PHYSICAL REVIEW VOLUME 96, NUMBER 4 NOVEMBER 15, 1954

Magnetic Analysis of the $O^{17}(d,p)O^{18}$ Reaction

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(Received June 28, 1954)

Separated iostopic targets of O^{17} were used to study the reaction $O^{17}(d,p)O^{18}$. The energy spectrum of protons from this reaction has been analyzed at 61.0° and 134.7° to the incident 0.855-Mev deuteron beam, using a double focusing magnetic spectrometer and photographic detection. The survey covers a range of excitation in O^{18} from 0 to 4.8 Mev. Two proton groups were identified with the reaction $O^{17}(d,p)O^{18}$, giving $Q_0=5821\pm10$ kev and $Q_1=3835\pm8$ kev.

INTRODUCTION

OXYGEN-17 has not been reported elsewhere as target nucleus for precision measurements of nuclear energy levels—its isotopic abundance is only 0.04 percent. An earlier paper[1] described the separation method used for thin O^{17} targets and reported a measurement of the reaction energy of $O^{17}(d,p)O^{18}$. This systematic survey over the energy region below this proton group has been undertaken in order to obtain information about the hitherto unknown level scheme of O^{18}.

APPARATUS AND EXPERIMENTAL PROCEDURE

The apparatus and experimental procedure used in the investigation are essentially similar to those described in earlier papers.[2,3] The apparatus consisted of the Nobel Institute 1.4-Mev Cockcroft-Walton accelerator, a deflecting magnet and slit system to define the energy of the deuteron beam, and a double focusing magnetic spectrometer to analyze the particles leaving the target. The spectrometer is movable in the angle interval 0° to 135° to the incident beam. Ilford nuclear track plates were used to detect the particles deflected by the spectrometer.

Two series of plates were taken, at the observation angles 61.0° and 134.7° to the incident beam. This was done in order to diminish the chance that a O^{17} group with low intensity would be masked by some contaminant group at the same time as it was used to identify the various groups.

The O^{17} targets used were all produced from gaseous

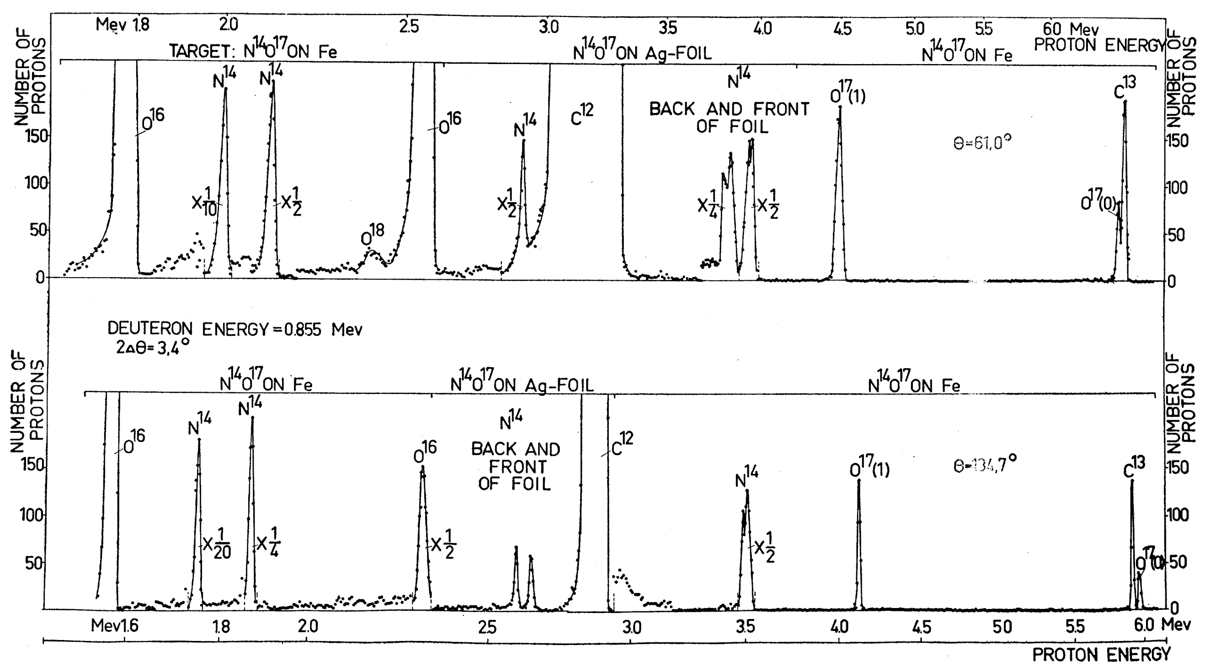

FIG. 1. Spectra of protons from O^{17} target bombarded with 0.855-Mev deuterons. The upper curve is obtained at the observation angle $\theta=61.0°$ and the lower at $\theta=134.7°$. Each point in the figure stands for the mean of two measured points. The types of target used in different energy regions are indicated in the figure.

