The sodium cell was irradiated with microwave power by a wave guide horn with suitable polarization for either σ or π excitation. The microwave oscillator was frequency-modulated at 30 cycles per second and the output of the photocell amplifier was fed into a phase-sensitive detector, thus obtaining the derivative of the resonance line. The microwave frequency was obtained by multiplication from a crystal oscillator at 24.6 Mc/sec. The frequency of the crystal oscillator was measured with a Berkeley counter monitored with station *WWV* with a short-term accuracy of 1 part in 10^8 to 1 part in 10^7. It was found that the $\Delta m_F=0$, $m_F=0$ transition would be observed with a signal-to-noise ratio barely sufficient for direct display on a scope and with a signal-to-noise ratio of 20:1 when a bandwidth reduction to 0.05 cps was made with a lock-in amplifier.

The value of the hyperfine splitting of Na^{23} in the ground state was found to be

$$(1771.6262+0.0022H^2)\times10^6\pm100 \text{ cycles/sec.}$$

This frequency was obtained by direct measurements on a line whose width was 400 cps. The line width in this case is determined mostly by microwave saturation effects and partly by noise and instability in the oscillator. The value obtained by this method is slightly lower than the value given by atomic beam measurements.[5]

The effect of buffer gas pressure in shifting the hyperfine frequency was studied. Argon pressures of 1 mm, 5 mm, 10 mm, and 50 mm were used. No observable pressure shifts were measured with argon although the accuracy of the measurements leave the possibility that a pressure shift of several cps/mm might be present. Such a magnitude would be in agreement with measurements on Rb^{87}.[2] Neon shifts for pressures of 1 mm, 5 mm, 10 mm, and 50 mm were measured. A pressure shift to higher frequencies of 80 cps/mm was found. This surprising result we believe to be caused by exchange of the valence electron to the similar neon core with an accompanying spin-orbit interaction. We have also measured by microwave methods an effective cross section of 5×10^{-14} cm^2 for exchange collisions between sodium atoms which determine the line width at higher pressures of sodium.

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Ground-State Energy of Two-Electron Atoms. Corrective Results

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IN a Letter[1] last year we gave a preliminary report dealing with the ground-state energies of the He atom and homologous two-electron ions calculated by means of a 24-term function containing a nonconventional logarithmic term together with 3 terms of the type introduced by Kinoshita[2] in his formal solution of the Schrödinger equation for He. The contribution from this logarithmic term to the ground state energy in the limiting case of nuclear charge $Z\rightarrow\infty$ was of the order of magnitude 5–6 in the fifth decimal place as measured in Rydberg units, i.e., about 5 cm^{-1} in wave number units. For finite Z the contribution was smaller, but it did not surprise us that a contribution of about 2 cm^{-1} remained in the case of He. Soon afterwards we had a report of results obtained by Kinoshita for the ground-state energy of He, using a 39-term function. His energy value was about one cm^{-1} behind ours, in spite of his numerous terms. Because of the obviously well-adapted form of our logarithmic term, however, we did not for this reason mistrust our calculations. Then we had a report of the Hart and Herzberg[3] calculations based on a 20-parameter conventional wave function. The energy value obtained by these authors was only about one cm^{-1} behind that of Kinoshita. Next, from preliminary calculations they had found only a negligible contribution from our logarithmic term. On account of this discrepancy we decided to recalculate our matrix elements and as a matter of fact no mistake could be found in our basic calculations using the matrix $M-L+2N$ in place of the kinetic integral M (L and N being Coulomb and normalization integrals, respectively). Hence the important $Z\rightarrow\infty$ results were correct. However, for finite Z we had at a later stage to introduce also the M matrix and it was finally found that in the transition from $M-L+2N$ to M two figures containing the sequences $\cdots6480\cdots$ and $\cdots6048\cdots$ had in some way been confused. The mistake was, however, outside the row and column of the logarithmic term.

The correction of this mistake at first displaced the energy of He 2–3 cm^{-1} backwards, i.e., behind both the Kinoshita and the Hart-Herzberg values. It therefore

TABLE I. Corrected values of $E_2(Z)$.

Z	A	$-E_2(Z)$ Incorrect	$-E_2(Z)$ Corrected	Z	A	$-E_2(Z)$ Incorrect	$-E_2(Z)$ Corrected
1	H^-	0.305451	0.305434	7	N^{5+}	0.312893	0.312883
2	He	0.307457	0.307443	8	O^{6+}	0.313192	0.313182
3	Li^+	0.309818	0.309821	9	F^{7+}	0.313426	0.313417
4	Be^{++}	0.311131	0.311126	10	Ne^{8+}	0.313613	0.313604
5	B^{3+}	0.311945	0.311936	16	Ca^{18+}	0.314459	0.314457
6	C^{4+}	0.312496	0.312486	∞		0.315311	0.315315

became necessary to repeat the whole variational process with the electronic computer. The final energy value which could be obtained from our 24-parameter function is only about 0.2 cm^{-1} behind that of Kinoshita. Apart from He and H^- the error in the energy value introduced by the incorrect matrix element is less than 1 cm^{-1}. For H^- it is a little over 1.5 cm^{-1}.

