High-Pressure Noble Gas Broadening of the Cs Resonance Lines

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The noble gas broadening (Ar and Kr) of the Cs resonance lines 8944 and 8521 Å ($6^2S_{1/2}-6^2P_{1/2,3/2}$) was measured in absorption up to perturber pressures of about 20 atm. The experimental shapes of the 8944 Å line induced by multiperturber interaction are compared with theoretical shapes calculated by means of the quasistatic theory assuming additivity of the $A^2\Pi_{1/2}-X^2\Sigma_{1/2}$ difference potential energies.

1. Introduction

While the high density behaviour of spectral line cores has periodically been revisited in the last decades (for references see [1]), the interest in high density effects in the statistical wings grew significantly when Hindmarsh and Farr [2] postulated multiperturber satellites in the far wings due to extrema in the difference potentials composed of scalarly additive multiple atom-perturber interaction. In subsequent papers McCartan and Hindmarsh [3] and McCartan and Farr [4] reported the observation of secondary satellites in the red wings of noble gas broadened K and Na lines which arise because of extrema in the difference potentials of the alkali-NG_2 (NG: noble gas) molecules. In accordance with the prediction the positions of the secondary satellites were found to be twice the wavelength separation of the first satellites from the line centres. Further papers of other groups [5–8] dealed with the pressure dependence of multiperturber satellites and line wings. There are theoretical approaches based on the Anderson-Talman theory [9] to describe the shapes of spectral lines [10–13], where straight-line perturber trajectories, adiabatic potentials and scalarly additive interaction is assumed. Other theories [14, 15] are based on the same assumptions.

The most advanced experiments and theoretical descriptions have been published by Kielkopf and Allard [16, 17] and by West et al. [18, 19]. Kielkopf and Allard studied the high-pressure effect of Xe gas on the Cs 6S-7P, -8P and -9P absorption transitions, while West et al. were interested in the high-density effect of Kr and Xe on the Na D lines. Kielkopf and Allard used parametrized potentials which were fitted to the observed line wings, West et al. took into account interaction potentials which had been determined before from the temperature dependence of the far-wing data at low perturber pressures.

In our high-pressure perturber gas experiment the subjects of interest are the Cs resonance lines. The noble gases Ar and Kr are applied. We will compare the experimental line shapes with line wings calculated in the quasistatic approach, to see how useful the simple quasistatic theory is in the high-pressure case. The advantage in using the Cs resonance lines is obvious. Because the lines have a large fs splitting ($\Delta E_{fs} = 554\ cm^{-1}$) we can investigate the multiperturber effects in the wings in a large wavelength range without having overlap of the fs component. There is only one excited state potential ($A^2\Pi_{1/2}$) which together with the $X^2\Sigma_{1/2}$ ground state potential is responsible for the formation of the shape of the $6^2S_{1/2}$-$6^2P_{1/2}$ line at 8944 Å (see [28], preceding paper). We will assume the ground and excited state potentials to be scalarly additive in a multiatomic molecule $CsNG_n$ with $n \geqq 2$. As pointed out by Baylis [20] this assumption is right for the spherically symmetric $X\Sigma$ state while for a Π state the fs-splitting ΔE_{fs} of the P level has to be much smaller than the sum of the interaction energies $\sum_i V_i(r)$. The latter condition is not fulfilled for the 8944 Å line. On the other hand, Kielkopf and Allard have shown in their paper on the multiple satellite structure in the wings of the

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Cs 6S-9P doublet, where $\Delta E_{fs} > \sum_i V_i(r)$, that the additivity of the interaction is a useful approximation. The noble gas broadening of the $6^2S_{1/2}$-$6^2P_{3/2}$ line at 8521 Å is due to transitions from the ground state potential to two excited state potentials ($A^2\Pi_{3/2}$ and $B^2\Sigma_{1/2}$, see [28]). Here the assumption of additive interaction should be less adequate because the excited Π and Σ potentials are not additive [20]. Different from the investigations of Kielkopf and Allard we will use theoretical pseudopotentials [21, 22] in our calculations of the high-pressure broadening of the line wings. The theoretical potentials have been tested by measuring the statistical wings of the Cs resonance lines at low noble gas densities and comparing the data with quasistatic wings calculated from the potentials [28]).

It should be noted that, besides the basic interest in multiperturber effects, there is some interest with respect to excimer or exciplex systems which are used as laser media. The high pressures in the laser media require the consideration of multi-perturber interactions [23].

2. Experiment

The experimental set-up is the same as described in the preceding paper on the low-pressure noble gas broadening of the Cs resonance lines. Only the glass absorption cell was replaced by a stainless steel tube (length $L = 10$ cm) with sapphire windows which were sealed by commercial sealing rings (Parker Seal Mark II) to the steel cell. The cell was filled with pure Cs metal and high-purity noble gas and closed by a backable valve. The noble gas pressure was measured with a high-precision manometer (1% uncertainty). The cell was homogeneously heated in a cylindrical copper oven. To prevent the sapphire windows from being covered with Cs metal, they were locally heated to temperatures somewhat higher than the ambient temperature. The Cs number density was determined optically from the total absorption of higher-lying optically thin principal series lines. Taking into account experimental oscillator strengths [24] the particle density [Cs] was determined from the well-known relation $\int k_\lambda L \, d\lambda = (\pi e^2 \lambda^2 L [\mathrm{Cs}] f/(m c^2)$. The measured densities agree within 20–30% with the densities calculated from the vapour pressure formula of Taylor and Langmuir [25].

