*–1*s*5*s*	$^3P^\circ - {}^3S$ (16)	4120.82	20900	0.103	2.222	0.91	1.124	1.10	B+,B	5
12.	1*s*2*p*–1*s*3*d*	$^3P^\circ - {}^3D$ (11)	5875.62	20900 20000	0.103 1 -19	0.392	1.00	-0.074 (-16)-(-20)	1.81 5.80-0.29	B+,B D	5 6

*Electron density range (1.0–4.9) × 10^{17} cm^{-3}.

Iron

Fe I

Ground State: $1s^22s^22p^63s^23p^63d^64s^2\ {}^5D_4$

Ionization Energy: 7.870 eV = 63480 cm^{-1}

Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.
4210.34	3	4375.93	1	4920.50	4	5415.20	7
4222.21	3	4427.31	1	5371.49	2	5424.07	6
4233.60	3	4461.65	1	5383.37	6	5434.52	2
4235.94	3	4859.74	4	5397.13	2	5446.92	2
4260.47	3	4918.99	4	5405.77	2	5455.45	5

The Stark broadening of Fe I lines was recently studied with two transient plasma sources: a gas-driven shock tube[1] and a Z-pinch electrical discharge.[2] All results were normalized to an electron density of 1 × 10^{16} cm^{-3} and temperatures of 8000 K and 9500 K, respectively. In Ref. 1, the influence of self-absorption was studied by application of a theoretical formula for the optical depth at line center and by using available atomic data, and it was estimated to be small. However, inspection of the line widths within various multiplets (see the Fe I table) reveals large variations, which may be caused by underestimates of self-absorption for the stronger lines. We have thus applied conservative accuracy estimates to these data. Stark widths for transitions between higher-lying levels, which should be less influenced by self-absorption, have been estimated to be of somewhat higher accuracy.

Because of the lack of data for perturbing energy levels for Fe I, it was not possible to calculate theoretical Stark widths.

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Key data on experiments

Ref.	Plasma source	Method of measurement		Remarks
		Electron density	Temperature	
1	Gas-driven shock tube	Laser interferometry at 3.39 μm	Plasma composition data	Photographic technique; only theoretical estimation of self-absorption reported
2	Z-pinch	Michelson interferometer at 3.39 μm	Brightness emissivity method[3]	

Numerical results for Fe

No.	Transition array	Multiplet (No.)	Wavelength (Å)	Temperature (K)	Electron density (10^{17} cm^{-3})	w_m (Å)	w_m/w_{th}	d_m (Å)	d_m/d_{th}	Acc.	Ref.
1.	$3d^64s^2$– $3d^6(^5D)4s4p(^3P^\circ)$	$a\,^5D - z\,^7F^\circ$ (2)	4375.93	8000	0.1*	0.047				D	1
			4427.31	8000	0.1	0.058				D	1
			4461.65	8000	0.1	0.050				D	1
2.	$3d^7(^4F)4s$– $3d^6(^5D)4s4p(^3P^\circ)$	$a\,^5F - z\,^5D^\circ$ (15)	5371.49	8000	0.1	0.049				D	1
			5405.77	8000	0.1	0.098				D	1
			5434.52	8000	0.1	0.048				D	1
			5397.13	8000	0.1	0.082				D	1
			5446.92	8000	0.1	0.091				D	1
3.	$3d^64s4p(^3P^\circ)$– $3d^6(^5D)4s\ (^6D)5s$	$z\,^7D^\circ - e\,^7D$ (152)	4260.47	8000	0.1	0.096				D	1
			4235.94	8000	0.1	0.078				D	1
			4222.21	8000	0.1	0.057				D	1
			4210.34	8000	0.1	0.065				D	1
			4233.60	8000	0.1	0.061				D	1
4.		$z\,^7F^\circ - e\,^7D$ (318)	4920.50	8000	0.1	0.107				D	1
			4859.74	8000	0.1	0.081				D	1
			4918.99	8000	0.1	0.075				D	1
5.	$3d^74p$– $3d^7(^4F)4d$	$z\,^5G^\circ - f\,^5G$ (1145)	5455.45	8000	0.1	0.092				D+	1
6.		$z\,^5G^\circ - e\,^5H$ (1146)	5424.07	8000	0.1	0.130				D+	1
			5383.37	8000	0.1	0.152				D+	1
				9500**	0.1**	0.212				A	2
7.		$z\,^3G^\circ - e\,^3H$ (1165)	5415.20	8000	0.1	0.098				D+	1

*All results from ref. 1 taken in electron density range $(0.10–0.25)\times 10^{17}$ cm^{-3}.

**Results taken in electron density range $(0.5–0.9)\times 10^{16}$ cm^{-3} and temperature range 8500–11000 K.

Krypton

Kr I

Ground State: $1s^22s^22p^63s^23p^63d^{10}4s^24p^6\ {}^1S_0$

Ionization Energy: 13.999 eV = 112914.5 cm^{-1}

Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.
3665.32	12	4502.35	8	5870.91	4	7854.82	7
3679.56	11	5562.22	4	5879.90	5	8059.50	6
3773.42	13	5570.29	5	7587.41	3	8112.90	1
4319.58	8	5649.56	10	7601.54	2	8190.05	2
4376.12	9	5672.45	4	7685.24	7	8298.11	2

Stark width and shift parameters for a number of Kr I lines have recently been measured by four experimental groups.[1–4] Generally, the results are quite accurate. However, appreciable uncertainties are estimated for data taken in the presence of strong self-absorption (lines 5570.29 Å and 5870.91 Å in Refs. 1 and 4) and data taken in the presence of significant resonance broadening (lines 5870.91 Å and 5879.90 Å of Ref. 4—and possibly line 5870.91 Å of Ref. 1), as suggested by Brandt *et al.*[4]

In Refs. 1, 3, and 4, measurements were carried out over a wide electron density (N_e) range, and a linear dependence of the Stark width and shift with N_e was found. The results are therefore normalized either to $N_e = 1 \times 10^{17}$ cm^{-3} (Ref. 1) or 0.1×10^{17} cm^{-3} (Refs. 3, 4).