However, the contribution from the logarithmic term to the energy value for both large and small nuclear charge Z was still practically the same as before the correction.

This fairly appreciable contribution is larger than would be expected on the basis of the Hart-Herzberg results. Obviously their terms t^2u^2, t^2u^4, s^2t^2 and st^2u, which are not present in our wave function, are better suited to compensate for the logarithmic term than some of the terms used by us.

The old incorrect values together with the corrected ones, all of which have been separately calculated, are given in Table I, $E_2(Z)$ being defined by the formula

$$E=-2Z^2+(5/4)Z+E_2(Z).$$

A detailed account of the calculations will be published in the near future.

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Lifetime of a 1^- Level in Sm^{152}†

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A 961-kev level fed by K capture[1] from Eu^{152m} has been identified[2] as 1^- by internal conversion measurements of the 961- and 837-kev gamma transitions to the 0^+ ground state and 2^+ first excited state of Sm^{152}; the pertinent parts of the decay scheme[1,2] of Eu^{152m} are shown in Fig. 1. The spin of the 961-kev level has been confirmed[3] by an angular correlation measurement of the 1—2—0 gamma-ray cascade. The ratio of the reduced transition probabilities of the 961- and 837-kev transitions is 0.5±0.05, suggesting strongly that the 961-kev level is a member of the $K=0$ rotational band. The logft values of the transitions, shown in Fig. 1, to the ground state levels of Sm^{152} and Gd^{152} and especially the allowed logft value of the transition to the 961-kev level strongly favor odd parity for the 9-hour isomeric state of Eu^{152}. For first forbidden transitions such small ft values occur only near double magic nuclei.[4] (The spin-zero assignment to Eu^{152m} seems most reasonable since a search for an isomeric transition >25 kev carried out with a permanent magnetic spectrograph of 0.1% resolution places its mean life as greater than 5000

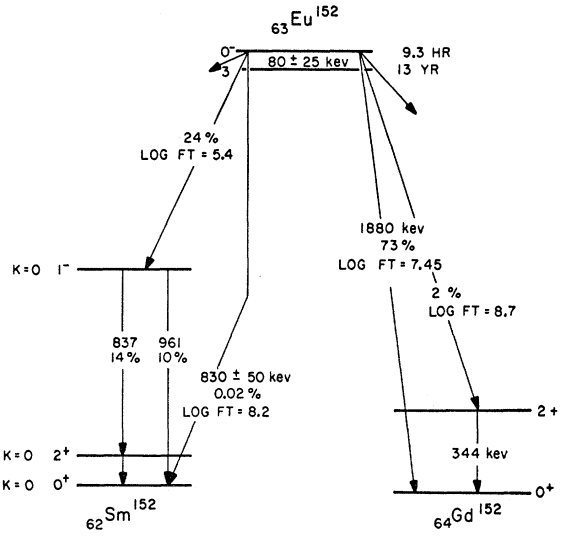

FIG. 1. Partial decay scheme of Eu^{152m}. The spin of the ground state has been measured as 3. {Abraham, Kedzie, and Jeffries, Phys. Rev. **108**, 58 (1957); Manenkov, Prokhorov, Trukhlayev, and Yakovlev, Doklady Akad. Nauk S.S.S.R. **112**, 623 (1957) [translation: Soviet Phys. Doklady **2**, 64 (1957)]; Nuclear Data Card 57-10-21 (National Research Council, Washington, D. C., 1957).}

hours, which is more than 10^{11} times slower than a single-proton $\Delta J=2$ transition.) The total K-capture energy is 890±50 kev, as deduced from the positron spectrum to the ground state of Sm^{152}, measured with a three-crystal pair spectrometer.[1]

As is well known,[5] resonance scattering of nuclear gamma rays is normally impossible unless the energy lost in emission and absorption, $\Delta E=E_\gamma^2/Mc^2$, is supplied to the emitted gamma ray. (For a 961-kev transition in Sm^{152}, $\Delta E=6.5$ ev.) However, for electric dipole transitions the ratio of the natural width Γ to ΔE may be large enough so that the wings of the emission and absorption lines can be used to excite the level. [$\Gamma_{961\,\mathrm{kev}}$ (single proton)$\simeq$3 ev.] Also, the mean life of such an electric dipole transition would be short enough ($\tau_{s.p.}\simeq 2\times10^{-16}$ sec) so that even in a solid source the gamma ray would be emitted before the recoiling nucleus slows down and would therefore be subject to a Doppler shift due to the recoiling nucleus.

The resonant scattering cross section was determined in the standard geometry shown in Fig. 1 of the following paper,[6] but without the magnet. Solid Eu_2O_3 sources and Eu_2O_3 dissolved in HCl were used. In the initial runs,[3] thin ring scatterers of 50 grams each of Sm_2O_3 and Nd_2O_3 were alternated. Since no resonance scattering of any kind was observed with Nd_2O_3, the subsequent runs using 1850 g of Sm_2O_3 were compared with a lead scatterer having a comparable number of electrons. The source strength was determined several days after a run by placing the source in a position corresponding to the mean distance of the scatterer, so that the efficiency of the detector was eliminated to a