

Electronic Polarizabilities of the Alkali Atoms*

R. M. STERNHEIMER

Brookhaven National Laboratory, Upton, New York

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The electronic dipole polarizabilities α_d of the alkali atoms have been calculated by a method in which the inhomogeneous Schrödinger equation for the dipole perturbation $u_1'(ns \rightarrow p)$ of the valence electron wave function is solved directly. The theoretical results for α_d are in reasonably good agreement with the observed values from two recent experiments.

I. INTRODUCTION

THE electronic dipole polarizabilities α_d of the alkali atoms have been recently measured in two experiments.^{1,2} Salop, Pollack, and Bederson¹ have measured the polarizabilities using an E - H gradient balance method, in which congruent inhomogeneous electric and magnetic fields are established in the same region of space. The condition that atoms in a particular magnetic substate should suffer no deflection on passing through the field region then gives a relation expressing α_d in terms of the electric and magnetic fields E and H , and the effective magnetic moment μ_{eff} in the field H . In the second experiment, Chamberlain and Zorn² have employed a modified electrostatic deflection technique, using a two-wire type inhomogeneous electric field. In this arrangement, the polarizability is obtained from the deflection of the collimated atomic beam in the inhomogeneous electric field.

In order to compare with these experimental results, we have carried out calculations of α_d for the alkali atoms, using the method previously employed by the author in the calculation of α_d for various positive and negative ions.^{3,4} According to this method^{3,4} the contribution to α_d due to the polarizability of the (n_0s) valence electron is given by

$$\alpha_d(n_0s \rightarrow p) = -\frac{4}{3} \int_0^\infty u_0'(n_0s) u_1'(n_0s \rightarrow p) r dr, \quad (1)$$

where $u_0'(n_0s)$ is r times the radial part of the unperturbed valence wave function, normalized as follows:

$$\int_0^\infty u_0'^2 dr = 1. \quad (2)$$

In Eq. (1), $u_1'(n_0s \rightarrow p)$ denotes r times the radial part of the $n_0s \rightarrow p$ (p wave) perturbation; u_1' is determined by the following equation:

$$[-(d^2/dr^2) + (2/r^2) + V_0 - E_0] u_1' = u_0' r, \quad (3)$$

where V_0 and E_0 are the unperturbed effective potential and energy eigenvalues, respectively, of the valence electron. The quantity $V_0 - E_0$ is determined from the condition that it should reproduce the unperturbed wave function $u_0'(n_0s)$. Thus $V_0 - E_0$ is obtained from the equation

$$V_0 - E_0 = (1/u_0')(d^2 u_0'/dr^2).$$

II. CALCULATIONS OF α_d

The calculated values of $\alpha_d(n_0s \rightarrow p)$ are very sensitive to the choice of the unperturbed wave functions $u_0'(n_0s)$. Thus if a Hartree-Fock wave function is used for the valence electron, the resulting α_d will be appreciably too large, because the Hartree-Fock wave function is slightly too external, on account of the neglect of electrostatic correlation effects with the core electrons of antiparallel spin. For this reason, in the present calculations, we have used valence wave functions which reproduce the observed ionization potentials. The effective potentials V_0 pertaining to these wave functions [Eq. (4)] therefore include in an approximate manner the correlation effect which is neglected in the Hartree-Fock method. Correspondingly, the wave functions used in the present work are expected to be somewhat more internal than the corresponding Hartree-Fock functions. This result was verified for the case of Na 3s, where the Hartree-Fock wave function is available.⁵

The valence wave functions used in the present work are as follows: (1) For Li, the 2s wave function obtained from the potential of Seitz⁶ (calculated $E_0 = -0.394$ Ry; experimental value⁷ $E_{0,\text{exp}} = -0.396$ Ry); (2) for Na, the 3s wave function obtained from the potential derived by Prokofjew⁸ ($E_0 = -0.379$ Ry; $E_{0,\text{exp}} = -0.378$ Ry); (3) for Rb, the 5s wave function given by Callaway and Morgan⁹ ($E_0 = -0.305$ Ry; $E_{0,\text{exp}} = -0.307$ Ry); (4) for Cs, the 6s wave function obtained by Sternheimer¹⁰ ($E_0 \cong E_{0,\text{exp}} = -0.286$ Ry).

For the case of potassium, the 4s wave function u_0'

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¹ A. Salop, E. Pollack, and B. Bederson, Phys. Rev. **124**, 1431 (1961).

