The resulting critical rf field for instability is given by Eq. (1). A similar calculation using conventional antiferromagnetic spin-wave theory gives the same result.

Physically, the interpretation here is exactly analogous to that of the instability in ferromagnetic systems.[3] When the uniform mode reaches a critical amplitude, the effect of the nonlinear terms is to cause an exponential growth of the degenerate higher-k spin-wave amplitudes. This exponential growth acts as a loss to the uniform mode and holds its amplitude fixed at the critical value. Therefore an increase in rf field does not yield a corresponding increase in transverse moment, since $k \neq 0$ spin waves have no net transverse moment. The instability thus produces an apparent saturation of the uniform-mode rf susceptibility in a magnetic resonance experiment.

Experimental evidence for premature saturation and spin-wave instability has been seen in the canted antiferromagnet, $KMnF_3$. A detailed account of these experiments together with a more general theory of instability in antiferromagnetic systems valid for canted as well as simple antiferromagnets will be published elsewhere.[7] An anomalous low-level saturation has also been observed[8] in $CuCl_2 \cdot 2H_2O$ below its Néel temperature.

We conclude therefore that studies of $k \neq 0$ spin-wave relaxation of the kind that have proven so fruitful in the understanding of relaxation processes in the ferromagnetic insulators are also possible in antiferromagnetic systems.

The possibility of spin-wave instability in antiferromagnetic systems was first considered while the authors were at the Physics Department of the University of California (Berkeley). It is a pleasure to thank A. M. Portis and C. Kittel for stimulating discussions.

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NEW β^- ACTIVITY INDUCED BY PHOTON BOMBARDMENT OF LITHIUM*

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We report here on the observance of a 110-msec electron activity, with $E_\beta(\max) > 15$ MeV, following the irradiation of lithium by high-energy photons. This activity is indicative of the thus far undiscovered isotope H^5.

A very pure lithium target of natural isotopic abundance was irradiated by the bremsstrahlung beam of the Purdue 320-MeV synchrotron. In the beginning of the experiment the target angle with respect to the beam was 30°. Facing the target at a distance of 3 in., well outside the beam, a β-ray detector was placed. In the latter part of the experiment the target was placed perpendicular to the beam in front of a small magnet that was used as a 90° spectrometer. The β-ray detector was placed $2\frac{1}{2}$ in. from the exit of the magnet and shielded from direct radiation by the target with lead 2 in. thick. The β-ray detector consisted of a thin plastic scintillator in coincidence with a 2-in. × 3-in. sodium-iodide counter. The coincidence arrangement was necessary to reduce the background. To eliminate most of the cosmic rays a large plastic anticoincidence counter was placed on top of the two counters. Five milliseconds after each beam burst (the duration of a burst was about 10 μsec) we started counting the pulses of the detector in ten consecutive gated scalers until the next burst. A block diagram of the electronics is shown in Fig. 1. The repetition rate of the synchrotron was usually 3 per sec and the length of each gate was 30 msec. Some runs were taken with shorter gates to study in detail the decay spectrum in the first 60 msec after the beam burst. The discriminator of the sodium-iodide counter was always set to eliminate all electrons with energy smaller than 6 MeV [that is well above $E_\beta(\max) = 3.5$ MeV of He^6]. Usually the discriminator setting was higher. The β-ray detector,

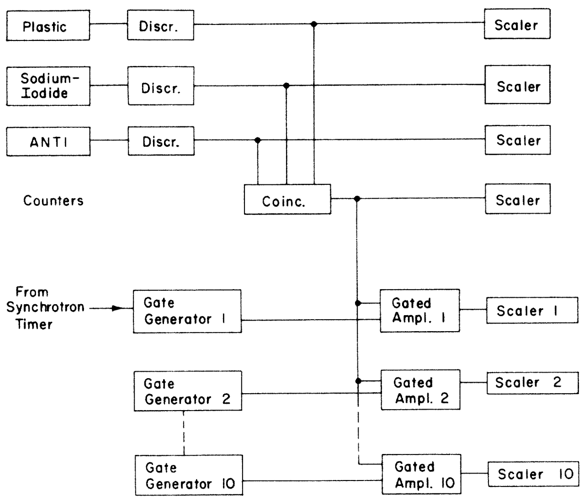

FIG. 1. Block diagram of electronics.

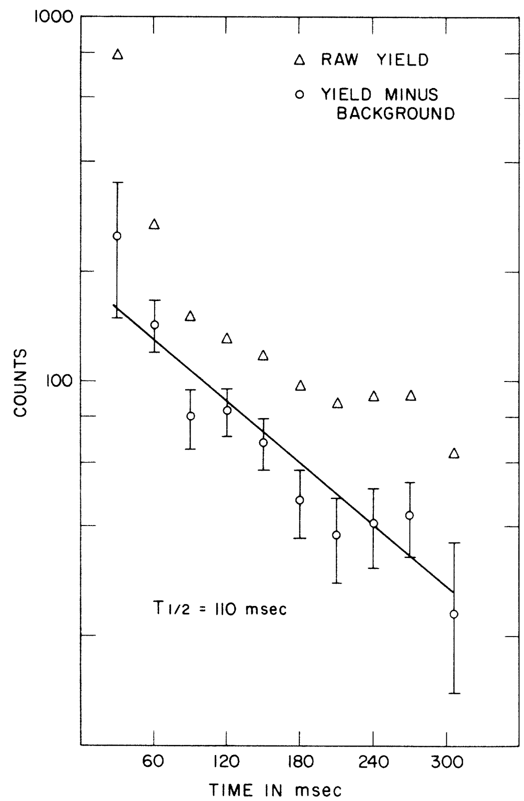

FIG. 2. A typical decay spectrum of the energetic β^- rays originating from the photon bombardment of lithium. The background target was $\frac{1}{20}$-in. iron.