In Ref. 4, the influence of ion broadening has been studied for the Kr I 4502.4 Å line and the ion broadening parameter α was determined. The asymmetry in the shape of this line has also been discussed.

No theoretical comparison data are available for this spectrum, since the recent comprehensive calculations for heavy elements[6] were restricted to spectra that follow *LS* coupling, which is not the case for Kr I.

References

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[5] T. Brandt, V. Helbig, and K. P. Nick, in *The Physics of Ionized Gases SPIG 1980* (Contributions), Boris ıric Institute of Nuclear Sciences, Beograd, Yugoslavia (1980), p. 208.

[6] M. S. Dimitrijević and N. Konjević, J. Quant. Spectrosc. Radiat. Transfer **30**, 45 (1983).

Key data on experiments

Ref.	Plasma source	Method of measurement		Remarks
		Electron density	Temperature	
1	Gas-driven shock tube	Laser interferometer at 6328 Å and 1.15 μm	Plasma composition data	Self-absorption check: ratio of line center and continuous background
2	Wall-stabilized arc	Stark width of Ar I 4259 Å line	Ratio of intensities of Ar I 4596 Å and Ar II 4590 Å lines	
3	Wall-stabilized arc	Laser interferometer at 6328 Å and 1.15 μm	Plasma composition data	
4	Wall-stabilized arc	Laser interferometer at 6328 Å and 1.15 μm		Temperature measurement not reported; it has been estimated from another paper[5] using plasma composition data

Numerical results for Kr

No.	Transition array	Multiplet (No.)	Wavelength (Å)	Temperature (K)	Electron density (10^{17} cm^{-3})	w_m (Å)	w_m/w_{th}	d_m (Å)	d_m/d_{th}	Acc.	Ref.
1.	$5s$-$5p$	$[3/2]^\circ - [5/2]$	8112.90	11500-13000	0.1	0.133				C+	2
2.		$[3/2]^\circ - [3/2]$	8298.11	11500-13000	0.1	0.147				C+	2
			8190.05	11500-13000	0.1	0.148				C+	2
			7601.54	11500-13000	0.1	0.160				C+	2
3.		$[3/2]^\circ - [1/2]$	7587.41	11500-13000	0.1	0.146				C+	2
4.	$5s$-$5p'$	$[3/2]^\circ - [3/2]$	5870.91	10300- 9300	1	1.220		0.218		D+,C	1
				10000-12300	0.1	0.058				C+	4
			5672.45	10100-12300	0.1	0.048				B	4
			5562.22	10100-12300	0.1	0.056				B	4
5.		$[3/2]^\circ - [1/2]$	5879.90	11000-12300	0.1	0.060				C+	4
			5570.29	10300- 9400	1	0.960		0.215		D+,C	1
				10100-12300	0.1	0.063				C+	4
6.	$5s'$-$5p'$	$[1/2]^\circ - [3/2]$	8059.50	11500-13000	0.1	1.09				C+	2
7.		$[1/2]^\circ - [1/2]$	7854.82	11500-13000	0.1	1.54				C+	2
			7685.24	11500-13000	0.1	1.79				C+	2
8.	$5s$-$6p$	$[3/2]^\circ - [5/2]$	4502.35	10000- 9200	1	3.18		1.35		C,C	1
				10000-13200	0.31-1.87	0.94-5.25				B	3
				10100-12300	0.1	0.26				B	4
			4319.58	10100-12300	0.1	0.27				B	4
9.		$[3/2]^\circ - [1/2]$	4376.12	10400- 9100	1	4.20		1.60		C,C	1
10.	$5s'$-$6p$	$[1/2]^\circ - [1/2]$	5649.56	10100-12300	0.1	0.38				B	4
11.	$5s$-$7p$	$[3/2]^\circ - [5/2]$	3679.56	10100-12300	0.1	0.67				B	4
12.		$[3/2]^\circ - [3/2]$	3665.32	10100-12300	0.1	0.75				B	4
13.		$[3/2]^\circ - [1/2]$	3773.42	10100-12300	0.1	0.71				B	4

Lead

Pb I

Ground State: $1s^22s^22p^63s^23p^63d^{10}4s^24p^64d^{10}4f^{14}5s^25p^65d^{10}6s^26p^2\ {}^3P_0$

Ionization Energy: 7.416 eV = 59819.4 cm^{-1}

The Stark width of the $6p^2\ {}^3P_2 - 6p7s\ {}^3P_1^\circ$ line at 4057.81 Å has been measured with a gas-driven shock tube,[1] which was operated in neon with a small admixture of tetraethyl lead ($Pb(C_2H_5)_2$). The electron density was determined via the Stark width of the hydrogen H_β line, and the temperature was obtained from line-reversal measurements of the hydrogen H_α line as well as from absolute total intensity measurements of the Ne I 5852 Å and the hydrogen H_β lines. Electron densities were varied over a range from 0.5×10^{17} cm^{-3} to 1.3×10^{17} cm^{-3} and temperatures were varied from 10300 K to 12400 K. The line profiles were recorded photographically. The result for the (full) Stark half-width, $w_m = 0.62$ Å, is given for a normalized density of 10^{17} cm^{-3} and a temperature of $T = 11600$ K. An accuracy rating of "D+" is estimated. The comparison with semiclassical theory[2] yields a ratio $w_m/w_{th} = 2.46$.

