The Magnetic Moment of the Deuteron

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RECENTLY Nafe, Nelson, and Rabi[1] have made very precise measurements of the hfs separations of the $^2S_{\frac{1}{2}}$ ground state of the hydrogen and deuterium atoms. The ratio of the hfs separations depends theoretically only on the ratio of the nuclear magnetic moments and the ratio of the reduced masses of the hydrogen and deuterium atoms:

$$\frac{\nu_H}{\nu_D}=\frac{4}{3}\frac{\mu_H}{\mu_D}\left(\frac{m_H}{m_D}\right)^3. \tag{1}$$

The initial experimental value of $\nu_{\rm H}/\nu_{\rm D}$ reported[1] did not agree with the computed value. Halpern[2] has given reasons why the reduced masses might enter to the $\frac{3}{2}$ power rather than the cube. Since the precision of the computed value depends upon the precision of measurement of $\mu_{\rm H}/\mu_{\rm D}$, we have undertaken to improve the precision of this value. Previous measurements gave the value 3.2571 ± 0.001.[3,4]

The measurements were carried out by means of the nuclear r-f absorption techniques of Purcell, Torrey, and Pound[5] and the author.[6] Two series of measurements were made in fields near 8000 gausses. In one series separate samples of D_2O and H_2O were placed in a magnetic field made as homogeneous as possible, and resonance absorption was detected simultaneously, using two detectors. The frequencies at which resonance occurred for both samples at the same value of the magnetic field were measured. The samples were then interchanged and the measurements repeated.

In the second series, a single sample of 85 percent D_2O was used, and two coils were wound about it; resonance was detected as before.

The results of the measurements are

$$\mu_{\rm H}/\mu_{\rm D}=3.25731\pm 0.00015.$$

The precision of these results was limited by a phenomenon we have not been able to explain. The deuteron resonance, displayed on a cathode-ray tube sweep, did not appear at two points on the sweep corresponding to the same value of the magnetic field, as does the proton resonance when sine-wave magnetic-field modulation is used. Instead, two rather indefinite series of wiggles appeared on the trace at values of the magnetic field which were not equal, but corresponded to times slightly later than those at which resonance was expected to occur. The displacement was roughly constant in magnetic field, at about 3 gausses above and below the resonant field, respectively. The type of signal observed was not affected by the addition of $FeCl_3$ to the D_2O, by switching from the bridge type of detection to the super-regenerative detector, or by changing the amplitude of the magnetic-field modulation.

Because of this effect the measurements could not be made by superposing the deuteron and proton resonances, as had originally been intended. Instead, the proton resonances had to be located on the trace at points corresponding to a field midway between the values at which the deuteron signals appeared.

The computed value of the hfs separation rate $\nu_{\rm H}/\nu_{\rm D}$, using Eq. (1) and the new value for $\mu_{\rm H}/\mu_{\rm D}$, is 4.33954 ± 0.0002. A $\frac{3}{2}$ power dependence of the reduced mass gives a computed value of 4.34131 ± 0.0002.

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Disintegration Scheme of 1.7-Year Cs^{134}

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THE disintegration of the long-lived isomer of Cs^{134} has been studied with a short magnetic lens β-ray spectrometer together with coincidence techniques.

The shape of the β-ray spectrum was studied down to the low energy cut-off of the counter window ($\sim$0.015 Mev) by use of a source of thickness $\sim$0.1 mg/cm^2 mounted on a mica backing ($\sim$1.0 mg/cm^2). A Fermi plot of this spectrum, using the exact Fermi function of (Z, η) for $Z=55$, is shown in Fig. 1. The spectrum has a maximum energy

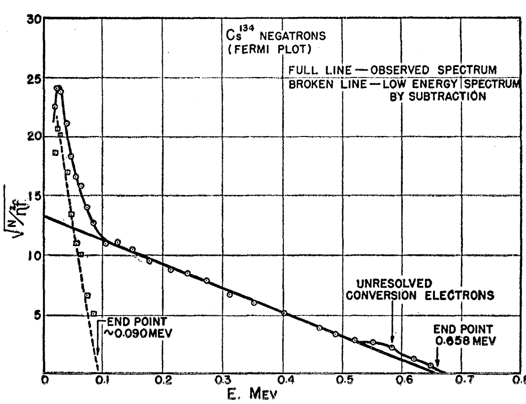

FIG. 1. Fermi plot of β-ray spectrum of Cs^{134}.

of 0.658 ± 0.030 Mev, and the Fermi plot is very closely represented by a straight line down to an energy of $\sim$0.09 Mev. To determine whether the rise at low energies is due to the β-spectrum being complex, a calibrated γ-counter was placed behind the source in the β-ray spectrometer, and coincidences were observed between γ-rays and β-rays above and below the break in the Fermi plot. The two β-ray energies selected were 0.250 Mev and 0.035 Mev, respectively. An observation of the number of coincidences per recorded β-ray showed that, on the average, each β-ray at the 0.035-Mev point is accompanied by 1.20 ± 0.03 times as much γ-ray energy as each high energy β-ray. This indi-