3. Experimental Results

In Figs. 1–6 we present our experimental results. In Figs. 1 and 4 we have plotted the reduced absorption coefficients $k/N_{Cs}N_{NG}$ of the 8944 Å line against the wavelength distance $\Delta\lambda$ from the unperturbed line centres. The perturber pressures were varied in a wide range (Ar: 700 Torr – 20.6 atm.; Kr: 700 Torr – 11 atm.). In Figs. 2 and 3 and Figs. 5 and 6 the reduced absorption coefficient of the central and the far wing regions of the 8521 Å line broadened by the two noble gases are displayed. Even in the far wings the uncertainty of the given data is estimated to be not larger than 30%. The main contribution to the uncertainty is due to the uncertainty in the Cs number density determination (see above). Systematic errors due to the overlap of the far wings of the 8521/8544 Å doublet have only to be taken into account for the highest perturber pressures and should be less than 10–15%.

We see in Fig. 1 (8944 Å line perturbed by Ar) a red shift and a decrease of the maximum of the line with increasing Ar density. This is a typical dependence observed for both resonance lines perturbed by Ar and Kr. While the reduced absorption coefficient in the red wing is increasing with the perturber density it decreases in the blue wing. The far red wing ($\Delta\lambda > 30$ A) was found to vary only little with N_{Ar}. Note that the blue satellite at about −12 Å disappears if N_{Ar} is increasing. This is an indication that one-perturber contributions become smaller with increasing noble gas density. The density dependence of the central part of the 8521 Å line, shown in Fig. 2, is similar to that of the 8944 Å line. It is interesting that the far blue satellite of this line is shifting towards longer wavelengths. Within the limits of uncertainty this shift is the same as the shift of the line maximum.

In Fig. 4 we can see a faint secondary satellite on the red wing of the 8944 Å line broadened by 700 Torr of Kr gas ($N_{Kr} = 2.29 \times 10^{19}$ cm^{-1}). The distance from the line centre is about twice the separation of the first red satellite at about +9 Å. With increasing Kr pressure the satellite structure disappears although the wing intensity increases in the relevant region. As already pointed out in the preceding paper there is no statistical blue wing of the 8944 Å line broadened by Kr.

In the case of the Kr broadened 8521 Å line, where the one-perturber red satellite has a larger distance from line centre than for the 8944 Å line, a

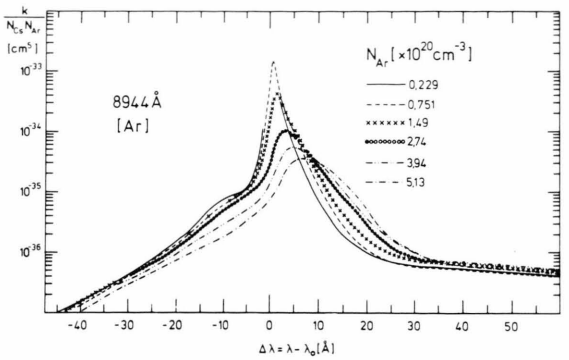


Fig. 1. The reduced absorption coefficient $k/N_{Cs}N_{Ar}$ of the Ar broadened 8944 Å line plotted against the wavelength difference from the unperturbed line centre.

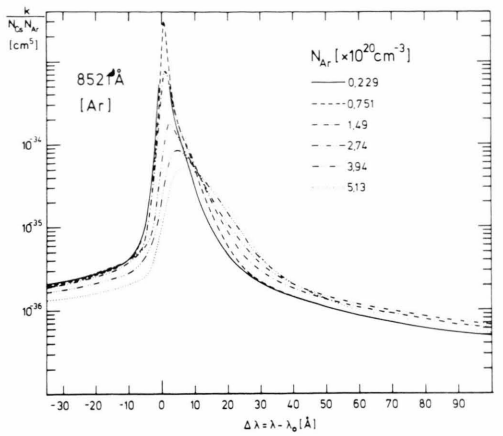


Fig. 2. The central part of the Ar broadened 8521 Å line. Plot of the reduced absorption coefficient against the wavelength separation from the unperturbed line centre.

