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†National Science Foundation Predoctoral Fellow, 1957-58.

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$$1+\epsilon=[\int|\psi(\vec{r}_1,\vec{r}_2)|^2{}_{r_2=0}d\vec{r}_1+\int|\psi(\vec{r}_1,\vec{r}_2)|^2{}_{r_1=0}d\vec{r}_2]/|\psi(0)|^2,$$

where $\psi(\vec{r}_1,\vec{r}_2)$ is the nonrelativistic $1s\,2s,\,{}^3S_1$ wave function and $\psi(\vec{r})$ is the nonrelativistic hydrogenic $1s$ wave function for He^+.

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MEASUREMENT OF THE NUCLEAR g FACTOR OF Li^8†*

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In many cases the capture of polarized thermal neutrons should result in product nuclei which are appreciably polarized.[1-3] If the product decays by beta emission, the well known asymmetry of the decay electrons from polarized nuclei should be observable unless relaxation processes destroy the polarization before the decay occurs. An asymmetry produced in this way was observed at this laboratory in 1957[1] with Li^8, a nuclide of mean life 1.2 sec.

Observation of the asymmetry in beta emission offers a means of measuring the polarization of very small samples of short-lived nuclei. If established resonance techniques are used to perturb the nuclear polarization due to the capture of polarized neutrons, the precise measurement of nuclear g factors should be possible in several cases which cannot be studied by conventional methods. This note describes the successful application of this idea to the case of Li^8.

The resonance effect used in this work was the destruction of the polarization by an rf field, well known in nuclear magnetic resonance work as "rf saturation."[4] The sample nuclei are created with their polarization along a static magnetic field H_0. An rf field $2H_1$ is impressed at right angles to H_0. As the radio-frequency is made to approach f_L, the nuclear Larmor frequency, the polarization along H_0 is destroyed and with it the beta-emission asymmetry. The measurement of f_L in the known field H_0 yields the g factor directly.

The geometry of the experiment is shown schematically in Fig. 1. The target was a single crystal of LiF. In order to avoid self-shielding due to the large Li^6 cross section, the crystal was

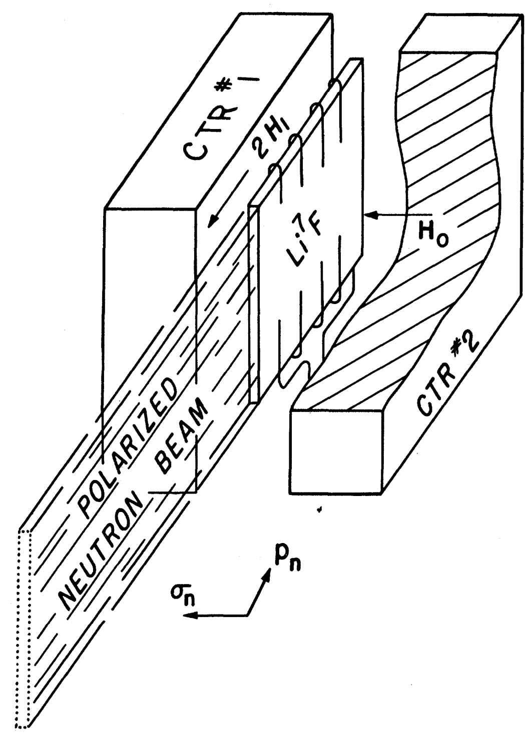

FIG. 1. Schematic experimental arrangement. Beta counters CTR No. 1 and CTR No. 2 detect the electrons emitted with a momentum component parallel or antiparallel to the nuclear polarization. The coil shown around the LiF target provides the rf field $2H_1$ which, at resonance, depolarizes the Li^8 nuclei.

grown from material in which the Li^6 had been depleted to 0.1% of the total Li.[5] The target was irradiated with slow neutrons which had been polarized by reflection from a magnetized cobalt alloy mirror.[6] The neutron polarization, of estimated magnitude 0.8 ± 0.1, was parallel to H_0. Decay electrons with a momentum component along or against H_0 were detected by plastic scintillation counter 1 or 2, respectively. The ratio of counting rates, R_2/R_1, changed by 10% when the neutrons were depolarized by passage through a 0.008-inch steel foil. If the Li^8 ground state has $J^\pi = 2^+$,[7] the observed sign and magnitude of the asymmetry effect require the conclusion that capture occurs almost entirely ($\geq 80\%$) by the $j = 2$ channel and that relaxation of the polarization is negligible.

The rf field, $2H_1$, was provided by the coil wound around the target crystal. When the two counting rates were monitored while the frequency was slowly varied, a narrow range was found in which appreciable depolarization occurred. Subsequent careful observations gave the resonance curve data of Fig. 2. It is interesting to note that only about 20 000 Li^8 atoms existed in the sample at any instant during these measurements. The curve for $2H_1 = 0.08$ oersted shows a width of about 0.35% or 19 oersteds in the 5400-oersted static field. In the main, this is accounted for by the local variation in static field due to the magnetic moments of nearby Li^7 and F^{19} nuclei, a width of 13 oersteds for the Li^7 and F^{19} resonances in LiF being found in nuclear magnetic resonance studies.[8] Part of the width may be due to the saturation broadening which clearly appears in the $2H_1 = 0.4$ oersted curve. This broadening may be understood qualitatively when it is realized that the local field at a point fluctuates rapidly (order of 10^4/sec) because of spin flips of adjacent nuclei so that the resonant H value exists for a small fraction of the time even when the external field H_0 is 10 oersteds or more from resonance. Since the time for depolarization is of the order $H_0/f_L H_1$, for sufficiently large H_1 the time at resonance is enough for appreciable depolarization even when the frequency is considerably off resonance in H_0. The inhomogeneity of H_0 was no more than 0.05% over the sample volume so that broadening from this source was negligible.

