measurements are being carried out on additional elements as more information is desirable to confirm the cross-section trends observed for the present elements.

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Cross Section for the Reaction $D(d,p)H^3$†

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Cross sections for the reaction $D(d,p)H^3$ have been measured between 50 and 100 kev, using thin targets of deuterium absorbed in zirconium. With the angular distribution data of Wenzel and Whaling, the total cross sections have been calculated. The total cross section at 100 kev is measured to be 14.8 millibarns. A gas target was used to determine the cross section at 420 kev. The value obtained was 49.3 millibarns.

INTRODUCTION

MEASUREMENT of the cross section for the reaction $D(d,p)H^3$ has been the object of several experiments,[1–4] using both thick and thin targets. The present investigation utilizes thin targets of deuterium absorbed in zirconium films evaporated on to $\frac{1}{2}$-in. aluminum disks. Targets of this type have been successfully used to measure the *d*-T cross section, and the paper by Conner, Bonner, and Smith[5] discusses their preparation.

EXPERIMENTAL METHOD

The experimental apparatus used was essentially the same as that employed in measuring the *d*-T cross section at low energies, and the reader is referred to the earlier paper for details of the construction. The deuteron beam from the Cockroft-Walton accelerator was separated into its mass components and deflected 10° by a magnetic field. The beam was collimated by two $\frac{3}{16}$-in. diameter apertures, one of which was 10 cm above, the other 30 cm below the center of the $2\frac{1}{2}$-in. diameter pole faces of the magnet. Deuterons then struck the target at an angle of 20° to the normal. Disintegration protons were counted at an angle of 90° to the incident deuteron beam by a counter filled to a pressure of $\frac{1}{2}$ atmosphere with a mixture of argon plus 5 percent CO_2. The counter accepted protons in a solid angle defined by a 1.00-cm circular aperture located 7.64 cm from the center of the target. The solid angle was thus 0.01346 steradian. With a voltage of 1300 v on the counter, the bias curve showed a plateau 40 volts wide.

The number of incident deuterons was determined by measuring the charge deposited on the target with a current integrator of the type described by Watt.[6] Secondary electrons produced at the lower slit and at the target were electrostatically repelled to their respective origins. Correction for neutralized deuterons in the beam was made by taking a background count with the charged beam bent away from the target by a strong permanent magnet placed between the target and the lower slit. At the highest energies the neutral correction amounted to 2 percent; at 50 kev it was 4 percent.

The number of deuterium atoms per square centimeter of the Zr targets was determined by comparing the proton yield of each target with that of a deuterium gas target. The gas target is illustrated in Fig. 1. The deuteron beam from the Van de Graaff generator was defined by S' to be 5 mm in diameter and then entered the target through an aluminum foil having a thickness of 1.26 mg/cm². The energy of the deuterons incident on the foil was 800 kev. The energy loss in the foil was calculated from the data of Warshaw[7] to be 380 kev, so that the energy of the deuterons incident on the deuterium gas was 420 kev. Protons from the *d*-D reaction were counted at an angle of 90° to the beam by a counter consisting of thin anthracene flakes mounted on a 5819 photomultiplier tube. The solid angle was defined by aperture B, a $\frac{3}{8}$-in. hole covered with an aluminum foil 0.020 mm thick and located 4.4 cm from the center of the beam. When the yield of the gas target was to be determined, slit A, 0.626 cm

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wide, defined a length of beam as the source of protons. The effective length of beam seen by the counter was calculated to be 0.690 cm. When the yields from the Zr–D targets were to be determined, slit *A* was removed and a target holder inserted. The Zr–D targets were held so that the deuteron beam struck them at an angle of 20° to the normal, which is the same angle at which data were taken on the Cockroft-Walton accelerator.