References

[1] M. H. Miller, R. D. Bengtson, and J. M. Lindsay, Phys. Rev. A **20**, 1997 (1979).

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Lithium

Li I

Ground State: $1s^22s\ ^2S_{1/2}$

Ionization Energy: 5.392 eV = 43487.150 cm^{-1}

The Stark width and shift of the $2s\ ^2S - 2p\ ^2P^\circ$ resonance multiplet at 6707.8 Å was measured with an electromagnetic T-tube.[1] The electron density was determined by single-wavelength laser interferometry (density range from 1.5 to 5.0×10^{17} cm^{-3}) and the temperature was obtained from Boltzmann plots of Ar II line intensities ($T = 15000$ to 26000 K). The T-tube was operated in argon, and lithium was introduced into the plasma in the form of a melted layer of its salt deposited at the end of the expansion tube. The Li impurity was found to be sufficient for detection, but small enough not to cause significant self-absorption. This was checked for analogous cases in some other alkalis by comparing the observed intensity ratios for the two lines of the resonance doublet with the well-known intensity ratios. However, this technique could not be applied to lithum directly, since the two lines—which are only 0.15 Å apart (6707.76 Å and 6707.91 Å)—completely overlap because of the large Stark widths (approx. 0.6 – 2 Å) encountered at the high electron densities of this experiment.

At temperatures of 17500 K and 26000 K, respectively, the following (full) Stark halfwidths were obtained, normalized to an electron density of 10^{17} cm^{-3}: $w_m =$ 0.38 Å and 0.46 Å. The corresponding values for the shifts are $d_m = -0.042$ Å and -0.039 Å. This yields ratios with the semiclassical theory of $w_m/w_{th} = 1.04$ and 1.03; also, of $d_m/d_{th} = 0.86$ and 0.86.

We conservatively estimate the accuracy of the width measurements as "D", since the authors did not perform a direct self-absorption check for Li, and since they provide no indication in their paper that they have considered Doppler or instrumental broadening. Since the shifts are much less influenced by these factors, their accuracy rating is increased to "C+".

Reference

[1] J. Puric, J. Labat, Lj. Cirkovic, I. Lakicevic, and S. Djenize, J. Phys. B **10**, 2375 (1977).

Magnesium

Mg I

Ground State: $1s^22s^22p^63s^2\ ^1S_0$

Ionization Energy: 7.646 eV = 61671.02 cm^{-1}

New measurements for three Mg I lines have recently been reported.[1,2] Two of the lines had been measured[3] with essentially the same experimental apparatus as in Ref. 1 and under similar experimental conditions. As in the previous case,[3] the results of the new experiment[1] are normalized to $N_e = 1 \times 10^{17}$ cm^{-3} and $T = 10000$ K.

Since the previous critical review on Mg I[4] contained a numerical error for the data of Ref. 3, the corrected data for these Mg I lines are listed again here.

References

[1] H. J. Kusch and H. Schweicker, Astron. Astrophys. **53**, 59 (1976).

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[3] V. Helbig and H. J. Kusch, Astron. Astrophys. **20**, 299 (1972).

[4] N. Konjević and J. R. Roberts, J. Phys. Chem. Ref. Data **5**, 209 (1976).

Key data on experiments

Ref.	Plasma source	Method of measurement		Remarks
		Electron density	Temperature	
1	Gas-stabilized high-pressure arc	H_β Stark width, and absolute intensity of hydrogen continuum at 4400 Å	Absolute intensity of H_β and from the intensity ratio of Mg I 4703 Å and Mg II 4481 Å lines	Photographic technique, van der Waals broadening comparable to Stark broadening
2	Wall-stabilized arc	Plasma composition data and absolute intensity of continuum at 4000 Å	Absolute intensity of Ar I 4300 Å and Ar II 4806 Å lines	
3	Gas-stabilized high-pressure arc	Shift of Ar I 4158 Å line, absolute intensity of Mg II lines, and from Ar I continuum at 3600 Å	Absolute intensity of Ar I 3158.6 Å line and from the intensity ratio of Mg I 4703 Å and Mg II 4481 Å lines	Photographic technique, van der Waals broadening comparable to Stark broadening

Numerical results for Mg

No.	Transition array	Multiplet (No.)	Wavelength (Å)	Temperature (K)	Electron density (10^{17} cm^{-3})	w_m (Å)	w_m/w_{th}	d_m (Å)	d_m/d_{th}	Acc.	Ref.
1.	$3s3p$–$3s4d$	$^1P^\circ$ - ^1D (9)	5528.41	10000	1	4.28	0.72	1.88	0.55	D,D+	3
2.	$3s3p$–$3s5d$	$^1P^\circ$ - ^1D (11)	4702.99	10000	1	8.44	0.61	1.98	0.26	D,D+	3
				10000	1	7.2	0.52	1.62	0.21	D,D+	1
3.	$3s3d$–$3p3d$	^1D - $^1F^\circ$ (15 UV)	2915.45	10000	1	0.50		-0.06		D,D	3
				10000	1	0.56		0.29		D,D	1
4.	$3s^2$–$3s3p$	^1S - $^1P^\circ$ (1 UV)	2852.13	12970–13370	1.10–1.28	0.054–0.071	0.51–0.57			B+	2

