Letters to the Editor

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L-Converted Isomeric Transition*

M. GOLDHABER,** C. O. MUEHLHAUSE, AND S. H. TURKEL
The Argonne National Laboratory, University of Chicago, Chicago, Illinois
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PRELIMINARY to an investigation of the activation of Ir by resonance neutrons, it seemed of interest to study the radiations associated with the 1.5 min. Ir activity produced by slow neutron capture[1] in Ir. These radiations had been previously believed to be β-rays, and on that basis an atomic activation cross section for thermal neutrons of 2×10^{-24} cm^2 was ascribed to this activity by Seren, Freidlander, and Turkel.[2] By studying the absorption in Be and Al of the radiations detected with a mica window Geiger counter we found, however, that they were largely x-rays of the L region of Ir. The main L emission lines of $_{77}$Ir and its neighbors, $_{76}$Os and $_{78}$Pt, are shown in Fig. 1, together with the K absorption edges of the elements from Fe–Se. There are three possible ways to account for such L radiation: (1) L electron capture in Ir leading to Os (L radiation of Os). (2) Internally converted isomeric transition in Ir (L radiation of Ir). (3) β-emission from Ir followed by a strongly internally converted γ-ray (L radiation of Pt). Number 3 could be excluded because no β-rays of an energy sufficiently high to be compatible with the short half-life of 1.5 min. could be found. To distinguish experimentally between the theoretically unlikely case number 1, and number 2, critical absorption measurements were made on the x-rays. Because of the wide spread in wave-length of the L radiations, it was important to isolate some of the L components for this work. This was accomplished by using a Zn filter (23.5 mg/cm^2) which practically completely removes all but the L III$-M$ V and L III$-M$ IV components of Ir and Os. These components were then shown to be more strongly absorbed in Cu than in Zn, indicating Ir L x-rays arising from the removal of an L III electron. The radiation filtered by 28.2 mg Cu/cm^2 was shown to be about equally well absorbed by further layers of Cu, Ni, or Fe, which excludes Os L x-rays.

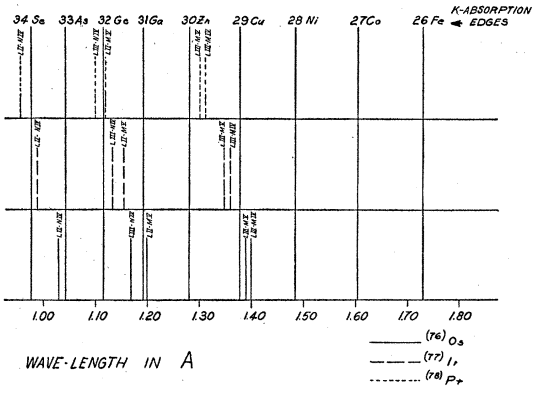

FIG. 1. The L emission lines of Os, Ir, Pt and the K absorption edges of the elements from Fe to Se.

In a few percent of the isomeric transitions unconverted γ-rays are emitted. Absorption in Pb and other elements shows that these are not homogeneous. An approximate energy of 60 Kev was obtained for the highest energy γ-rays present. Internal conversion electrons were detected with an ionization chamber, having a window equivalent to 1.5 mg Al/cm^2 in stopping power, and their energy compared with those from Co^{60} (10.7 min.).[3] In this manner a value of ~47 Kev was found for the internal conversion electrons of Ir. When the value of the Ir L work function is added, one obtains ~60 Kev as the energy of the isomeric transition, in agreement with the result deduced from Pb absorption for the hardest γ-rays. If we identify the excitation energy of the metastable state with this value it is definitely lower than the work function for a K-electron of Ir (76 Kev). The softer photons found have about one-half of the energy of the hard component. They are possibly due to "two-quantum" transitions.[4]

The atomic activation cross section of Ir (1.5 min.) for thermal neutrons can be estimated to be of the order of 100×10^{-24} cm^2. Unpublished experiments carried out at the Argonne Laboratory and at the University of Illinois make it probable that the 1.5 min. Ir activity is associated with a metastable state of Ir^{192} (70 d).

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** University of Illinois.
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[3] M. Deutsch and L. G. Elliott, Phys. Rev. **62**, 588 (1942).
[4] See M. Goeppert-Maier, Ann. d. Physik **9**, 273 (1931); R. G. Sachs, Phys. Rev. **57**, 194 (1940).

Magnetic Moment of the Triton

H. L. ANDERSON* AND A. NOVICK
Argonne National Laboratory, Chicago, Illinois
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WE have measured the ratio of the nuclear g values of the triton and the proton by the method of nuclear induction.[1] Our experimental arrangement was a modification of those which have been used by Bloch, Hansen, and Packard,[1b,d] and by Purcell, Torrey, and Pound.[1a] We were able to observe the nuclear induction peaks of both the triton and the proton simultaneously on the same cathode-ray oscillograph screen while both these substances were in the same magnetic field.