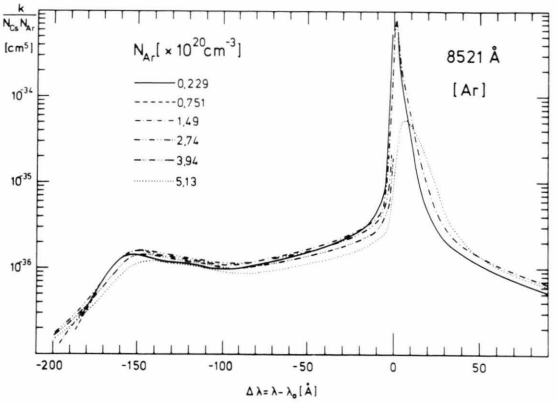


Fig. 3. The far wing region of the Ar broadened 8521 Å line.

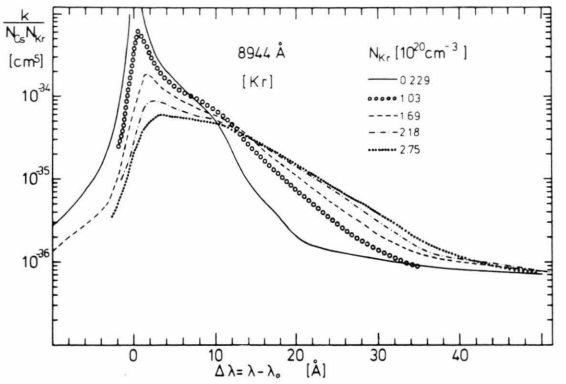


Fig. 4. The reduced absorption coefficient $k/N_{Cs}N_{Kr}$ of the Kr broadened 8944 Å line plotted against the wavelength difference from the unperturbed line centre.

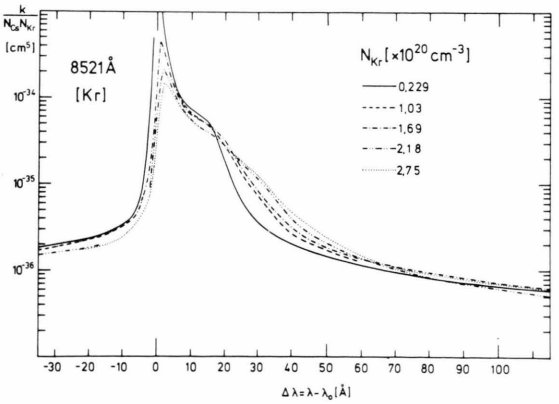


Fig. 5. The central part of the Kr broadened 8521 Å line. Plot of the reduced absorption coefficient against the wavelength separation from the unperturbed line centre.

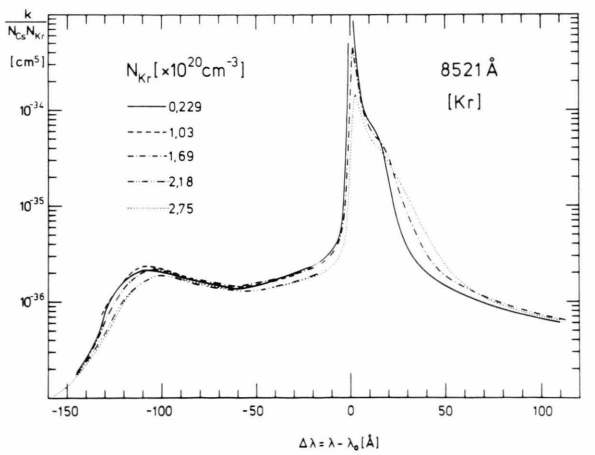


Fig. 6. The far wing region of the Kr broadened 8521 line.

secondary satellite could not be observed at a perturber pressure of 700 Torr ($N_{Kr}=2.29\times10^{19}\,cm^{-3}$). As found for Cs-Ar the strong blue satellite of the 8521 Å line is shifting towards longer wavelengths with increasing perturber density (Figure 6).

4. Calculation of the Multiperturber Effect in the Wings of the 8944 Å Line

As already mentioned above we will assume scalar additivity of the adiabatic interaction potentials in the $CsNG_n$ molecule, having in mind that it is not quite correct for the excited $A^2\Pi_{1/2}$ state [20]. The procedure for the calculation of a quasistatic multiperturber profile is discussed in detail by West et al. [18].

The total density of absorbing species $[Cs]_t$ is given by

$$[Cs]_t = [Cs] + [CsNG] + [CsNG_2] + [CsNG_3] + \ldots , \quad (1)$$

where [Cs] is the free number density of Cs and $[CsNG_n]$ is the density of the quasimolecules with n perturbers inside a certain interaction radius r_0 around the Cs atoms. In our case the parameter r_0 was chosen near to the Weisskopf radius (about 11–12 Å).

