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Cross Sections for the $O^{16}(n,p)N^{16}$ Reaction from 12 to 18 Mev[*]

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The energy dependence of the $O^{16}(n,p)N^{16}$ reaction cross section has been determined for neutron energies from 12 to 18 Mev. For 14-Mev neutrons, the absolute value of the reaction cross section was found to be 89±30 mb.

CROSS sections for the $O^{16}(n,p)N^{16}$ reaction have been measured for neutron energies from 12 to 18 Mev. The residual nucleus N^{16} has a 7.35-sec half-life and decays back to O^{16} by complex beta emission;[1] the energy dependence of the cross section was determined by observing the relative amounts of this activity that were induced in a water sample. An approximate absolute scale was assigned to these data by irradiating a CuO sample with 14-Mev neutrons and comparing the N^{16} activity from the $O^{16}(n,p)N^{16}$ reaction to the 9.9-min Cu^{62} activity from the $Cu^{63}(n,2n)Cu^{62}$ reaction, which has a known cross section of 0.51±0.04 barn.[2]

Monoergic neutrons were made by bombarding a 3-cm-long tritium gas target with deuterons from a 2.5-Mev electrostatic accelerator. The target was filled to a pressure of 25-cm Hg. With a deuteron energy of 1.80 Mev at the center of the gas target, the energy of the neutrons from the $T(d,n)He^4$ reaction varied from 18.0 Mev at an angle of 0° with respect to the deuteron beam to 12.4 Mev at an angle of 150°.[3]

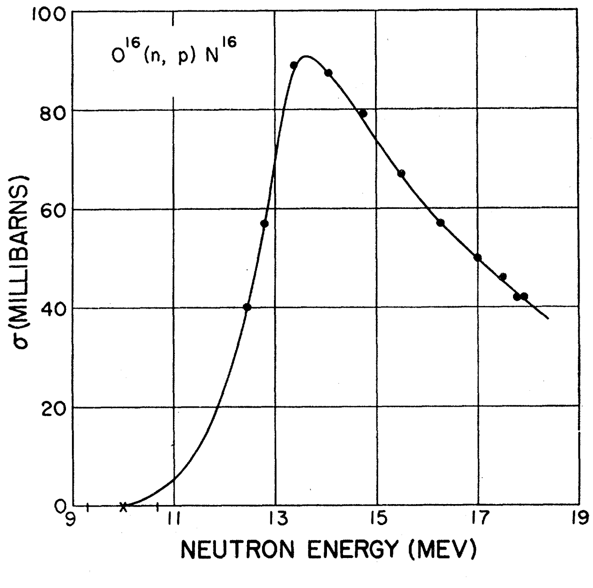

FIG. 1. Cross section for the $O^{16}(n,p)N^{16}$ reaction.

Irradiations of 40-sec duration were made on a 5-g water sample successively placed at 15° angular intervals at a distance of 9 cm from the neutron source. The water sample was contained in a Lucite cell. At least four irradiations of the sample were made at each position, and the relative intensity of each irradiation was determined by measuring the integrated beam current. Deuteron beams of approximately three μa were used; during each irradiation the variation in beam current was held to within ±3 percent.

A $\frac{1}{2}$-mm thick × 4-cm diameter stilbene crystal mounted in a Lucite holder on a 5819 photomultiplier was used to detect the N^{16} activity. When the scintillator was placed near the neutron source following an irradiation, the background counting rate due to activities induced in the materials of the gas target assembly was very large, and it was necessary to remove the water sample from the vicinity of the source for counting. Therefore, the detector was placed on the floor 8 ft below the neutron source, and an arrangement was used which allowed the irradiated sample to slide down a rod into position near the scintillator. Pulses from the photomultiplier were fed to a preamplifier, amplifier, and scaler; the register pulse from the scaler was fed to one pen of a dual-pen Brush recorder, and timing pulses were fed to the other pen. The timing sequence for irradiating and counting the sample was controlled by a system of relays and timers interlocked with the accelerator's beam shutter and the detecting system.

To determine the approximate value of the $O^{16}(n,p)N^{16}$ reaction cross section at 14 Mev, the Lucite cell was filled with CuO, two irradiations of 100 and 200 sec duration were made, and the "background" activity from the empty Lucite cell was measured. In each case a cross section of 89 mb was obtained for the $O^{16}(n,p)N^{16}$ reaction. Even though the decay schemes of N^{16} and Cu^{62} are dissimilar, it was assumed that the two activities were detected with equal efficiency. Since the N^{16} betas have higher energies than the Cu^{62} positrons, the value of 89 mb may represent an upper limit because of the difference in self-absorption in the sample. However, this value is probably not in error by more than 30 percent and agrees within experimental error with the cross section of 49±25 mb reported by Paul and Clark.[4]

Figure 1 shows the data normalized to the value of 89 mb at 14 Mev. The threshold of 10.0±0.7 Mev was

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[*] Work done under the auspices of the U. S. Atomic Energy Commission.

[1] Bleuler, Scherrer, Walter, and Zunti, Helv. Phys. Acta **20**, 96 (1947).

[2] Stuart G. Forbes, Phys. Rev. **88**, 1309 (1952).