electronics, and magnet were frequently tested using the following β emitters[1]: Li^8, $E_\beta(\max)=13$ MeV, $T_{1/2}=0.8$ sec, produced in the reaction $Be^9(\gamma,p)Li^8$; B^{12}, $E_\beta(\max)=13$ MeV, $T_{1/2}=0.02$ sec, produced in the reaction $C^{13}(\gamma,p)B^{12}$; N^{12}, $E_\beta(\max)=16$ MeV, $T_{1/2}=0.01$ sec, produced in the reaction $C^{12}(\gamma,\pi^-)N^{12}$.

In the first part of the experiment the runs were taken with a 1-in. lithium target that was wrapped in 1-mil aluminum. Background runs were taken with a $\frac{1}{20}$-in. iron target, also wrapped in 1-mil aluminum. After the installation of the magnet, the runs were taken with a 1-in. lithium and a $\frac{1}{16}$-in. copper target. The magnet current was varied to take both the electron and positron spectrum of each target. A typical spectrum is shown in Fig. 2. The background consisted mainly of cosmic rays, except in the first 60 msec after the beam when the room background was the dominant one. The room background was independent of the target and of the magnet setting. A small fraction of the background was due to interactions in the scintillator. In the case of the background targets a small number of counts originated from photodisintegration products of these targets. We have found a 110-msec electron activity in the runs taken with a lithium target. The half-life is slightly dependent upon the background target, insofar as the background target gives the above-mentioned noncosmic-ray counts. The half-life, averaged over all the runs, is 110 ± 30 msec.

Because of the small production cross section and the large cosmic-ray background we could measure only a lower limit of 15 MeV for the end-point energy of the activity. A comparison of the measured part of the spectrum of the new activity with a measurement of the well-known β spectrum[2] of Li^8 indicates that the end-point energy is probably several MeV higher.

The production cross section for the new activity is 1.8 ± 0.6 μb. Production cross section σ is defined by the expression

$$Y=\sigma NQ\Omega\eta,$$

where Y is the electron yield, N is the target thickness in atoms per cm^2, Q is the number of effective quanta, Ω is the solid angle, and η is the efficiency of the β-ray detector. The uncertainty in the cross section is mostly due to the uncertainty in the absolute efficiency of the detector for the new activity.

To test the possibility that the observed activity might have been induced by slow neutrons, we put a copper target in the beam and placed the lithium target in front of the detector just outside the beam. The slow neutron flux at this point was the same as in the beam. The effective solid angle of the detector for counts from the lithium in this position was four times larger than from lithium placed in the beam. No counts were observed outside the normal background. To test if the observed activity was produced in the second half of the lithium by pions, fast protons, etc. generated in the first part of the target, we made a run with $\frac{1}{16}$-in. lead in the beam 5 in. before the lithium. No increase in counting rate originating from the lithium was observed. To test the possibility that the observed activity was produced in an oxygen contamination of the lithium, we made a few runs with a water target. On the basis of these runs we have excluded this possibility. Thus, we conclude that the observed electron activity is produced in a gamma-induced reaction.

The most likely origin of the new activity is a new isotope. The inspection of a list of nuclear ground-state energies[3] suggests H^5. A particle-stable H^5 can decay by β^- emission to the ground state with $E_\beta(\max) \sim 19$ MeV, or to the first excited state of He^5 with $E_\beta(\max) \sim 14$ MeV. The transition is first-forbidden since the ground state of H^5 is $(\frac{1}{2}^+)$, while the ground state and first excited state of He^5 are odd. Assuming the new activity is the β decay of H^5 to the ground state of He^5, we find its $\log ft = 5.4 \pm 0.1$ (we assumed the branching rate is 90%). This is quite appropriate[4] for a favored first-forbidden transition, such as those observed to occur in nuclei with a few particles above or below the doubly magic Pb^{208}.

Several authors[5-8] have speculated on the existence of H^5 with quite opposite conclusions regarding the stability of H^5 against particle emission.[9] An experiment[10] designed to look for H^5 by searching for delayed neutrons after the photon bombardment of lithium is reported unsuccessful.

Assuming that the activity is produced in the reaction $Li^7(\gamma, 2p)H^5$,[11] the production cross section seems low in comparison with $(\gamma, 2p)$ cross sections in other light elements like N^{14}, O^{16}, F^{19},[10,12] etc. This is not surprising since the production of H^5 requires the breakup of the tightly bound helium core in Li^7. We note that the $He^4(\gamma, 2p-2n)$ cross section is also very small.[13]

We conclude that the $\log ft$ value, end-point energy, and cross section of the electron activity created by the photon bombardment of lithium are in the range that one might expect for H^5 and thus provide strong evidence for the stability of H^5 against particle emission.[14]

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