Mercury

Hg I

Ground State: $1s^22s^22p^63s^23p^63d^{10}4s^24p^64d^{10}4f^{14}5s^25p^65d^{10}6s^2\ ^1S_0$

Ionization Energy: 10.437 eV = 84184.1 cm^{-1}

The only available data source is an experiment in which the Stark constant C_4 for the Hg I 5460.7 Å line has been measured.[1] A cylindrical quartz lamp, filled with 75 mg of Hg and operated at 50 Hz, 8 A, 1500 W was employed, which produced a pure Hg discharge. The electron density was determined from measurements of the absolute continuum intensity at 5000 Å (N_e = 0.02 – 0.12 × 10^{17} cm^{-3}), and the temperature was determined from absolute intensity measurements of the Hg I 5769.6 Å and 4916.0 Å lines (T = 5000–6200 K). Since under these experimental conditions the 5460.7 Å line was optically thick, the C_4 constant was determined by comparing the experimental profile with constructed ones, which were obtained by assuming various values for this constant and for the transition probability. The best fit was obtained for $C_4 = 5 \times 10^{-14}$ cm^{4}s^{-1}.

Although according to the paper "excellent agreement" was obtained between experimental and theoretical profiles, the accuracy for the Stark broadening data is estimated to be no better than "D", for two reasons:

(a) The shape of the self-reversed line profile depends in a complicated way on a large number of parameters, and especially the considerable contribution of van der Waals broadening (the authors estimate that it is 20% of the Stark broadening) is considered only in an approximate manner.

(b) The authors did not attempt to estimate the accuracy of their result.

Using the reported C_4 constant for the Hg I 5460.7 Å line, we have calculated the Stark width for a typical experimental condition ($T_e = 6000$ K and $N_e = 0.1 \times 10^{17}$ cm^{-3}) by using the well-known relation (see, e.g., Ref. 2):

$$\gamma_4 = 38.8\ C_4^{2/3}\ v^{1/3}\ N_e,$$

where γ_4 is the electron-impact total halfwidth in frequency units of the Lorentzian line, and N_e and v are the number density and the mean relative velocity of the electrons. The full Stark width is obtained as $w_m = 0.303$ Å, and the comparison with semiclassical calculations[3] yields a ratio $w_m/w_{th} = 5.68$.

References

[1] J. J. Damelincourt, D. Karabourniotis, L. Scoarnec, and P. Herbert, Proceedings of the Thirteenth International Conference on Phenomena in Ionized Gases, Part I, p. 127, Physical Society of GDR, East Berlin (1977).

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Nitrogen

N I

Ground State: $1s^22s^22p^3\ ^4S^{\circ}_{3/2}$

Ionization Energy: 14.534 eV = 117225.4 cm^{-1}

Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.
1135	1	1199.55	2	1310.95	13	1411.9	6
1143.65	16	1200.22	2	1316.29	12	1492.63	3
1164	10	1200.71	2	1319.00	11	1494.68	3
1166	9	1243.18	5	1319.68	11	1742.73	4
1168	8	1243.31	5	1326.57	15	4935.12	18
1170	7	1310.54	13	1327.92	15	7468.31	17
1177	14						

The wall-stabilized arc was used as the plasma source for two recent experimental studies of the Stark broadening of neutral nitrogen lines in the vacuum UV.[1,2] A number of lines were studied in both experiments and the intercomparison of these data shows good (within ±20%) agreement. The only exception are the results for multiplet No. 11 UV, where the discrepancy is of the order of 40%. Comparisons with semiclassical theoretical data[3] typically show agreement within ±20% for the widths and within ±30% for the shifts.

It should be underlined that most Stark width and shift measurements in Ref. 2 were made with high precision, so that they are useful for plasma diagnostic purposes. In the same paper, the ion contribution to the Stark width has been studied in detail for the N I 1199.55 Å, 1411.94 Å, 1494.67 Å, and 1742.73 Å lines. For the last three lines the measured lineshape asymmetries agree with the theoretically expected ones[3] within the limits of the given uncertainties.

In addition to the preceding experimental papers dealing with VUV lines, in Ref. 4 results for two N I lines in the visible region are reported, for an electron density range from 0.5 to 1.0 × 10^{17} cm^{-3}.

In several cases, two VUV lines in the doublets have practically the same wavelength, as noted in the table. Since these are completely blended, the width measurements pertain to the strong line and any small distorting influence of the weaker component is neglected.