[3] Hanson, Taschek, and Williams, Revs. Modern Phys. **21**, 635 (1949).

[4] E. B. Paul and R. L. Clark, Can. J. Phys. **31**, 267 (1953).

TABLE I. Laboratory differential cross sections for neutrons from the $T(d,n)He^4$ reaction for a deuteron energy of 1.80 Mev.

θ_{lab}	0°	30°	60°	90°	120°	150°
$\sigma(\theta_{\text{lab}})$ mb/sterad	22.5	18.8	12.5	9.5	8.8	9.7

determined from the reported reaction Q value of 9.4 Mev.[5] Neutron energy spreads vary from ±0.2 Mev at a mean energy of 18 Mev to nearly ±1 Mev from 12 to 15 Mev. In correcting the observed activities for the angular distribution of the $T(d,n)He^4$ neutrons, the laboratory differential cross sections shown in Table I were used.[3,6] Relative errors in these values are about ±10 percent.[7]

A possible cause of the decrease in the $O^{16}(n,p)N^{16}$ cross section above 13.5 Mev is the competitive effect of inelastic scattering. Since O^{16} has a group of levels near 13 Mev,[8] an increase in the inelastic-scattering cross section at the expense of the (n,p) reaction at this energy seems plausible.

A half-life of 7.38±0.05 seconds was obtained for the N^{16} activity, in good agreement with the value of 7.35±0.05 sec reported by Bleuler *et al.*[1]

The writer is indebted to Dr. R. F. Taschek and other members of the 2.5-Mev electrostatic accelerator group for many helpful suggestions.

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[5] Hornyak, Lauritsen, Morrison, and Fowler, Revs. Modern Phys. **22**, 291 (1950).

[6] T. F. Stratton and G. D. Freier, Phys. Rev. **88**, 261 (1952).

[7] *Note added in proof.*—Recent measurements by S. J. Bame of this laboratory have shown that the angular distribution of the neutrons from the $T(d,n)He^4$ reaction given in Table I is probably too strongly peaked at small angles. Hence, in Fig. 1, the cross section at 18 Mev should be increased from 40 mb to about 60 mb.

[8] F. Ajzenberg and T. Lauritsen, Revs. Modern Phys. **24**, 321 (1952).

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Range Distribution of Alpha Particles Following the Decays of Li^8 and B^8

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The range distributions of the alpha particles resulting from the decays of Li^8 and B^8 nuclei in nuclear track emulsion have been determined and compared. The range distribution from the decay of Li^8 nuclei is found to be similar to that measured by previous investigators and, within statistical error, the range distribution from the decay of B^8 nuclei is the same as that found from Li^8 nuclei.

In recent experiments[1] designed to analyze the high-energy disintegration products produced by 375-Mev alpha particles bombarding beryllium, a large number of B^8 and Li^8 hammer tracks (note Fig. 1) were found in the nuclear track emulsions used as detectors. Dr. Walter H. Barkas has suggested that by analyzing the range distribution of the alpha tracks resulting from the reactions

$$\left.\begin{array}{ll} B^8\to e^+ + Be^{8*} & \\ & \\ Li^8\to e^- + Be^{8*} & \end{array}\right\} Be^{8*}\to 2He^4, \qquad \begin{array}{r}(1)\\ \\ (2)\end{array}$$

the energy level structures arising from these mirror processes in the short-lived Be^8 nuclei may be compared. Although the Be^8 from the decay of Li^8 has been studied by many investigators,[2–4] additional measurements were taken on the alpha particles from reaction (2) as a means of calibration of the method and in the hope of improving the statistics over previous investigations. The alpha-particle range distribution from reaction (1) was studied for the purposes of (*a*) checking the similarity of the two mirror nuclei, Li^8 and B^8, and (*b*) searching for a possible new level in the excited Be^8 nucleus.

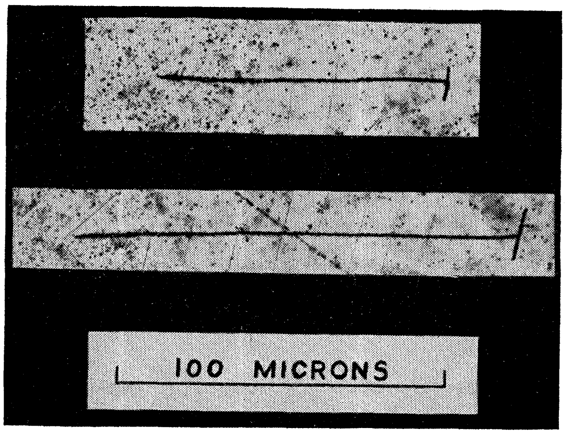

FIG. 1. Photomicrographs of tracks of Li^8 and B^8 nuclei: (top) a 28-Mev Li^8 track, (bottom) a 66-Mev B^8 track.

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[2] F. Ajzenberg and T. Lauritsen, Revs. Modern Phys. **24**, 336 (1952).

[3] C. M. Class and S. S. Hanna, Phys. Rev. **89**, 877 (1953).

[4] D. St P. Bunbury, Phys. Rev. **90**, 1121 (1953).