The absorption coefficient $k(\Delta\bar{\nu})$ in the quasistatic wings is proportional to the total probability $P_t(\Delta\bar{\nu})$ that the perturber atoms cause a shift $\Delta\bar{\nu}=\bar{\nu}-\bar{\nu}_0$ ($\bar{\nu}_0$ is the wavenumber of the unperturbed line centre). The normalization factor is given by the Ladenburg equation

$$\int k(\bar{\nu})\,d\bar{\nu} = (\pi e^2/m c^2)\,[Cs]\,f = C . \quad (2)$$

$P_t(\Delta\bar{\nu})$ can be derived from the sum of the partial probabilities $P_1(\Delta\bar{\nu})$, $P_2(\Delta\bar{\nu})$, $P_3(\Delta\bar{\nu}), \ldots$, where $P_n(\Delta\bar{\nu})$ is the probability that n perturbers produce a shift of $\Delta\nu_n$. As outlined in the preceding paper (see formula (3) in the preceding paper) the position probability of the nearest perturber atom $W(r)\,dr$ which is proportional to $P_1(\Delta\bar{\nu})\,d(\Delta\bar{\nu})$ is given by

$$W(r)\,dr = 4\pi r^2\,[NG]\exp(-\Delta V_1/kT)\,dr , \quad (3)$$

where $\Delta V_1(r)$ is dissociation energy of the lower potential. Putting the exponential factor

$$\exp(-\Delta V_1(r)/kT) \cong 1 ,$$

the integration of the position probability between the limits $r=0$ and the cut-off parameter r_0 yields

$$\int_0^{r_0} W(r)\,dr = 4\pi r_0^3\,[NG]/3 . \quad (4)$$

With the normalisation $\int_0^{r_0} W(r)\,dr = 1$ a position probability $W'(r)\,dr$ for the nearest perturber inside r_0 can be found

$$W'(r)\,dr = (3r^2/r_0^3)\exp(-\Delta V_1(r)/kT) . \quad (5)$$

Using the relation $P_1(\Delta\bar{\nu})\,d(\Delta\nu) = W'(r)\,dr$ we find for $P_1(\Delta\bar{\nu})$

$$P_1(\Delta\bar{\nu}) = [(3r^2)/(r_0^3\,|\,d(\Delta\bar{\nu})/dr\,|)] \cdot \exp(-\Delta V_1(r)/kT) , \quad (6)$$

with $|\,d(\Delta\bar{\nu})/dr\,| = |\,dV(r)/dr\,|/hc$. $V(r)$ is the difference of the upper and lower state potentials.

For the calculation of $P_2(\Delta\bar{\nu})$ we have to perform the convolution

$$P_2(\Delta\bar{\nu}) = \int P_1(\Delta\bar{\nu}')\,P_1(\Delta\bar{\nu}-\Delta\bar{\nu}')\,d(\Delta\bar{\nu}') . \quad (7a)$$

For three perturber atoms the probability is

$$P_3(\Delta\bar{\nu}) = \int P_2(\Delta\bar{\nu}')\,P_1(\Delta\bar{\nu}-\Delta\bar{\nu}')\,d(\Delta\bar{\nu}') , \quad (7b)$$

or generalized for n perturbers

$$P_n(\Delta\bar{\nu}) = \int P_{n-1}(\Delta\bar{\nu}')\,P_1(\Delta\bar{\nu}-\Delta\bar{\nu}')\,d(\Delta\bar{\nu}') . \quad (7c)$$

$P_n(\Delta\bar{\nu})$ should satisfy

$$\int P_n(\Delta\bar{\nu})\,d(\Delta\bar{\nu}) = 1 \quad \text{and} \quad P_0(\Delta\bar{\nu}) = \delta(\Delta\bar{\nu}) . \quad (8a, 8b)$$

The partial probabilities have to be weighted by the probabilities A_n to find n noble gas atoms within the volume $(4\pi r_0\,[NG])/3$ and to be summed up to find the total probability

$$P_t(\Delta\bar{\nu}) = \sum_{h=0}^{\infty} A_n P_n(\Delta\bar{\nu}) \quad (9)$$

with

$$\int P_t(\Delta\bar{\nu})\,d(\Delta\bar{\nu}) = 1 .$$

Introducing A_n which is given by the Poisson distribution [26]

$$A_n = \exp(-\tau)\,\tau^n/n! , \quad \text{with} \quad \tau = (4\pi r^3\,[NG])/3 , \quad (10)$$

and taking into account the normalization by the Ladenburg equation the absorption coefficient in

the quasistatic wings is given by

$$k(\Delta\bar{\nu}) = CP_1(\Delta\bar{\nu}) = C\exp(-\tau)\sum_{n=0}^{\infty} P_n(\Delta\bar{\nu})\,\tau^n/n!\,. \qquad (11)$$

We would like to note that formula (11) yields the reduced absorption coefficient for the one-perturber case (equation (6) in the preceding paper) if P_n with $n \geqq 2$ can be neglected.

In our treatment we will neglect the interaction among the noble gas atoms which becomes important for small interatomic separation [18].