² G. E. Chamberlain and J. C. Zorn, Bull. Am. Phys. Soc. **7**, 70 (1962).

³ R. M. Sternheimer, Phys. Rev. **96**, 951 (1954); **107**, 1565 (1957).

⁴ R. M. Sternheimer, Phys. Rev. **115**, 1198 (1959).

⁵ D. R. Hartree and W. Hartree, Proc. Roy. Soc. (London) **A193**, 299 (1948).

⁶ F. Seitz, Phys. Rev. **47**, 400 (1935); W. Kohn and N. Rostoker, Phys. Rev. **94**, 1111 (1954).

⁷ R. F. Bacher and S. A. Goudsmit, *Atomic Energy States* (McGraw-Hill Book Company, Inc., New York, 1932).

⁸ W. Prokofjew, Z. Physik **48**, 255 (1929).

⁹ J. Callaway and D. F. Morgan, Phys. Rev. **112**, 334 (1958).

¹⁰ R. M. Sternheimer, Phys. Rev. **78**, 235 (1950).

was obtained in the following manner. At large distances r from the nucleus, u_0' was determined by solving the Schrödinger equation using the observed energy eigenvalue⁷ ($E_{0,\text{exp}} = -0.3190$ Ry), and the following effective potential:

$$V_0 = -(2/r) - (\alpha_{\text{ion}}/r^4), \quad (5)$$

where V_0 is in Rydbergs, r is in units of the Bohr radius a_H , and α_{ion} is the polarizability of the K^+ ion, in units a_H^3 . The term α_{ion}/r^4 in Eq. (5) represents the effect of the dipole moment induced in the ion core.¹¹ For α_{ion} , we used the experimental value $1.0 \text{ \AA}^3 = 6.76 a_H^3$ (see Table III of reference 4). The Schrödinger equation with the potential V_0 was numerically integrated inward from a large radius ($r = 20 a_H$) down to $r \sim 4 a_H$.

For smaller radii, we have employed the Hartree-Fock wave function¹² $u_{0,\text{HF}}'(4s)$ for K. The effective potential $V_{0,\text{HF}}$ pertaining to $u_{0,\text{HF}}'$ was obtained by means of Eq. (4). A small term δV (representing corre-

lation effects) was added to $V_{0,\text{HF}}$ to obtain the total effective potential V_0 in the internal region ($r \lesssim 4 a_H$). The magnitude of δV was derived from the requirement that the internal solution u_0' should join smoothly with the external solution [calculated with the potential (5)] at a radius $r \sim 4 a_H$. As a check on the accuracy of the resulting $4s$ wave function, we note that the calculated $4s$ electron density at the nucleus is in good agreement with the experimental value ($1.042 a_H^{-3}$ as compared to $1.075 a_H^{-3}$). We also note that integration of the Schrödinger equation with the same effective potential as used above for the $4s$ level gives the following energy eigenvalues for the $4p$ and $5s$ states, which are in good agreement (within 1%) with the corresponding observed ionization potentials.⁷ For $4p$, the calculated E_0 is -0.2018 Ry, as compared to the experimental value $E_{0,\text{exp}} = -0.2003$ Ry. Similarly, for $5s$, $E_0 = -0.1266$ Ry, as compared to $E_{0,\text{exp}} = -0.1274$ Ry.

The above-mentioned valence wave functions for Li, Na, K, and Cs are presented in Table I. Additional

TABLE I. Values of the radial wave functions u_0' for Li $2s$, Na $3s$, K $4s$, and Cs $6s$. The radius r is in units a_H . The energy eigenvalues E_0 at the bottom of the table are in Rydberg units. The electron densities $[\psi^2(0)]_{\text{theor}}$ and $[\psi^2(0)]_{\text{exp}}$ are in units a_H^{-3} .