The magnetic field was provided by an electromagnet with 5-inch diameter pole pieces and with a 1-inch gap. The radiofrequency (r-f) fields for the two samples were produced inside of two equal coils about $\frac{1}{2}$ inch in diameter and about $\frac{1}{2}$ inch long. These were symmetrically disposed about the center of the magnetic field and spaced 1 inch apart. The axes of the coils were at right angles to the direction of the magnetic field. The r-f current for the coils was produced by two generators, one crystal controlled (Set A), while with the other it was possible to vary the frequency continuously (Set B). In each case the coil was in one arm of a "twin T" network which was inserted between the generator and a high frequency receiver (National RHO). The network could be adjusted so that no signal would be transmitted to the receiver from the generator. However, a modulated r-f signal of the same frequency developed in the coil would be detected by the receiver and presented as an audio signal on a cathode-ray oscilloscope screen.

To present the nuclear induction peaks on the cathode-ray screen, a small 60-cycle component was superimposed on the main magnetic field by means of a 60-cycle alternating current flowing through an auxiliary winding on the poles of the magnet. In this way, the magnetic field would give the magnetic moments inside the coil a Larmor precession frequency which varied through the frequency of the generator twice each cycle.

To observe the proton peaks, a drop of ordinary distilled water contained in a Pyrex tube was inserted in one of the coils. Following Bloch, Hansen, and Packard,[1] a small amount of $Fe(NO_3)_3$ was added to the water to speed the establishment of thermal equilibrium. Two peaks per cycle were observed when the frequency of the generator was near 23 megacycles and the magnetic field near 5400 gauss, corresponding to each coincidence of the Larmor with the applied frequency.

With a drop of water made from some tritium gas which was available in this laboratory, and conditioned in the same way, we observed identical peaks at the same frequency and field due to the ordinary hydrogen which was present in this water. In addition, however, we observed the same pattern at a *lower* value of the magnetic field, while keeping the frequency of the generator fixed. These second peaks were not present in the ordinary water sample and we, therefore, identified them with the magnetic moment of the triton.

For a precise determination of the ratio of the nuclear g values of the triton and the proton, the tritium water was put in one coil while the ordinary water was put in the other. The audio outputs of the two receivers were connected to the same oscilloscope through an electronic switch so that the patterns due to both samples could be observed simultaneously. The frequencies of the two generators were then adjusted so that the peaks due to the triton moments in the one sample coincided with those due to the proton moments in the other. The frequencies of the two generators were measured using a Signal Corps BC-221 AE frequency meter. With the samples interchanged, the ratio of the triton frequency to the proton frequency differed by 0.05 percent, this being the difference in the value of the magnetic field at the positions of the two samples. The geometric mean of these two frequency ratios gives directly the ratio of the nuclear g values and cancels any error due to differences in the value of the magnetic field at the two samples. Measurements made at three values of the crystal frequency of Set A, 23.0947, 25.4902, and 22.8301 megacycles, gave the same result within 0.01 percent. Our result gives for the ratio of the nuclear g value of the triton to that of the proton, 1.06666 ± 0.00010.

The fact that the nuclear g value of the triton is larger than that of the proton disagrees with the estimate of Sachs and Schwinger[2] based on the wave function obtained by Gerjuoy and Schwinger.[3] In fact, it shows that the admixture of ${}^4D_{\frac{1}{2}}$ wave functions to the ground state of the triton is not sufficient to account for its magnetic moment.

This work was done under the auspices of the Manhattan District at the Argonne National Laboratory.

* Member of the Institute for Nuclear Studies, University of Chicago.

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Spin and Magnetic Moment of Tritium*

F. Bloch, A. C. Graves, M. Packard, and R. W. Spence
Stanford University, California, and the Los Alamos Scientific Laboratory, Santa Fe, New Mexico

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NUCLEAR induction[1] has been applied to a small sample containing a 0.3 molar solution of $MnSO_4$ in H_2O, and clearly distinguishable signals have been obtained from both hydrogen isotopes, H_1 (proton), and H_3 (triton) present in the sample. A density determination indicated that about 80 percent of the hydrogen was present in the form of H_3, and about 20 percent in the form of H_1.

A first series of observations was performed by keeping the frequency constant at $\nu = 41.5$ megacycles, and merely varying the magnetic field B_0. The signal originating from H_3 appeared at a field $B_0 = 9160$ gauss, and, except for being about three times larger, had an identical sign and shape as the signal originating from H_1, which appeared at a field $B_0 = 9770$ gauss. It leads to the following conclusions:

(a) The gyromagnetic ratio γ_T of H_3 is about 7 percent larger than γ_P, the gyromagnetic ratio for H_1, as indicated by the ratio of the respective resonance fields B_0.

(b) Within the observational error of about 30 percent, the magnitude of the signals agrees in their ratio with the ratio of the respective amounts of the two isotopes. This shows that the spin of H_3 is the same as that of H_1, which is known to be $\frac{1}{2}$. A spin of $\frac{3}{2}$ or more for H_3 would have resulted in a fivefold[2] larger signal relative to that of H_1 than was observed and could therefore be definitely excluded.

(c) With the signals which originate under identical radio frequency conditions from the two isotopes having the same sign, the relative orientation of their magnetic moments and angular momenta is the same. Since H_1 is