5. Comparison of the experimental and calculated line wings

a) Cs-Ar

In Fig. 7 we display as a full curve the difference potential $A^2\Pi_{1/2} - X^2\Sigma_{1/2}$ of the CsAr molecule as calculated by Pascale and Vandeplanque [22]. In the preceding paper the observed wings of the 8944 Å line broadened by Ar were found to be in reasonable agreement with quasistatic wings calculated from this difference potential. Only the position of the blue satellite (maximum in the difference potential curve) was slightly different. Inserting

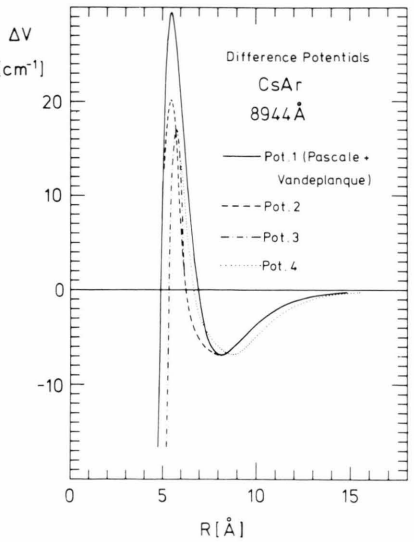
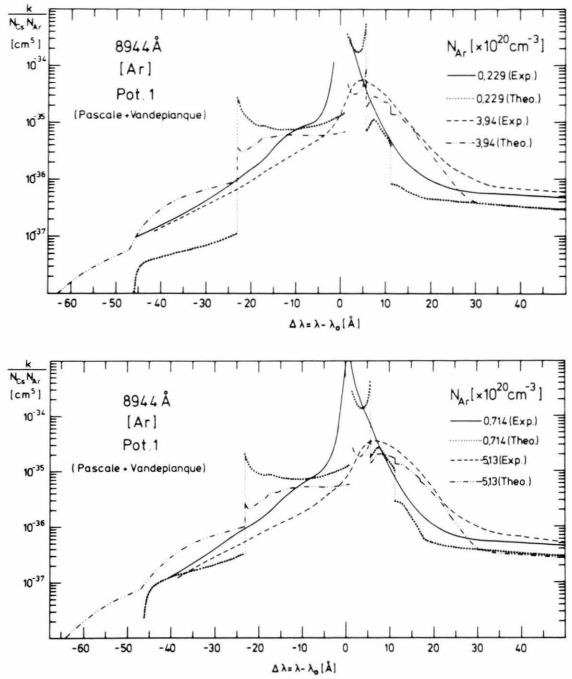


Fig. 7. The difference potential $A^2\Pi_{1/2} - X^2\Sigma_{1/2}$ of the CsAr molecule. Potential 1 is the difference potential of Pascale and Vandeplanque [22]. The potentials 2–4 are modified difference potentials.



Figs. 8 and 9. Comparison of the experimental and theoretical quasistatic wings of the 8944 Å line broadened by Ar. The theoretical wings are calculated with the potentials of Pascale and Vandeplanque.

the difference potential data of Pascale and Vandeplanque we derived the quasistatic multiperturber wings which are shown together with the experimental data in Figs. 8 and 9.

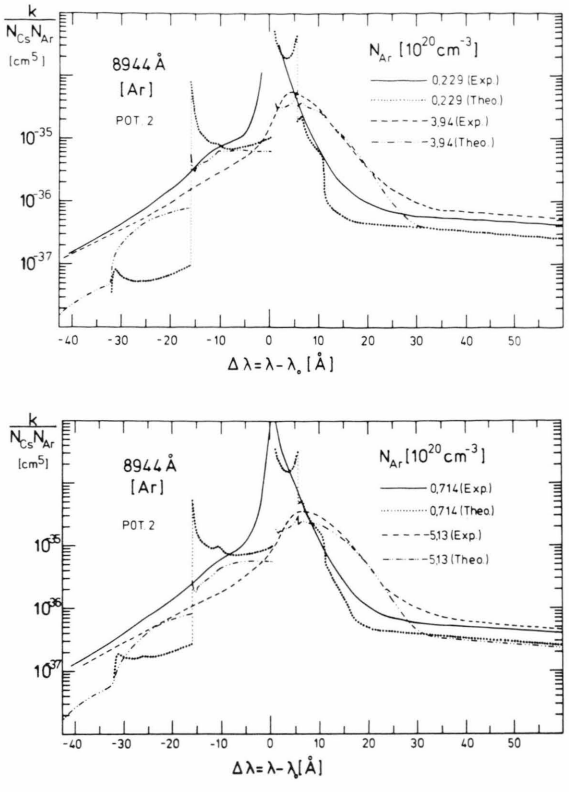
The calculation was performed with a small Basic-computer. In most cases the one-perturber profiles $P_1(\Delta\bar{\nu})$ were introduced in step widths of 0.5 cm^{-1}. It was checked that smaller step widths did not alter the quasistatic multiperturber profiles significantly, except the quasistatic satellite structures which are not correctly described anyway. The large steps widths led to multiperturber profiles with multiperturber satellites which are no distinct singularities as can be found in the one-perturber profiles. This can be seen in Figs. 8 and 9 at + 12 or − 14 Å where secondary satellites arise. The absence of sharp satellites is no disadvantage because they are smeared out anyway as discussed in the preceding paper on low-pressure noble gas broadening of the Cs resonance lines.