r	$u_{2s}'(\text{Li})$	$u_{3s}'(\text{Na})$	$u_{4s}'(\text{K})$	$u_{6s}'(\text{Cs})$	r	$u_{2s}'(\text{Li})$	$u_{3s}'(\text{Na})$	$u_{4s}'(\text{K})$	$u_{6s}'(\text{Cs})$
0.01	0.0163	0.0263	0.0299	0.0310	2.2	-0.4580	0.4321	-0.2145	-0.0110
0.02	0.0315	0.0468	0.0486	0.0286	2.4	-0.4862	0.4655	-0.2753	-0.0828
0.03	0.0460	0.0624	0.0586	+0.0114	2.6	-0.5057	0.4898	-0.3286	-0.1512
0.04	0.0596	0.0737	0.0623	+0.0099	2.8	-0.5177	0.5061	-0.3740	-0.2142
0.05	0.0723	0.0811	0.0598	-0.0291	3.0	-0.5229	0.5154	-0.4115	-0.2707
0.06	0.0842	0.0853	0.0536	-0.0435	3.2	-0.5224	0.5187	-0.4414	-0.3202
0.07	0.0955	0.0865	0.0461	-0.0518	3.4	-0.5170	0.5167	-0.4638	-0.3623
0.08	0.1060	0.0855	0.0349	-0.0542	3.6	-0.5075	0.5106	-0.4795	-0.3973
0.09	0.1158	0.0824	0.0224	-0.0513	3.8	-0.4952	0.5008	-0.4887	-0.4250
0.10	0.1248	0.0778	+0.0100	-0.0442	4.0	-0.4803	0.4881	-0.4923	-0.4470
0.12	0.1411	0.0645	-0.0149	-0.0214	4.5	-0.4340	0.4472	-0.4844	-0.4766
0.14	0.1549	0.0476	-0.0399	+0.0065	5.0	-0.3829	0.3990	-0.4593	-0.4781
0.16	0.1665	0.0288	-0.0610	0.0333	5.5	-0.3310	0.3485	-0.4236	-0.4593
0.18	0.1762	+0.0086	-0.0785	0.0553	6.0	-0.2816	0.2994	-0.3825	-0.4286
0.20	0.1839	-0.0117	-0.0922	0.0705	6.5	-0.2362	0.2537	-0.3394	-0.3920
0.22	0.1898	-0.0318	-0.1009	0.0782	7.0	-0.1958	0.2126	-0.2970	-0.3529
0.24	0.1943	-0.0511	-0.1071	0.0788	7.5	-0.1611	0.1764	-0.2568	-0.3135
0.26	0.1974	-0.0693	-0.1096	0.0730	8.0	-0.1312	0.1452	-0.2199	-0.2754
0.28	0.1990	-0.0864	-0.1084	0.0621	8.5	-0.1064	0.1185	-0.1866	-0.2392
0.30	0.1994	-0.1021	-0.1046	0.0474	9.0	-0.0855	0.0962	-0.1572	-0.2066
0.35	0.1960	-0.1348	-0.0860	+0.0016	9.5	-0.0685	0.0776	-0.1316	-0.1768
0.40	0.1871	-0.1581	-0.0548	-0.0452	10.0	-0.0546	0.0624	-0.1095	-0.1502
0.45	0.1741	-0.1723	-0.0174	-0.0830	11	-0.0342	0.0397	-0.0746	-0.1065
0.50	0.1578	-0.1785	+0.0199	-0.1078	12	-0.0210	0.0250	-0.0501	-0.0735
0.55	0.1392	-0.1774	0.0561	-0.1176	13	-0.0127	0.0155	-0.0331	-0.0490
0.60	0.1186	-0.1703	0.0897	-0.1147	14	-0.0075	0.0096	-0.0217	-0.0315
0.65	0.0967	-0.1581	0.1203	-0.1005	15	-0.0044	0.0061	-0.0140	-0.0202
0.70	0.0739	-0.1420	0.1458	-0.0780	16	-0.0026	0.0040	-0.0090	-0.0129
0.8	+0.0265	-0.1012	0.1819	-0.0191	17	-0.0015	0.0026	-0.0057	-0.0083
0.9	-0.0218	-0.0537	0.1993	+0.0444	18	-0.0009	0.0017	-0.0036	-0.0054
1.0	-0.0695	-0.0033	0.1981	0.1014	19	-0.0005	0.0011	-0.0022	-0.0034
1.1	-0.1159	+0.0473	0.1831	0.1467	20	-0.0003	0.0008	-0.0014	-0.0022
1.2	-0.1601	0.0964	0.1582	0.1775					
1.3	-0.2022	0.1432	0.1261	0.1941	$-E_0$	0.3940	0.3789	0.3190	0.2862
1.4	-0.2416	0.1873	0.0909	0.1984	a_1	1.678	2.927	3.619	5.651
1.6	-0.3122	0.2666	+0.0112	0.1760	$[\psi^2(0)]_{\text{theor}}$	0.2241	0.6818	1.042	2.541
1.8	-0.3717	0.3335	-0.0698	0.1260	$[\psi^2(0)]_{\text{exp}}$	0.2314	0.7411	1.075	2.925
2.0	-0.4202	0.3884	-0.1458	+0.0605					

¹¹ M. Born and W. Heisenberg, Z. Physik **23**, 388 (1924).