RESULTS

Three calibrated targets were used to determine the D–D cross section at 100 kev. Two of these had Zr deposits of 50 $\mu g/cm^2$, and the third had 25 $\mu g/cm^2$. The respective energy losses for deuterons at 100 kev, including the loss in the deuterium, were 8 and 4 kev.[7,8]

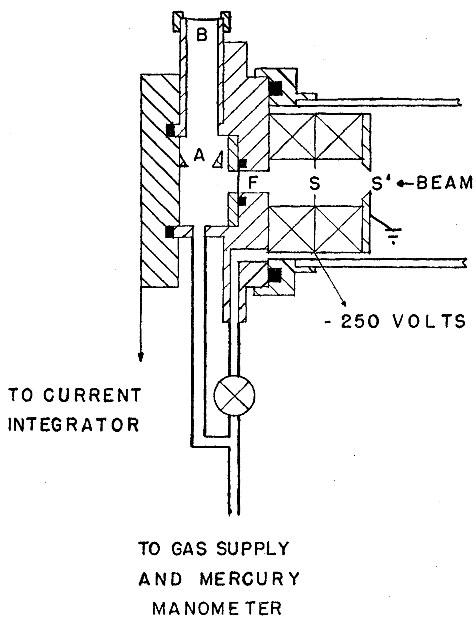

FIG. 1. Gas target arrangement for calibration of zirconium-deuterium filled targets with the Van de Graaff. The analyzed beam passed through collimator *S'*, through the secondary electron guard electrode *S*, through the foil *F* into the gas target. Connections to *S'* and *S* were made by colloidal graphite lines painted on the inside of the glass tube. The slits *A* and *B* defined the counting length of the beam as seen by the photomultiplier.

The average value for the differential cross section at 90° was found to be 1.01 mb/steradian at 100 kev. The total cross section was computed from the differential cross section, using the angular distribution data of Wenzel and Whaling.[4] The value obtained was 14.8 mb. The probable error, computed from the deviations from the mean with the three targets, was 4 percent. Total error is estimated at 6 percent.

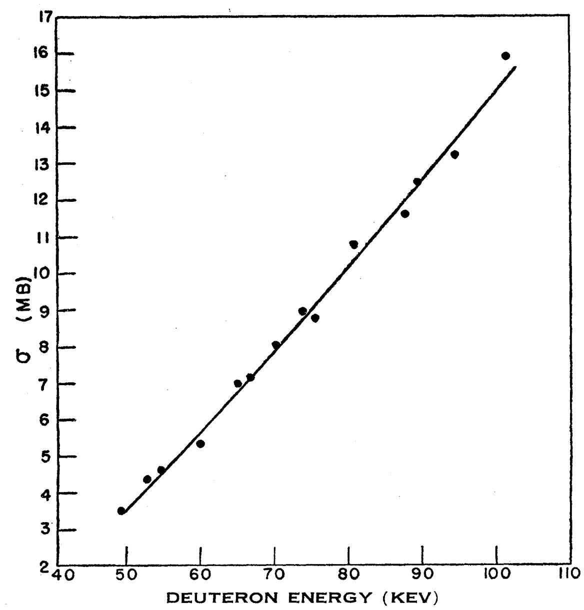

FIG. 2. D(d,p)H^3 total cross section. Deuteron energies plotted are those at the center of the target.

Cross sections below 100 kev were obtained with a Zr–D target for which the energy loss for 100-kev deuterons was 8.5 kev. This target was not calibrated, but absolute magnitudes were obtained by normalizing the yield curve to the mean value given by the three calibrated targets at 100 kev. The *d*–D excitation curve for the region 50–100 kev appears in Fig. 2. Since the curve is approximately linear in this region, deuteron energies plotted are those at the center of the target.

The gas target yield obtained during the Zr–D target calibration was used to calculate a value for the cross section at 420 kev. The resulting value was 2.88 mb/steradian at 90° in the laboratory system. Using the angular distribution data of Wenzel and Whaling, we obtain 49.3 mb as the total cross section at 420 kev.

Our measurements using Zr–D targets are from 4 percent (at 100 kev) to 17 percent (at 60 kev) lower than the recent measurements of Arnold *et al.*,[3] and from 7 percent to 25 percent below the results of Wenzel and Whaling.[4] The value for the cross section at 420 kev is 8 percent below that reported by Wenzel and Whaling.

[8] C. M. Crenshaw, Phys. Rev. **62**, 54 (1942).