References

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Key data on experiments

Ref.	Plasma source	Method of measurement Electron density	 Temperature	Remarks
1	Wall-stabilized arc	H_β Stark width	Plasma composition data	Line wing measurements and curve-of-growth method used to determine Stark widths
2	Wall-stabilized arc	Plasma composition data	Absolute intensity of Ar II 4806 Å line	
4	Plasma jet	H_α Stark width	Plasma composition data	

Numerical results for N

No.	Transition array	Multiplet (No.)	Wavelength (Å)	Temperature (K)	Electron density (10^{17} cm^{-3})	w_m (Å)	w_m/w_{th}	d_m (Å)	d_m/d_{th}	Acc.	Ref.
1.	$2s^22p^3$-$2s2p^4$	$^4S^\circ$ - ^4P (2 UV)	1135*	12350	0.1	6.2(-4)***				C	1
2.	$2p^3$-$2p^2(^3P)3s$	$^4S^\circ$ - ^4P	1199.55	12350	0.1	1.62(-3)	1.06			C	1
		(1 UV)		11000-15000	1	1.62(-2)	1.05****	0.93(-2)	1.04****	A,A	2
			1200.22	12350	0.1	1.62(-3)	1.06			C	1
				11000-15000	1	1.65(-2)	1.06****	1.03(-2)	1.16****	A,A	2
			1200.71	12350	0.1	1.62(-3)	1.06			C	1
				11000-15000	1	1.62(-2)	1.05****	0.98(-2)	1.10****	A,A	2
3.		$^2D^\circ$ - ^2P	1492.63	12350	0.1	3.40(-3)	1.26			C	1
		(4 UV)		11000-15000	1	3.03(-2)	1.10****	1.55(-2)	0.96****	A,A	2
			1494.68	12350	0.1	3.40(-3)	1.26			C	1
				11000-15000	1	2.96(-2)	1.08****	1.51(-2)	0.94****	A,A	2
4.		$^2P^\circ$ - ^2P	1742.73**	12350	0.1	4.00(-3)	1.08			C	1
		(9 UV)		11000-15000	1	4.23(-2)	1.12****	2.11(-2)	0.95****	A,A	2
5.	$2p^3$- $2p^2(^1D)3s'$	$^2D^\circ$ - ^2D	1243.18**	12350	0.1	1.92(-3)	1.13			C	1
		(5 UV)		11000-15000	1	1.61(-2)	0.94****	1.02(-2)	1.01****	B,A	2
			1243.31**	12350	0.1	1.92(-3)	1.13			C	1
				11000-15000	1	1.82(-2)	1.06****	0.98(-2)	0.97****	B,A	2
6.		$^2P^\circ$ - ^2D	1411.9*	12350	0.1	2.60(-3)	1.20			C	1
		(10 UV)		11000-15000	1	2.64(-2)	1.15****	1.03(-2)	0.76****	A,B+	2
7.	$2p^3$-$2p^2(^3P)3d$	$^2D^\circ$ - ^4F	1170*	12350	0.1	6.80(-3)				C	1
8.		$^2D^\circ$ - ^2F (6 UV)	1168*	12350	0.1	1.20(-2)	2.01			C	1
9.		$^2D^\circ$ - ^4D	1166*	12350	0.1	7.80(-3)				C	1
10.		$^2D^\circ$ - ^2D (7 UV)	1164*	12350	0.1	6.40(-3)	0.95			C	1
11.		$^2P^\circ$ - ^2P	1319.68**	12350	0.1	7.80(-3)	1.06			C	1
		(12 UV)		11000-15000	1	8.64(-2)	1.15****	2.85(-2)	0.67****	B+,B+	2
			1319.00**	12350	0.1	7.80(-3)	1.06			C	1
				11000-15000	1	8.29(-2)	1.10****	3.72(-2)	0.87****	B+,B+	2
12.		$^2P^\circ$ - ^2F	1316.29	12350	0.1	5.20(-3)	0.68			C	1
13.		$^2P^\circ$ - ^2D	1310.54	12350	0.1	8.20(-3)	0.97			C	1
		(13 UV)		11000-15000	1	7.71(-2)	0.85****	3.31(-2)	0.73****	A,A	2
			1310.95**	12350	0.1	8.20(-3)	0.97			C	1
				11000-15000	1	8.38(-2)	0.92****	3.38(-2)	0.74****	A,A	2

Numerical results for N—continued

No.	Transition array	Multiplet (No.)	Wavelength (Å)	Temperature (K)	Electron density (10^{17} cm^{-3})	w_m (Å)	w_m/w_{th}	d_m (Å)	d_m/d_{th}	Acc.	Ref.
14.	$2p^3$-$2p^2(^3P)4s$	$^2D^\circ$ - ^2P	1177*	12350	0.1	1.42(-2)	1.29			C	1
15.		$^2P^\circ$ - ^2P (11 UV)	1327.92**	12350	0.1	7.80(-3)	0.54			C	1
				11000-15000	1	1.33(-1)	0.88****	7.17(-2)	0.88****	A,A	2
			1326.57**	12350	0.1	7.80(-3)	0.54			C	1
				11000-15000	1	1.29(-1)	0.85****	7.07(-2)	0.86****	A,B	2
16.	$2p^3$-$2p^2(^1S)3s''$	$^2P^\circ$ - ^2S	1143.65**	12350	0.1	1.82(-3)				C	1
17.	$2p^23s$-$2p^2(^3P)3p$	^4P - $^4S^\circ$ (3)	7468.31	13500	1	0.82	0.76			B	4
18.	$2p^23s$-$2p^2(^3P)4p$	^2P - $^2S^\circ$ (9)	4935.12	13500	1	1.95	0.78			B	4

*Average wavelength for multiplet.
**Two blended lines in multiplet at this wavelength.
***The number in parentheses following the tabulated value indicates the power of ten by which this value has to be multiplied.
****Ratios taken at 13000 K.