Due to the quasistatic approach the theoretical absorption coefficient in a one-perturber wing just beyond a satellite is underestimated. Of course, this

uncertainty propagates in calculating a multiperturber wing. But we will see that the strength of multipertuber satellites is relatively small compared with the absorption coefficients of the underlying line wing. Therefore the uncertainties in the theoretical data just beyond multiperturber satellites is less severe than for a one-perturber satellite. Up to seven perturber atoms were taken into account. For the highest experimental perturber densities convergence of the computed wing data was reached for four to five perturbers depending on the kind of the perturber. Here we would like to note that the assumption of negligible interaction between up to five noble gas atoms within an interaction radius of about 12 Å around a Cs atom may introduce some uncertainty in the high-pressure wing data.

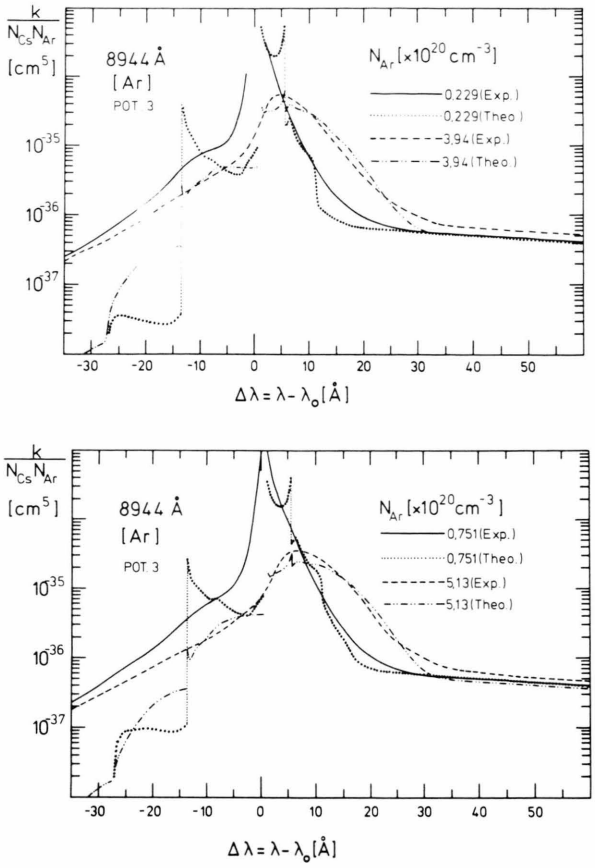
Let us start the comparison between the experimental and calculated quasistatic wings with the lowest Ar perturber pressure 700 Torr which corresponds to a density of $2.29 \times 10^{19}\,\mathrm{cm}^{-3}$. We see from the theoretical quasistatic wing (dotted wing in Fig. 7) that even for this low density multiperturber effects have to be taken into account. In the preceding paper these effects have been neglected. The features beyond the first red satellite up to the secondary satellite at about + 12 Å and the theoretical wing beyond the blue satellite at about − 23 Å are due to the perturbation by two Ar atoms. There is even a faint indication of a three perturber feature beyond the secondary red satellite. The very weak bump at about − 18 Å is also a secondary satellite. It arises if the distance between the Cs atom and one Ar perturber is about 8 Å and between the Cs atom and a second Ar perturber about 5.5 Å. At 8 and 5.5 Å the difference potential of Pascale and Vandeplanque (full curve in Fig. 7) has a minimum ($\Delta V \approx -7\,\mathrm{cm}^{-1}$) and a maximum ($\Delta V \approx +29.5\,\mathrm{cm}^{-1}$), respectively. In the one-perturber line wings the minimum and the maximum produce one red and one blue satellite at about $\Delta\lambda = +5.5$ Å and $\Delta\lambda = -23.5$ Å, respectively (see Figure 8). The scalar addition of the difference potential energies -7 and $+29.5\,\mathrm{cm}^{-1}$ result in $+22.5\,\mathrm{cm}^{-1}$ which corresponds to about $\Delta\lambda = -18$ Å in the wavelength scale. Here a secondary satellite arises in the blue quasistatic two-perturber wing.

With increasing density [Ar] the contributions by two, three and more perturbers increase compared to the one perturber contribution. At higher densities even the two perturber contribution to the line profile is decreasing with [Ar]. It should be noted that even five perturbers have to be taken into account in some regions of the wings.



Figs. 10 and 11. Comparison of the experimental and theoretical quasistatic wings of the 8944 Å line broadened by Ar. The theoretical wings are calculated with the difference potential 2.