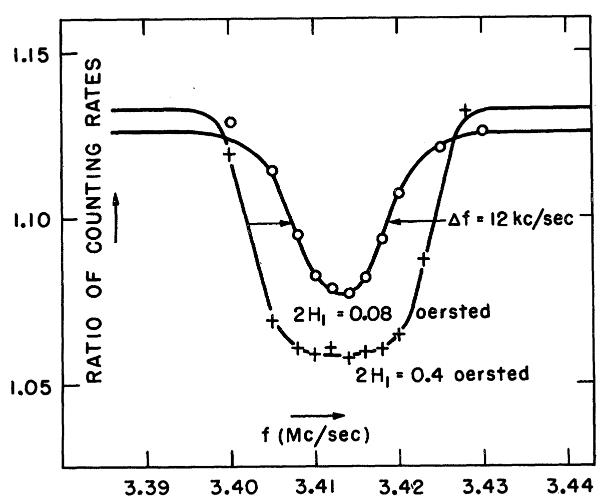

FIG. 2. Nuclear resonance of Li^8 as shown by change of beta-emission asymmetry when the frequency of the rf field is varied. Static field $H_0 = 5418$ oersteds, rf field strength $2H_1$ as shown on curves. The asymmetry effect appears to be 7% rather than 10% as given in the text because no correction has been made for an unusually high background due to pile gammas at the time these data were taken. Other data show definitely that complete depolarization is obtained at resonance with $2H_1 \geq 0.4$ oersted.

From the data of Fig. 2, one obtains for the resonance frequency in 5418 ± 1 oersteds (measured with nuclear magnetic resonance techniques), $f_L = 3.413 \pm 0.001$ Mc/sec. The g factor is therefore $g(Li^8) = 0.8265 \pm 0.0004$ nm/h when no diamagnetic corrections are applied. With spin 2,[7] the magnetic moment is $\mu(Li^8) = 1.653 \pm 0.0008$ nm. This g value is very close to that of Li^6 (0.8292). The calculated value for either nucleus in extreme j-j coupling, assuming both the odd neutron and the odd proton to be in $p_{3/2}$ states, is 0.63 or 0.69, corresponding to the use of free-nucleon or "empirical" g factors for the odd nucleons.[9] In LS coupling, for Li^8 the value 0.49 is obtained.[10] (For Li^6, the LS value is 0.85.)With intermediate coupling, Kurath[11] is able to fit the observed value.

Attempts to apply this method to other nuclides are in progress.

I am indebted to T. B. Novey of this laboratory and to V. L. Telegdi of the University of Chicago for having suggested this experiment and for many stimulating discussions.

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MAGNETIC MOMENT CALCULATION FOR Li^{8}†

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In view of the recent measurement[1] of the nuclear g factor of Li^8, it is of interest to see whether the intermediate-coupling model[2] is consistent with the measurement. The ground state is assumed to be the $(J=2,\ T=1)$ state, which is consistent with the experimental evidence and is also the theoretically predicted assignment for the ground state. The calculation has been carried out as a function of the spin-orbit coupling parameter, a/K, for the relative range of nuclear forces given by $L/K=6.8$. These quantities are defined in reference 2.

The resulting values for the magnetic moment are given in Fig. 1, and an intersection[3] of the theoretical curve with the experimental value occurs for $a/K \approx 2.1$. This is consistent with the other evidence[4] for $A=8$, the $M1$ transition width for the 17.6-Mev gamma decay of the $(J=1,\ T=1)$ state in Be^8, which leads to a value of $a/K \sim 2.5$. Therefore the intermediate-coupling model is in agreement with the experimental evidence.

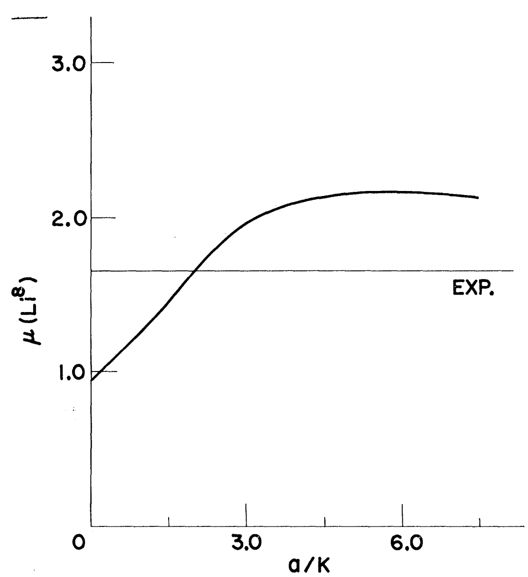

FIG. 1. Magnetic dipole moment of Li^8 in nuclear magnetons as a function of a/K.

†Work performed under the auspices of the U. S. Atomic Energy Commission.

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