coefficients of the perturbing configuration disappear by using Fock's field.[3]

The usual computation of nuclear g factors is not necessarily wrong, but it is fair to say that it is uncertain on account of the sensitiveness of the theoretical values to perturbations.[4] We intended to postpone publication until sufficiently detailed calculations were made to ascertain the g factors. Professor J. H. Bartlett kindly informed us that he and his co-workers[5] have made related calculations for K using the Hartree field and for Na using Fock's field, and it seemed of interest to report the present state of our calculation.

The results of Shoupp, Bartlett and Dunn for $3s$, $3p$ are easily extended to $4s$, $4p$. We summarize in Table I their values, our Hartree field values, and our Fock field values for $4p$. The ratio $\psi_{3s}^2(0)/\psi_{4s}^2(0)=4.75$ by using Fock's functions, and 4.28 by using $Z_i Z_0^2/n^{*3}$. For Hartree′, Fock′ it was supposed that the ratio of the h.f.s. and the multiplet

TABLE I.

		$3s$	$3p_{3/2}$	$4p_{3/2}$
a	Experiment[7]	0.029	$8.3\times10^{-4}(7.5\times10^{-4})$	1.87×10^{-4}
	Hartree	5.85	22 (20)	10.4
	Fock	2.5*	5.1* (4.6)	3.1
μ	Goudsmit-Fermi[7]	2.0	2.8 (2.6)	2.0
	Hartree′		3.3 (3.0)	2.4
	Fock′		3.1* (2.9)	2.3
	Hartree		2.6 cm^{-1}	1.2 cm^{-1}
$\Delta\nu$	Fock		10.7*	4.0
	Experiment		17.2	5.49

frequency separations is given correctly by the respective functions of Hartree and Fock. The ratio of the two frequency differences as obtained from experiment was then equated to its theoretical value which involves μ and hence μ was determined. This amounts to defining an effective Z_i by $\overline{Z_i=-(dV/rdr)}/\overline{(1/r^3)}$ where V is the potential of the central field, and by using this Z_i in Goudsmit's[6] Eq. (6). The Hartree and Fock values of Z_i are 8.91 and 8.54. The first of these was communicated by us to Ellett and Heydenburg.[7] The Z_i and μ thus determined are insensitive to progressive errors in the computation of the wave function and depend essentially on its shape for small r. They may be expected to be nearly the same for any central field calculation. The values of μ obtained by means of this Z_i will be correct if there exists a central field which suffices for the discussion of the hyperfine and the ordinary fine structures; they may be wrong if there are pertubations affecting the multiplet and h.f.s. structures unequally.

The values marked* were kindly supplied to us by Shoupp, Bartlett and Dunn.

Values of μ obtained[8, 9] from $6s$, $6p$, $7p$, $8p$ of Cs check each other satisfactorily. Measurements of Wood and Fortrat on the principal series of Na disagree with the Landé gross doublet formula while for K, Cs the formula holds well. There is thus some evidence that Na is a poor element for testing the theory. The difference between μ $(3p)$ and μ $(4p)$ may be due, however, partly to experimental error as is seen by comparing values in each row of the $3p$ column.

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[1] G. Breit, Phys. Rev. **46**, 340 (1934).
[2] J. McDougall, Proc. Roy. Soc. **A138**, 550 (1932).
[3] Chr. Møller and M. S. Plesset, Phys. Rev. **46**, 618 (1934).
[4] G. Breit and I. I. Rabi, Phys. Rev. **46**, 231 (1934).
[5] W. E. Shoupp, J. H. Bartlett, Jr. and C. G. Dunn, Phys. Rev. this issue.
[6] S. Goudsmit, Phys. Rev. **43**, 636 (1933).
[7] A. Ellett and N. P. Heydenburg, Phys. Rev. **46**, 583 (1934).
[8] L. P. Granath and R. K. Stranathan, Phys. Rev. **46**, 316 (1934); Bull. Am. Phys. Soc. April 25–27 (1935); Paper 80.
[9] N. P. Heydenburg, Phys. Rev. **46**, 802 (1934).

The Magnetic Moment of the Na^{23} Nucleus

From the most recent experiments with sodium[1–5] it has been concluded that the nuclear spin $I=3/2$ and that the total h.f.s. splitting[1] for the $3\,^2S_{\frac{1}{2}}$ state is 0.0583 cm^{-1}, for the $3\,^2P_{3/2}$ state 0.0050 cm^{-1}, and for the $3\,^2P_{\frac{1}{2}}$ state 0.0083 cm^{-1}. Ellett and Heydenburg, using formulae developed by Goudsmit[6] and Fermi and Segré,[7] have calculated values of the nuclear magnetic moment. From the $3\,^2S_{\frac{1}{2}}$ state, they find $\mu=2.02$ nuclear magnetons; while from the $3\,^2P$ states, they obtain $\mu=2.3-2.6$ n.m. Hartree wave functions were used by Wills and Breit,[8] who obtained values $\mu=5.8$ and $\mu=22.6$ from the S and P states, respectively. Since, however, their calculations show the multiplet splitting for the ^2P state to be 2.60 cm^{-1}, as compared with the observed value of 17.6 cm^{-1}, it is fairly obvious that better wave functions than those of Hartree are needed for accurate calculations. It is the purpose of this note to investigate whether or not the functions recently published by Fock and Petrashen[9] will serve the purpose.