¹² D. R. Hartree and W. Hartree, Proc. Cambridge Phil. Soc. **34**, 550 (1938).

¹³ H. Brooks and F. S. Ham, Phys. Rev. **112**, 344 (1958).

TABLE II. Values of the cesium $6s$ wave function u_0' near the nucleus.

r	$u_{6s}'(\text{Cs})$
0.002	0.0101
0.004	0.0180
0.006	0.0240
0.008	0.0283
0.010	0.0310
0.015	0.0326
0.020	0.0286
0.025	0.0210
0.030	0.0114
0.035	0.0008
0.040	-0.0099
0.045	-0.0200
0.050	-0.0291

values of the cesium $6s$ wave function¹⁰ near $r=0$ are listed in Table II. At the bottom of Table I, we give the energy eigenvalue E_0 and the value of u_0'/r at $r=0$, which is denoted by a_1 . With the present normalization of u_0' , the density $\psi^2(0)$ of the valence electron wave function at the nucleus is given by $a_1^2/4\pi$. This value is listed as $[\psi^2(0)]_{\text{theor}}$. For comparison, we have also given in Table I the values $[\psi^2(0)]_{\text{exp}}$ deduced by Brooks and Ham¹³ from the observed hyperfine splittings $\Delta\nu$ in the $2S_{1/2}$ state. It is seen that in each case the calculated result $[\psi^2(0)]_{\text{theor}}$ is in reasonably good agreement with the experimental value $[\psi^2(0)]_{\text{exp}}$. For the cases of lithium and sodium, a similar comparison of $[\psi^2(0)]_{\text{theor}}$ as obtained from wave functions for the Seitz and Prokofjew potentials has been carried out previously by Kohn.¹⁴

The procedure of the calculation of $u_1'(n_0s \rightarrow p)$ from Eq. (3) has been previously described in references 3 and 4. In the outer regions u_1' is obtained by inward numerical integration starting from a large radius r_1 (~ 16 – $20a_H$). Near the nucleus, u_1' is obtained by outward numerical integration, and the two solutions are joined at an intermediate radius r_0 (~ 0.2 – $0.4a_H$). It is estimated that for a given effective potential V_0 , the accuracy of the resulting value of $\alpha_d(n_0s \rightarrow p)$ is within 2%.

The calculated values of $\alpha_d(n_0s \rightarrow p)$ are given in the first row of Table III. The experimental values of Salop *et al.*¹ and of Chamberlain and Zorn² are given in the second and third rows. For comparison with the present result for Na, obtained with the $3s$ function pertaining to the potential of Prokofjew ($\alpha_d=23.2 \text{ \AA}^3$), we note that the corresponding Na $3s$ Hartree-Fock function⁵ would give $\alpha_d(3s \rightarrow p)=29.0 \text{ \AA}^3$. Thus the replacement of the Hartree-Fock function by a function which reproduces the atomic $3s$ eigenvalue decreases the calculated α_d by a factor of 1.25, and thus brings α_d into much better agreement with experiment. We note that, in contrast with the large change of α_d , the eigenvalues pertaining to the Hartree-Fock and Prokofjew wave

TABLE III. Values of α_d and ξ_{val} for the alkali atoms. All values of α_d are in units \AA^3 .

	Li	Na	K	Rb	Cs
$\alpha_d(n_0s \rightarrow p)$	24.9	23.2	45.9	51.3	71.9
$\alpha_{d,\text{exp}}^a$	20 ± 3	20 ± 2.5	36 ± 4.5	40 ± 5	52.5 ± 6.5
$\alpha_{d,\text{exp}}^b$	22.0 ± 2	21.5 ± 2	38 ± 4	38 ± 4	48 ± 6
ξ_{val}	2.57	2.66	3.27	3.39	3.85
$\alpha_{\text{ion,exp}}$	0.03	0.22	1.0	1.6	2.8
α_{total}	24.9	22.9	44.4	49.1	67.7

^a See reference 1.