Potassium

K I

Ground State: $1s^22s^22p^63s^23p^64s\ ^2S_{1/2}$

Ionization Energy: 4.341 eV = 35009.77 cm^{-1}

Two experimental papers[1,2] contain essentially the same results. The data from the later publication are used in this analysis, since a more detailed description of the measurements is provided. No estimate for the experimental error of measured Stark broadening parameters is given, however, and there is no discussion of the influence of other broadening mechanisms on the line width; thus it is difficult to assess the accuracy of these data.

References

[1] J. Puric, J. Labat, S. Djenize, and Lj. Cirkovic, "Proceedings of the Twelfth International Conference on Phenomena in Ionized Gases," Part 1, p. 368, North Holland, Amsterdam (1975).
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Key data on experiments

Ref.	Plasma source	Method of measurement: Electron density	Method of measurement: Temperature	Remarks
1,2	T-tube	Laser interferometry at 6328 Å	Boltzmann plot of Ar II line intensities	No correction for Doppler and instrumental broadening reported

Numerical results for K

No.	Transition array	Multiplet (No.)	Wavelength (Å)	Temperature (K)	Electron density (10^{17} cm^{-3})	w_m (Å)	w_m/w_{th}	d_m (Å)	d_m/d_{th}	Acc.	Ref.
1.	$4s$-$4p$	$^2S - {}^2P^\circ$ (1)	7664.90	15000-26000*	1	1.18-1.30**	1.00-0.99	0.27-0.28	0.80-0.89	C,B	1
			7698.96	15000-26000	1	1.05-1.36**	1.05-1.03	0.29-0.32	0.86-1.02	C,B	1

*Temperature range for shift measurements; for width: 20800-26000 K.
**Results are normalized to the electron density 1×10^{17} cm^{-3}.

Rubidium

Rb I

Ground State: $1s^22s^22p^63s^23p^63d^{10}4s^24p^65s\ {}^2S_{1/2}$

Ionization Energy: 4.177 eV = 33690.81 cm^{-1}

The Stark broadening parameters of the rubidium resonance lines were recently determined[1,2] at electron densities from 1.5 to 5×10^{17} cm^{-3} and for a temperature range from 15000 to 26000 K. They are always normalized to an electron density of 1×10^{17} cm^{-3}. It is difficult to judge the accuracy of the data since the authors do not provide uncertainty estimates for their measurements. The measured Stark widths are estimated to be somewhat more uncertain than the shifts since instrumental broadening, which is apparently not considered, may be significant.

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Key data on experiments

Ref.	Plasma source	Method of measurement		Remarks
		Electron density	Temperature	
1,2	T-tube	Laser interferometry at 6328 Å	Boltzmann plot of Ar II line intensities	No correction for instrumental broadening reported

Numerical results for Rb

No.	Transition array	Multiplet (No.)	Wavelength (Å)	Temperature (K)	Electron density (10^{17} cm^{-3})	w_m (Å)	w_m/w_{th}	d_m (Å)	d_m/d_{th}	Acc.	Ref.
1.	$5s$-$5p$	$^2S - {}^2P^\circ$ (1)	7800.27	15000-26000	1	1.66-1.92	1.18-1.12	0.52-0.51	1.14-1.12	C+,B	1
			7947.60	15000-26000	1	1.82-2.20	1.28-1.28	0.55-0.45	1.20-0.99	C+,B	1

Sodium

Na I

Ground State: $1s^22s^22p^63s\ ^2S_{1/2}$

Ionization Energy: 5.139 eV = 41449.44 cm^{-1}

Three experimental studies on the Stark broadening of Na I lines were recently published.[1-4] (Refs. 1 and 2 contain essentially the same results.) In one of the papers,[3] detailed profiles of $3\ ^2P^\circ - n\ ^2D$ (n=4–6) lines, including the forbidden components $3\ ^2P^\circ - n\ ^2F^\circ$, ^2G, are discussed and presented. This experiment was performed with a hot-wall stabilized arc in a sodium-argon mixture at $N_e = 0.042 \times 10^{17}$ cm^{-3} and at T = 4500 K. The experimental profiles were compared by the authors with their own theoretical calculations[3] as well as with other theoretical data.[5,6] It was found that the electron density deduced from their own calculations[3] was 20% larger than the one obtained from older calculations for isolated lines.[5] With other recent calculations,[6] this discrepancy practically disappears for the $3p$–$4d$ line and is reduced to 10% for the $3p$–$5d$ line. However, it should be pointed out that no independent measurement of the electron density was carried out, and only the experimental profile for the $3\ ^2P^\circ - 5\ ^2D$, $^2F^\circ$ transition was graphically presented.[3] Therefore, there are no data from Ref. 3 in the Na I table, and the other two experiments[1,2,4] deal with the resonance multiplet only.

The data of Refs. 1 and 2 were obtained over a wide range of electron densities, $(1.5 - 5.0) \times 10^{17}$ cm^{-3}, but there is no estimate of the experimental uncertainties and no discussion on the contributions of other broadening mechanisms and instrumental broadening to the line width. Thus, it is difficult to estimate the accuracy of these results.