Except for the far region ($\Delta\lambda \geqq 30$ Å) the pressure dependence of the wing is reasonably described by the quasistatic theoretical multiperturber wings. The agreement would be even better if we had allowed for the shift of the satellites which is the same as for the line centre [27]. The far red wing results from transitions at small interatomic distance and shows a relatively weak dependence on the perturber density. The pressure dependence of the blue wing is less satisfactory described by the theoretical quasistatic multiperturber wings. As already pointed out in the preceding paper the theoretical position of the one-perturber blue satellite is not in line with observation. Furthermore, the theoretical reduced absorption coeffi-



Figs. 12 and 13. Comparison of the experimental and theoretical quasistatic wings of the 8944 Å line broadened by Ar. The theoretical wings are calculated with the difference potential 3.

cients are larger than the experimental data. Therefore we have modified the difference potentials by Pascale and Vandeplanque. We have changed the height of the maximum (position of the blue satellite), leaving the interatomic distance of the maximum unchanged. The modified potential (potential 2) is shown as a dashed curve in Figure 7. In Figs. 10 and 11 we compare the calculated multiperturber wings based on potential 2 with the experimental line shapes. Now the position of the blue one-perturber satellite is better adjusted; but the absorption coefficient is still too large in the region of the blue satellite. With increasing perturber density the strength of the blue one-perturber satellite decreases while in the far blue wing the change with pressure is much smaller. This is mainly due to the increase of two- and three-perturber contributions. To get a better agreement between the experimental and theoretical far red wings ($\Delta\lambda > 30$ Å) we have modified the difference potential a second time by changing the position of the steep increase of the potential energy at small interatomic separation (about 5 Å). Moreover, the height of the maximum was lowered once more. Additionally the position of the maximum was shifted slightly to a larger separation. As expected the absorption coefficients of the calculated far red wings are now larger than before and in better agreement with the experimental wings (see Figs. 12 and 13). On the other hand, the absorption coefficients in the theoretical blue wings are much smaller than the experimental data beyond the one-perturber satellite.

The theoretical wings based on the potential 4 (see Fig. 7) are not shown here. The difference between the experimental and theoretical wings is larger than for potential 3.

b) Cs-Kr

For the calculation of the quasistatic multiperturber line wings of the 8944 Å line due to Kr we have used the pseudopotentials of Baylis [21]. Baylis'

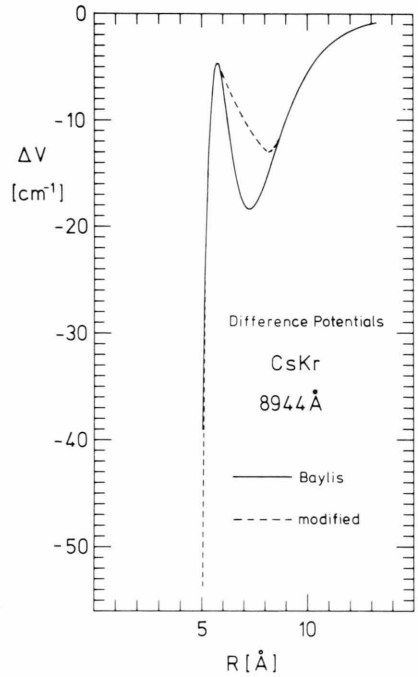
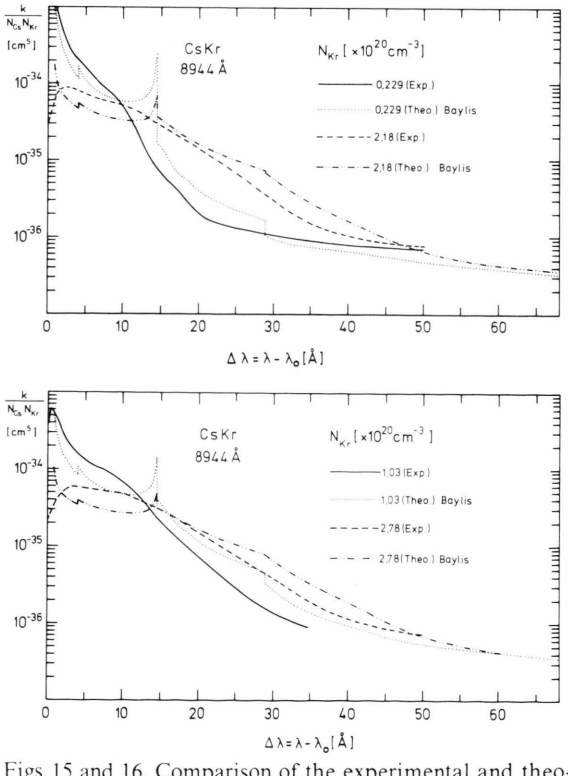
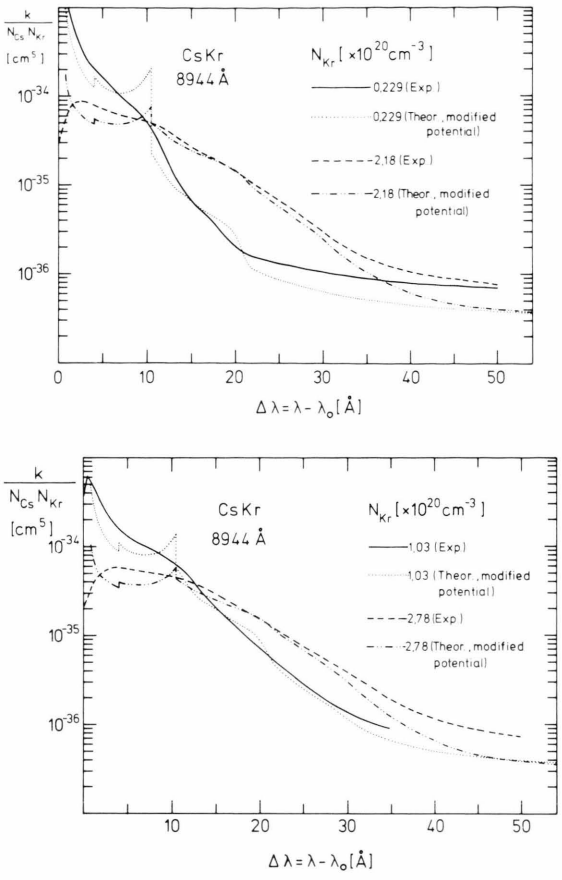