The h.f.s. separation of a ^2S state is $\Delta(s)=(8\pi/3)\{(2I+1)/I\}\mu\mu_0\overline{\psi^2(0)}$; that of a $^2P_{3/2}$ state is $\Delta^2P_{3/2}=(8/3)\{(2I+1)/I\}\mu\mu_0\overline{(1/r^3)}$. The gross structure separation for the ^2P state is[7] $\delta=(3\mu_0^2/hca_0^3)\overline{(1/r)(dU/dr)}$, where $U(r)=-11/r+V(r)$, and $V(r)$, is tabulated by Fock and Petrashen.

We find the following results: $\lim_{r\to0}(f_{3s}/r)=2.86$; $\overline{(1/r^3)}_{3p}=0.144$; $\overline{(1/r)(dU/dr)}_{3p}=1.23$; from ^2S, $\mu=2.5$ n.m.; from ^2P, $\mu=5.1$ n.m.; and $\delta=10.7$ cm^{-1}. The values of $(1/r)(dV/dr)$ are given in Table I.

TABLE I.

r	$\frac{-1}{r}\frac{dV}{dr}$	r	$\frac{-1}{r}\frac{dV}{dr}$	r	$\frac{-1}{r}\frac{dV}{dr}$	r	$\frac{-1}{r}\frac{dV}{dr}$
0.00		0.24	147	0.60	23.1	1.4	3.43
.02	2400	.26	123	.65	19.9	1.5	2.84
.04	1700	.28	105	.70	17.2	1.6	2.37
.06	1300	.30	90.0	.75	15.0	1.7	1.99
.08	987	.32	78.1	.80	13.2	1.8	1.69
.10	747	.34	68.5	.85	11.6	1.9	1.44
.12	571	.36	60.7	.90	10.2	2.0	1.24
.14	441	.38	56.2	.95	9.12	2.2	↓
.16	345	.40	49.2	1.0	8.04	2.4	10
.18	273	.45	39.2	1.1	6.37	↓	$\overline{r^3}$
.20	220	.50	32.4	1.2	5.17		
.22	179	.55	27.1	1.3	4.20		

It is seen that the introduction of the Fock functions serves to improve the calculated value of the ^2P multiplet splitting very much. If one assumes the ratio $\overline{(1/r^3)_{3p}} : \overline{(1/r)(dU/dr)_{3p}}$ to be approximately the same for the Hartree and Fock functions, then this means that $\mu\delta$ is also approximately the same. For the Hartree case, $\mu\delta = 58.8$; for the Fock case $\mu\delta = 54.6$. If we suppose that this latter value is not very different from that which would be obtained with exact wave functions, and that the present theory of multiplet separations is correct, then it is permissible to use the experimental value of δ and to solve, and one obtains $\mu = 3.1$ n.m.

The agreement between the value $\mu = 2.5$ n.m. from the ^2S state and the estimated value $\mu = 3.1$ n.m. from the ^2P state seems to indicate that the true value of the magnetic moment of the Na^{23} nucleus lies in this neighborhood. It may be remarked that our method of estimation seems capable of yielding good results for p electrons even with a rather poor wave function (such as Hartree's), but that accurate results for s electrons will probably be obtained only with quite accurate wave functions, as may be seen by comparing the values $\mu = 5.8$ (Hartree function) and $\mu = 2.5$ (Fock function).

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[1] L. P. Granath and C. M. Van Atta, Phys. Rev. **44**, 935 (1933).
[2] J. Joffe, Phys. Rev. **45**, 468 (1934).
[3] L. Larrick, Phys. Rev. **46**, 581 (1934).
[4] A. Ellett and N. D. Heydenburg, Phys. Rev. **46**, 583 (1934).
[5] I. I. Rabi and V. W. Cohen, Phys. Rev. **46**, 707 (1934).
[6] S. Goudsmit, Phys. Rev. **43**, 636 (1933).
[7] E. Fermi and E. Segrè, Zeits. f. Physik **82**, 729 (1933).
[8] L. A. Wills and G. Breit, (preceding letter, this issue of Phys. Rev.).
[9] V. Fock and N. J. Petrashen, Physik. Zeits. d. Sowjetunion **6**, 368 (1934).