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Key data on experiments

Ref.	Plasma source	Method of measurement Electron density	 Temperature	Remarks
1,2	T-tube	Laser interferometry at 6328 Å	Boltzmann plot of Ar II line intensities	No correction for Doppler and instrumental broadening reported
3	Hot-wall stabilized arc	Stark broadening theory is used for several Na I lines; no measurement independent of Na I Stark broadening is carried out	Boltzmann plot of Na I line intensities	
4	Gas-driven shock tube	Michelson interferometer at 6328 Å and 1.15 μm; Stark width at H_β	Line-reversal technique	

Numerical results for Na

No.	Transition array	Multiplet (No.)	Wavelength (Å)	Temperature (K)	Electron density (10^{17} cm^{-3})	w_m (Å)	w_m/w_{th}	d_m (Å)	d_m/d_{th}	Acc.	Ref.
1.	$3s$–$3p$	$^2S - {}^2P^\circ$ (1)	5889.95	15000–26000	1	0.36–0.46	0.95–0.97	0.112–0.110	0.85–0.87	C+,B	1,2
				7500	1	0.244	0.83			B	4
			5895.92	15000–26000	1	0.37–0.43	0.98–0.91	0.105–0.097	0.79–0.77	C+,B	1,2

Tin

Sn I

Ground State: $1s^22s^22p^63s^23p^63d^{10}4s^24p^64d^{10}5s^25p^2\ {}^3P_0$

Ionization Energy: 7.344 eV = 59231.8 cm^{-1}

The Stark width of the $5p^2\ {}^1S_0 - 5p6s\ {}^1P_1^\circ$ line at 4524.74 Å has been measured with a gas-driven shock tube,[1] which was operated in neon with a small admixture of tetramethyl tin, Sn[CH$_3$]$_4$. The electron density was determined from a measurement of the Stark width of the hydrogen Balmer line H_β, and the temperature was determined from line-reversal measurements of the hydrogen H_α line, as well as from absolute (total) intensity measurements of the Ne I 5852 Å and the hydrogen H_β lines. Electron densities were varied over a range from 0.5×10^{17} cm^{-3} to 1.2×10^{17} cm^{-3} and temperatures covered a range from 9600 K to 12400 K. The line profile for the Sn I 4524.74 Å line was measured photographically and a (full) Stark half-width $w_m = 1.3$ Å was obtained for a normalized electron density of 10^{17} cm^{-3} and a temperature of 11600 K. The comparison with semiclassical calculations[2] yields a ratio $w_m/w_{th} = 2.94$. A "C" accuracy rating is estimated.

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Xenon

Xe I

Ground State: $1s^22s^22p^63s^23p^63d^{10}4s^24p^64d^{10}5s^25p^6\ {}^1S_0$

Ionization Energy: 12.130 eV = 97834.0 cm^{-1}

In all four selected experiments,[1-4] gas-driven shock tubes are used as the plasma source. Ref. 2 contains only shift data. For these measurements the Rozhdestvenskii hook method[5] is used to determine the position of the shifted line in the plasma. References 3 and 4 report essentially the same results, but the latter one is taken for our analysis, since the work is presented in more detail. In this experiment,[4] three different gas-driven shock tubes were employed for three independent experiments. Therefore, whenever different results are reported from the three different shock tube experiments, they are entered separately in the Xe I table. The mutual agreement between these three experiments[4] and the width data from Ref. 1 is within the limits of the estimated experimental errors. The Stark shift results from Ref. 1 are systematically larger than in Ref. 4. This is especially the case with the shift data for the lines 4734.15 Å and 4500.97 Å, where the discrepancy goes up to a factor of two. A possible source of this disagreement may be low spectral resolution of the fiber-optic channels, with spacing of 0.4 Å in first order, in Ref. 1.

In Ref. 4, semiclassical theoretical results are included, which are calculated according to Refs. 6 and 7. Satisfactory agreement between the theoretical Stark widths and the experiment was found except for the lines at $\lambda = 4807$ and 4697 Å.[4] The authors suggest that a redetermination of the oscillator strengths involving interacting levels should improve the agreement between theory and experiment for these two lines. They also found marked differences between the theoretical and experimental shifts for a number of Xe I lines. It is suspected that this is due to the ambiguity arising from taking averages of strongly oscillating phases in the S matrix for close encounters.[4]

No theoretical comparison data are tabulated, since the recent comprehensive calculations for heavy elements[8] were restricted to spectra that follow LS coupling, which is not the case for Xe I.

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Key data on experiments

Ref.	Plasma source	Method of measurement: Electron density	Method of measurement: Temperature	Remarks
1	Gas–driven shock tube	Laser interferometer at 6328 Å and 1.15 μm	Plasma composition data	Self–absorption check: ratio of line center and continuous background
2	Gas–driven shock tube	Two–wavelength interferometry	Plasma composition data	Shift measurements only
4	Gas–driven shock tube	Laser interferometry and H_β Stark width	Plasma composition data and line–reversal method	Photographic technique