^b See reference 2.

functions differ by a very small amount, namely 0.018 Ry; we have: $E_{0,\text{HF}} = -0.361$ Ry; $E_{0,\text{P}} = -0.379$ Ry; $E_{0,\text{exp}} = -0.378$ Ry. This result illustrates the sensitivity of α_d to the detailed behavior of the unperturbed valence wave function, which is not reflected in an appreciable change of E_0 . We note that similar calculations of α_d for the lithium atom have been carried out by Sundbom¹⁵ and by Parkinson,^{16,17}

III. ELECTRIC FIELD AT THE NUCLEUS

In connection with our previous discussion of the electric field at the nucleus due to the induced dipole moment, as given in references 3 and 4, it is of interest to calculate the electric field at the nucleus $\Delta E_{\text{val}}(0)$ due to the perturbation of the valence electron wave function. If an external charge $+e$ is located at $x=+R$, the induced field at the nucleus due to the valence electron is given by

$$\Delta E_{\text{val},x}(0) = +(e/R^2)\xi_{\text{val}}, \quad (6)$$

where ξ_{val} is given by

$$\xi_{\text{val}} = -\frac{4}{3} \int_0^\infty u_0'(n_0s)u_1'(n_0s \rightarrow p)r^{-2}dr. \quad (7)$$

In Eq. (6), the subscript x of $\Delta E_{\text{val},x}(0)$ indicates the component of the field along the positive x axis. The values of ξ_{val} are given in Table III. The positive sign of ξ_{val} together with Eq. (6) indicates that $\Delta E_{\text{val},x}(0)$ is positive, as is expected since the induced charge distribution along the $+x$ axis will be predominantly negative (for an external positive charge, as is here considered).

It is known from general arguments that the total field at the nucleus for a neutral atom in an external electric field must be exactly zero.¹⁸ In the present case, the relatively large value of ξ_{val} is compensated by an additional term $\xi_{\text{core, val}}$ produced by the dipole moment which is induced in the ion core by the large induced dipole moment of the valence electron. It is easily seen that this additional dipole moment induced in the core

¹⁵ M. Sundbom, Arkiv Fysik **13**, 539 (1958).

¹⁶ D. Parkinson, Proc. Phys. Soc. (London) **A75**, 169 (1960).

¹⁷ See also A. Dalgarno and A. E. Kingston, Proc. Phys. Soc. (London) **A73**, 455 (1959).

¹⁸ R. P. Feynman, Phys. Rev. **56**, 340 (1939).

¹⁴ W. Kohn, Phys. Rev. **96**, 590 (1954); T. Kjeldaa and W. Kohn, *ibid.* **101**, 66 (1956).

will have opposite sign to the moment induced in the valence electron distribution, and will therefore tend to cancel the effect of ξ_{val} .

In the extreme case in which the valence electron distribution is completely outside the core, it can be shown that $\xi_{\text{core, val}} \cong -\xi_{\text{val}}$, so that the net contribution to the field at the nucleus, $E_x(0)$, is very small. For a completely external valence electron, the total field acting on the ion core would be

$$E_{0,x} = -(e/R^2)(1 - \xi_{\text{val}}). \quad (8)$$

The resulting dipole perturbation of the core gives rise to a total induced dipole moment: $(1 - \xi_{\text{val}})\alpha_{\text{ion}}(-e/R^2)$, corresponding to an effective polarizability

$$\alpha_{\text{ion, eff}} = (1 - \xi_{\text{val}})\alpha_{\text{ion}}, \quad (9)$$

where α_{ion} is the ionic dipole polarizability in an external field (in the absence of the valence electron).

Similarly, in view of the results of references 3 and 4, the total perturbation of the ion core gives rise to the following field at the nucleus

$$\Delta E_{\text{core, x}}(0) = (e/R^2)(1 - Z^{-1})(1 - \xi_{\text{val}}). \quad (10)$$

Thus we obtain

$$\xi_{\text{core, val}} = -\xi_{\text{val}}(1 - Z^{-1}) \cong -\xi_{\text{val}}, \quad (11)$$

where $\xi_{\text{core, val}}$ is the part of $E_{\text{core, x}}(0)/(e/R^2)$ which pertains to the perturbation of the core produced by the distortion of the valence electron distribution.