Fig. 14. The difference potential $A^2\Pi_{1/2} - X^2\Sigma_{1/2}$ of the CsKr molecule. The full curve is the difference potential of Baylis [21]. The dashed curve is a modified potential.

difference potential $A^2\Pi_{1/2} - X^2\Sigma_{1/2}$ is shown as a full curve in Figure 14. In Figs. 15 and 16 we display the calculated multiperturber wings together with the experimental data. As already discussed in the preceding paper, the position of the theoretical one-perturber satellite at about +14 Å is more apart from the line centre than the experimental one. The predicted one-perturber satellite at about +3.6 Å, due to a maximum in the difference potential, could not be observed. Because the theoretical position of the one-perturber satellite at +14 Å is wrong, the position of the secondary satellite which can be observed at a Kr perturber density of $2.29 \times 10^{19}\,cm^{-1}$ at about +18 Å (see Fig. 15) is also predicted too far from the line centre (at about +28 Å). Furthermore, we notice the larger theoretical reduced absorption coefficients compared with the experimental values in the region beyond the one-perturber satellite at +14 Å. It is interesting to demonstrate again the general behaviour of the quasistatic wings on the perturber density. While the one-perturber contributions to the line wing (e.g. the one-perturber satellites) decrease with the Kr density, the two- and more-perturber contributions increase. But this does not mean necessarily that, for example, the secondary satellites should be more pronounced in the spectrum if the density is higher. For the 8944 Å line broadened by Kr the three- and more-perturber contributions – up to 5 perturber have been included in the calculations – are significant in the region of the secondary satellite at +28 Å. As can be seen in Figs. 15 and 16, the relative strength of this satellite in comparison with the wing background becomes smaller with increasing Kr density. We would like to warn to predict the strengths of secondary satellites by taking only into account a second perturber atom and neglecting the contributions by three- and more-perturber interactions.



Figs. 15 and 16. Comparison of the experimental and theoretical quasistatic wings of the 8944 Å line broadened by Kr. The theoretical quasistatic wings are calculated with the potentials of Baylis.



Figs. 17 and 18. Comparison of the experimental and theoretical quasistatic wings of the 8944 Å line broadened by Kr. The theoretical wings are calculated from the modified difference potential shown in Figure 14.

To get a better fit to the experimental wings we have modified Baylis' difference potential by changing the height and the position of the minimum which is responsible for the detectable one-perturber satellite (dashed potential in Fig. 14). The comparison between the experimental and theoretical profiles is shown in Figs. 17 and 18. Except for the far red wing which arise from transitions at small interatomic separation around 5 Å the general dependence of the wing intensities is well described in consideration of the crude quasistatic approximation. Agreement in the far wing could be achieved by shifting the maximum and the rapid fall-off in the difference potential at about 5.8 and 5 Å, respectively, slightly towards larger interatomic values, as demonstrated for the Cs-Ar system. The reason why the secondary satellite is not presented as a sharp step in the calculated wing can be found in the large step width of 0.5 cm^{-1} for the one-perturber profile which was used in the calculation.

6. Conclusions

We have measured in absorption the multiperturber broadening of the Cs D lines by Ar and Kr up to noble gas pressures of 20.6 and 11 atm., respectively. Theoretical line wings have been calculated on the assumption of scalarly additive interaction for the Cs D1 line using the very simple quasistatic theory. As for the low-pressure broadening we have found that the general dependence of the absorption coefficient in the line wings on the perturber density can be described by this crude approximation, if the used difference potentials have been checked first in a low-pressure experiment. It has been shown that small ad hoc changes in the difference potentials affect strongly the theoretical multiperturber line shapes. We are aware that in particular the near regions beyond the satellites are not described properly. Here and for the region of the line centre the "unified theory" of Szudy and Baylis [27] should be used in a next step. It is likely that the agreement between observed and theoretical line shapes would be better. But we think that as long as no better theoretical potentials are available one should renounce of this more extensive calculations. In any case, for getting a rough impression how the intensities in the line wings are changing in dependence on the perturber density the quasistatic approach should be a useful method.

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