The Nuclear Spin of C^{13}

Using Rabi's magnetic-resonance molecular-beam method, Hay has observed both the sign and the magnitude of the gyromagnetic ratio of the C^{13} nucleus.[1] By making the rather safe but still slightly theoretical assumptions that he is dealing with a ^2P state and that the spin part S of the "nuclear spin" I consists of neutron spin with no large admixture of proton spin, he is able to conclude from the sign of the gyromagnetic ratio that the nuclear spin is 1/2. This disagrees with the nuclear spin 3/2 inferred earlier from analysis of a band spectrum which could not be completely resolved.[2] It is unfortunate, especially in view of such a disagreement, that an experimental determination should have to lean so heavily on theoretical hypotheses.

It is possible to reach Hay's conclusion from a well-established empirical rule, instead of theoretical hypothesis, if we make use of the observed magnitude of the gyromagnetic ratio as well as its sign. The rule is that all hitherto known magnetic moments of odd nuclei (there are more than fifty of them) lie between the limits given by the simple single-particle model.[3] The corresponding limits for the gyromagnetic ratio g in the odd-neutron case are

$$\mu_\nu/I < g < -\mu_\nu/(I+1),$$

where $\mu_\nu = -1.96$, the lower limit of the observed magnetic moment of the neutron,[4] in nuclear magnetons. The measured gyromagnetic ratio, $g = +1.401 \pm 0.004$, does not lie strictly within these limits for any value of I. However, it exceeds the upper limit 1.30 for $I = 1/2$ by only a few percent. For higher values of I, it exceeds the limit by about a factor two or more.

In Fig. 1, nuclear magnetic moments are plotted against

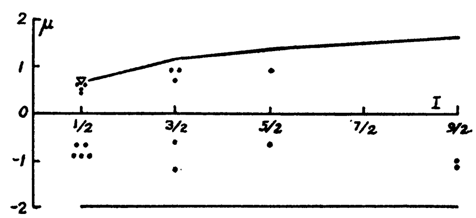

FIG. 1. The magnetic moments and nuclear spins of the odd-neutron nuclei. The triangles are possibilities for C^{13}.

nuclear spins, for odd-neutron nuclei only.[3] The upper line is the limit given by the single-particle model with $I = L - 1/2$, and the lower line with $I = L + 1/2$. The dots represent the previously known data for the odd-neutron nuclei. (The data for the odd-proton nuclei, not shown, are about twice as numerous.) The triangles show two possibilities for C^{13}. The previous data for small values of I tend to crowd close to the limit given by $I = L - 1/2$, *both in Fig. 1 and in the odd-proton case*,[3] and the triangle for $I = 1/2$, just above the limit, does not deviate appreciably from the regularity of the other data. The triangle for $I = 3/2$ would be seriously discordant with the other data, and may therefore be rejected.

One notes that the nuclear spin 1/2 for C^{13}, thus determined in another way from Hay's data with a minimum of theoretical description, is the value predicted both by the Hartree model[5] and by the alpha-model[6] on the basis of the Larmor-Thomas type of spin-orbit coupling. The magnetic moment is smaller than these models would suggest.

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Concentration of Radioactive Bromine Produced by Gamma-Radiation

One of the difficulties encountered in the study of nuclear reactions of the (γ, n) type is the small beta-ray activity ordinarily obtained, even with the strongest gamma-ray sources. The high energy gamma-rays used for such work (*viz.* those from the reaction $Li^7(p, \gamma)Be^8$) are but weakly absorbed in matter, and this suggests that a concentration of the radioactive atoms produced in a large bulk of material should increase the activity obtained. Moreover, the (γ, n) reaction, which is the only one thus far observed under gamma-ray bombardment, leads to an isotope of the irradiated element. Accordingly, we have made some experiments with a view to adapting the Szilard-Chalmers[1] technique to this problem.

Bromine was irradiated in the form of ethyl bromide, 500 cc of which were contained in a spherical vessel constructed so as to surround almost completely the source of gamma-rays. The active bromine was separated as silver bromide in the usual way. A composite decay curve was obtained which was resolvable into periods of 6.4 minutes, 18 minutes and 4.5 hours with relative intensities at saturation of 1 : 3 : 2, respectively. The 6.4-minute period is that of Br^{78} and the others belong to the isomeric Br^{80}. These isotopes are formed from the two stable ones Br^{79} and Br^{81}, in each case by the loss of a neutron. It is noteworthy that the method of concentrating the activity also establishes the chemical nature of the isotope.

The radioactive sources prepared in this way were at least ten times as strong as those obtainable without concentrating the activity. Beta-ray sources with initial activity of several thousand counts per minute were made. Contaminating activity produced by fast neutrons from the normal deuterium content of the ion beam striking the lithium target was shown to be negligible.

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