IV. RESULTS AND DISCUSSION

An estimate has been made of the effect of the penetration of the valence electron in the ion core on the magnitude of the term $-\xi_{\text{val}}\alpha_{\text{ion}}$ of Eq. (9) for $\alpha_{\text{ion, eff}}$. Thus we write:

$$\alpha_{\text{ion, eff}} = (1 - \beta\xi_{\text{val}})\alpha_{\text{ion}}, \quad (12)$$

for the effective polarizability of the ion core under the influence of the external charge and the dipole moment induced in the valence electron distribution. The factor β , which arises from the penetration of the valence electron, was found to have the following approximate values: $\beta \sim 1$ for Li, 0.85 for Na, 0.75 for K, 0.70 for Rb, and 0.65 for Cs.

The total polarizability of the alkali atom is then given by

$$\alpha_{\text{total}} = \alpha_d(n_0s \rightarrow p) + \alpha_{\text{ion, eff}}, \quad (13)$$

where $\alpha_{\text{ion, eff}}$ is given by Eq. (12). It should be noted that because of the smallness of the ratio $\alpha_{\text{ion, eff}}/\alpha_d(n_0s \rightarrow p)$ (which is less than 0.1), α_{total} is not sensitive to the uncertainty in the estimated value of β in Eq. (12).

Upon using the above values of β , we obtain the calculated values α_{total} given in the last row of Table III.

These values are in reasonably good agreement with the experimental results of Salop *et al.*¹ and Chamberlain and Zorn.² For Li and Na, the calculated values lie essentially within the limits of error of the experimental results, while for K, Rb, and Cs, the theoretical results exceed the experimental values by ~ 1.5 , ~ 2 , and ~ 3 times the experimental errors, respectively. If we compare the theoretical values for Rb and Cs with the averages of the results from the two experiments, we obtain for the ratios: $R_{\text{Rb}} = 49.1/39 = 1.26$, and $R_{\text{Cs}} = 67.7/50 = 1.35$. In view of the great sensitivity of $\alpha_d(n_0s \rightarrow p)$ to the detailed behavior of the valence wave function, it would seem that if the actual wave functions for Rb 5s and Cs 6s were slightly more internal than those used here, $\alpha_d(n_0s \rightarrow p)$ would be sufficiently decreased to give agreement of α_{total} with the experimental values. In this connection, it may be noted that the agreement which has been obtained in the present work for the Rb and Cs valence electrons is considerably better than that found for the Rb^+ and Cs^+ ions in reference 4, where it was necessary to use Hartree wave functions, since Hartree-Fock functions for these ions are not available (see Table III of reference 4). Thus for Rb^+ , the average of the experimental values⁴ of α_{ion} is 1.6 \AA^3 , while the theoretical result is 2.92 \AA^3 , giving a ratio $R_{\text{Rb}^+} = 1.83$. Similarly, for Cs^+ , the average of the experimental values is $\alpha_{\text{ion, exp}} = 2.8 \text{ \AA}^3$, while the calculated value is 5.60 \AA^3 , giving $R_{\text{Cs}^+} = 2.0$. It should be pointed out that the accuracy of the calculation of α_{ion} in reference 4 is estimated to be within 3%, and the discrepancy for Rb^+ and Cs^+ is therefore almost completely due to the use of Hartree wave functions, which are somewhat more external than the actual core wave functions, since they do not include exchange and correlation effects.

We note that in the calculation of $\alpha_{\text{ion, eff}}$ from Eq. (12), approximate experimental values of α_{ion} (as obtained in reference 4) were used. These values are listed in Table III. Since the term $\alpha_{\text{ion, eff}}$ is negative, i.e., $1 - \beta\xi_{\text{val}} < 0$, the use of the theoretical values of α_{ion} for Rb^+ and Cs^+ , which are appreciably too large, would have artificially improved the result, since it would have led to smaller values of α_{total} , in better apparent agreement with experiment. By the use of the experimental values of α_{ion} in Eq. (12), one decreases the uncertainty in the term $\alpha_{\text{ion, eff}}$ so that the comparison between the experimental α_d and the calculated α_{total} becomes more closely a test of the accuracy of the valence electron term $\alpha_d(n_0s \rightarrow p)$.

The reasonably good agreement with experiment which has been obtained for α_d of the alkalis and the sensitivity of α_d to the valence wave function indicate that the calculation of the dipole polarizability can be used as a test of the accuracy of the valence wave functions of the alkali atoms.