Letters to the Editor

PUBLICATION of brief reports of important discoveries in physics may be secured by addressing them to this department. The closing date for this department is, for the issue of the 1st of the month, the 8th of the preceding month and for the issue of the 15th, the 23rd of the preceding month. No proof will be sent to the authors. The Board of Editors does not hold itself responsible for the opinions expressed by the correspondents. Communications should not exceed 600 words in length.

(d–n) Reactions at 15 Mev

R. B. ROBERTS AND P. H. ABELSON
Carnegie Institution of Washington, Department of Terrestrial Magnetism, Washington, D. C.
May 24, 1947

NEUTRON emission is usually considered as "evaporation" from an excited nucleus. According to this picture most of the neutrons should have relatively low energies, and there should be no large directional effects.

Neutron emission has also been observed from the disintegration of the deuteron on striking the target. In this process the neutrons are predominately in the forward direction and have roughly one-half the energy of the incident deuteron. Although this process was suggested in 1933,[1] it has only been observed with 200-Mev deuterons.[2] At lower energies the only evidence for this type of disintegration comes from the d–p reactions in which the neutron is captured.

We have investigated the neutrons produced by the 60-inch cyclotron by placing threshold detectors[3,4] at 0° and 90° with respect to the cyclotron beam.

Table I shows the effects produced in various detectors for different bombarding particles and targets. The observed activities are reduced to numbers proportional to the number of radioactive atoms formed in the detector per particle impinging on the target. Each column is then normalized. A probe target was used, and the energies listed are calculated from the radius at the probe. The relative values for any one bombardment are considerably more accurate (10 percent) than relative values from one target to another (30 percent). Any background would tend to reduce the following prominent features of the observed distribution.

TABLE I. Summary of data.

Detector		$Cu^{63}(n, 2n)Cu^{62}$	$Ag^{107}(n, 2n)Ag^{106}$	$Al^{27}(n, \alpha)Na^{24}$	$Al^{27}(n, p)Mg^{27}$	$Mn^{55}(n, \gamma)Mn^{56}$
Threshold		12–13 Mev	5–7 Mev	3.77 Mev	1.95 Mev	0
Bombarding particle and target						
H^2+Au 15 Mev	0°	9	18	14	20	210
	90°	<1	3	2	5	140
H^2+Cu 15 Mev	0°	230	290	210	360	1300
	90°	<2	43	42	130	940
H^2+Al 15 Mev	0°	1000	1000	1000	1000	1000
	90°	<20	550	42	110	690
H^2+C 16 Mev	0°	<20	230	830	1600	920
	90°	<10	4	14	55	600
H^1+Cu 7.5 Mev	0°		<0.1	<0.2	0.08	50
	90°		<0.05	<0.1	0.06	30
He^4+Cu 30 Mev	0°				13	82
	90°				7	48

1. With protons and alpha-particles the distribution is symmetrical and agrees with evaporation from a compound nucleus.
2. The yield of neutrons from deuteron bombardment is far greater than from alpha-bombardment, although the total energy available is about the same and both are above the barrier.
3. With deuteron bombardment there is a large excess of neutrons in the forward direction.
4. This excess is greater for the higher energy neutrons.
5. Neutrons are emitted in the forward direction with sufficient energy to produce the $Cu^{63}(n, 2n)Cu^{62}$ reaction, which has a threshold of 12–13 Mev.[3]
6. The yield of high energy neutrons is far greater for aluminum than for gold or copper.

These observations indicate that the usual concept of neutron evaporation is not adequate to explain these d–n reactions. There is a considerable similarity to the deuteron disintegration observed at 200 Mev (forward distribution of high energy neutrons). However, certain differences are also apparent. The theory of deuteron disintegration[2,5,6] predicts an increase in cross section with Z. Our observations show far greater yields with aluminum than with copper or gold. Also neutrons are present with nearly the full kinetic energy of the incident deuteron.

The observations of Pool[7] at 6.3 Mev show practically no change in neutron yield from aluminum to silver.

Further work is in progress to determine whether the reaction Q is an important factor in this process, as might be indicated by the anomalous results obtained with carbon.

[1] E. O. Lawrence, M. S. Livingston, and G. N. Lewis, Phys. Rev. **44**, 56 (1933).
[2] J. R. Oppenheimer, Richtmyer Lecture, January 30, 1947.
[3] R. Sagane, Phys. Rev. **53**, 492 (1938).
[4] B. T. Feld, R. Scalettar, and L. Szilard, Phys. Rev. **71**, 464 (1947).
[5] J. R. Oppenheimer, Phys. Rev. **47**, 845 (1935).
[6] S. M. Dancoff, Abstract G5, Washington Meeting Am. Phys. Soc., 1947.
[7] M. L. Pool, Phys. Rev. **53**, 707 (1938).

The Magnetic Susceptibility of Sodium in Liquid Ammonia Solutions at Low Temperatures

R. B. GIBNEY AND G. L. PEARSON
Bell Telephone Laboratories, Inc., Murray Hill, New Jersey
June 4, 1947

R. A. OGG[1] has recently reported the existence of superconductivity in quickly frozen solutions of sodium in liquid ammonia at temperatures as high as 180 degrees Kelvin. Experimental evidence presented to support the occurrence of superconductivity at this remarkably high temperature includes the detection of persistent currents[1] by means of an adaption of the classical Kammerlingh Onnes "ring experiment" and a qualitative demonstration which led to the conclusion that these solutions have an abnormally high diamagnetic susceptibility.[2]