Numerical results for Xe

No.	Transition array	Multiplet (No.)	Wavelength (Å)	Temperature (K)	Electron density (10^{17} cm^{-3})	w_m (Å)	w_m/w_{th}	d_m (Å)	d_m/d_{th}	Acc.	Ref.
1.	$6s$–$6p$	$[3/2]^\circ - [5/2]$	9045.45	8000–10000	0.30–0.87			0.41–1.18		C	2
			8819.41	8000–10000	0.30–0.87			0.55–1.52		C	2
2.		$[3/2]^\circ - [3/2]$	8952.25	8000–10000	0.30–0.87			0.51–1.44		C	2
			8231.64	8000–10000	0.30–1.14			0.44–1.58		C	2
3.		$[3/2]^\circ - [1/2]$	8280.12	8000–10000	0.30–1.15			0.33–1.22		C	2
4.	$6s$–$6p'$	$[3/2]^\circ - [3/2]$	4734.15	9000– 8100	1	1.42[a]		0.28[a]		C,C	1
				10000	1	1.2				C	4
				10000	1	1.01				B	4
				10000	1	1.21		0.14		B,B	4
			4524.68	10000	1	1.1				C	4
				10000	1	0.82		0.23		B,B	4
5.		$[3/2]^\circ - [1/2]$	4500.97	9000– 8200	1	1.46[b]		0.343[b]		C,C	1
				10000	1	1.4				C	4
				10000	1	1.28				B	4
				10000	1	1.34		0.18		B,B	4

Numerical results for Xe—continued

No.	Transition array	Multiplet (No.)	Wavelength (Å)	Temperature (K)	Electron density (10^{17} cm^{-3})	w_m (Å)	w_m/w_{th}	d_m (Å)	d_m/d_{th}	Acc.	Ref.
6.	6*s*–7*p*	$[\frac{3}{2}]^\circ - [\frac{5}{2}]$	4697.02	10000	1	5.5				C+	4
			4671.23	9000- 7800	1	6.68^c		2.43^c		C,C	1
				10000	1	5.7				C+	4
				10000	1	5.34				B	4
				10000	1	5.57		1.9		B,B	4
7.		$[\frac{3}{2}]^\circ - [\frac{3}{2}]$	4843.29	10000	1	6.9				C	4
			4829.71	8900- 8000	1	4.76^d		2.80^d		C,C	1
			4624.28	9000- 8000	1	8.20^e		2.14^e		C,C	1
				10000	1	6.8				C+	4
				10000	1	6.46				B	4
				10000	1	6.94		1.4		C + ,C	4
8.		$[\frac{3}{2}]^\circ - [\frac{1}{2}]$	4807.02	10000	1	3.78		0.9		B,C	4

*Results taken in electron density range: a (0.46–1.14)×10^{17}, b (0.53–1.09)×10^{17}, c (0.36–1.16)×10^{17}, d (0.40–1.02)×10^{17}, and e (0.41–1.12)×10^{17} cm^{-3}.

Zinc

Zn I

Ground State: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 \ {}^1S_0$

Ionization Energy: 9.394 eV = 75768.10 cm^{-1}

An experiment[1] was recently performed with a pulsed discharge, where the measurements of Zn I Stark profiles were carried out in the presence of strong self-absorption. In order to derive Stark halfwidths from the experimental line shapes, the authors had to make numerous theoretical assumptions. For this reason we estimate that the uncertainties of these data are rather large.

The results of Ref. 3, already listed in the previous critical review,[4] are presented again with comparisons to new semiclassical results.[5]

The line at 3345.02 Å is blended with two other lines of the same multiplet at 3345.57 Å and 3345.93 Å; also, the line at 3302.58 Å has a similar blend at 3302.94 Å. While these lines are considerably weaker than the listed lines (see Ref. 6, part II, for the pertinent transition probabilities), they may distort the measured line shapes and tend to make them appear broader; this has not been considered in Ref. 3.

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Key data on experiments

Ref.	Plasma source	Method of measurement		Remarks
		Electron density	Temperature	
1	Wall-stabilized pulsed discharge	H_β Stark width	Absolute intensity of stronger maximum of self-absorbed line[2]	Photographic technique; numerous theoretical assumptions made in order to derive Stark widths from experimental line shape measurements
3	Pulsed discharge	H_β Stark width	Plasma composition data	Photographic technique

Numerical results for Zn

No.	Transition array	Multiplet (No.)	Wavelength (Å)	Temperature (K)	Electron density (10^{17} cm^{-3})	w_m (Å)	w_m/w_{th}	d_m (Å)	d_m/d_{th}	Acc.	Ref.
1.	4*s*4*p*–4*s*5*s*	$^3P^\circ - ^3S$ (2)	4810.53	11000	4.5	0.92	0.40			D+	1
				11000	1.0	1.65	3.25			D	3
			4722.15	11000	4.5	1.20	0.52	0.78	0.69	D+,C	1
				11000	1.0	1.57	3.09			D	3
			4680.14	11000	4.5	1.29	0.56			D+	1
				11000	1.0	0.84	1.66			D	3
2.	4*s*4*p*–4*s*4*d*	$^3P^\circ - ^3D$ (4)	3345.02*	11000	1.0	1.74	2.66			D	3
			3302.58*	11000	1.0	1.40	2.14			D	3
			3282.33	11000	1.0	0.91	1.39			D	3
3.	4*s*4*p*–4*s*6*s*	$^3P^\circ - ^3S$ (5)	3072.06	11000	1.0	0.70	0.65			D	3
			3035.78	11000	1.0	0.61	0.57			D	3
			3018.36	11000	1.0	0.56	0.52			D	3
4.	4*s*4*p*–4*s*5*d*	$^3P^\circ - ^3D$ (5 UV)	2800.9*	11000	1.0	1.96	0.39			D	3
			2770.9*	11000	1.0	2.49	0.50			D	3
			2756.45	11000	1.0	1.27	0.25			D	3

*Blended within multiplet.