[1] Ahnlund, Thulin, and Pauli, Arkiv. Fysik. (to be published).
[2] C. Mileikowsky and R. Pauli, Arkiv. Fysik 4, 287 (1952).
[3] C. Mileikowsky, Arkiv. Fysik. 7, 89 (1953).

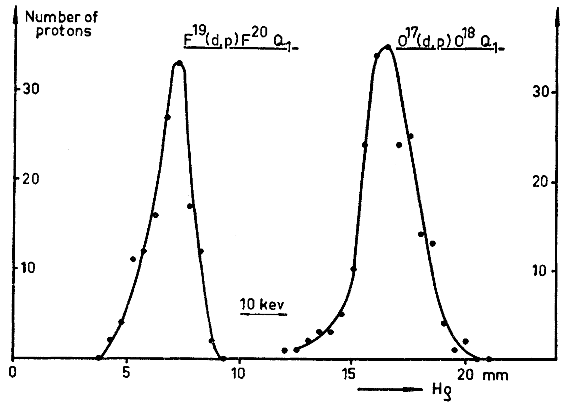

FIG. 2. Spectrum of short-range protons from $O^{17}(d,p)O^{18}$ compared to the proton spectrum from $F^{19}(d,p)F^{20}$, Q_1. Deuteron energy=0.855 Mev, $\theta=134.7°$, $2\Delta\theta=3.4°$. Both targets were on thick backings.

oxygen enriched by thermal diffusion in O^{17} and O^{18} by a factor of about one hundred. This was accomplished by Professor K. Clusius of Zürich. By electromagnetic isotope separation at the Nobel Institute, thin O^{17} targets were collected from $N^{14}O^{17}$ ions. Two types of target backing were used. For the work in the region $E_p=2.0-4.0$ Mev the O^{17} nuclei were collected on a thin 0.28-mg/cm² Ag foil. In this energy region a thick target backing could not be used, because of a serious background of protons from the reaction $D(d,p)H^3$. For the rest of the spectrum we chose a thick backing of stainless steel, as Fe has been found to be able to hold more oxygen atoms in its surface than other backing materials tried.[4]

The bombardments used for each exposure were 2400 microcoulombs of deuterons on the steel targets, and 4000 microcoulombs on the Ag-foil target. Each photographic plate covers a range of 4 percent in the $H\rho$ value of the nuclear spectrometer. The calibration of the deuteron beam and the measurement of target layers were made in the way described earlier.

[4] R. Pauli, Arkiv. Fysik. (to be published).

RESULTS AND DISCUSSION

Figure 1 shows the spectrum of protons, observed from the bombardment of the O^{17} target with 0.855-Mev deuterons, as a function of their energy. The groups of protons marked $O^{17}(0)$ and $O^{17}(1)$ refer to particles which have left the residual nucleus O^{18} in the ground state and first excited state, respectively. Other groups resulting from reactions with contaminant elements are marked according to the target nuclei. One region is masked at both angles by the intense group from $C^{12}(d,p)C^{13}$. At 134.7° its width is about 150 kev. The corresponding region in O^{18} can only be covered by use of a deuteron beam of 6–8 Mev. The energies of the O^{17} groups have been calculated using the high energy edges, minimum observation angle, and external layer correction. The long-range group was calibrated[1] with α particles from ThC giving $Q_0=5821\pm10$ kev, while the short-range group was compared with protons from $F^{19}(d,p)F^{20}$, $Q_1=3721\pm6$ kev[5] at the observation angle $\theta=134.7°$ as shown in Fig. 2 giving $Q_1=3835\pm8$ kev. An earlier determination of Q_1 was made by use of a less intense oxidized O^{17} target. The protons from O^{17} were compared with protons from $B^{10}(d,p)B^{11}$, $Q_3=4201\pm8$ kev[6] at $\theta=134.7°$, giving the result $Q_1=3835\pm10$ kev.

We adopt the values:

$$O^{17}(d,p)O^{18}:\quad Q_0=5821\pm10 \text{ kev},\quad Q_1=3835\pm\ 8 \text{ kev}.$$

The corresponding excitation energy in O^{18} is 1986 kev. Using our latest values for the reaction energies of $O^{18}(p,\alpha)N^{15}$, $Q=3967\pm9$ kev,[3] and of $O^{17}(d,\alpha)N^{15}$, $Q=9807\pm12$ kev,[7] we close the corresponding nuclear reaction cycle by 19 ± 18 kev.

My thanks are due to Professor K. Clusius who kindly presented the sample of enriched $O^{17}O^{18}$ gas and to Tekn. lic. S. Thulin who produced the separated targets.

[5] H. A. Watson and W. W. Buechner, Phys. Rev. **88**, 1324 (1952).
[6] Van Patter, Buechner, and Sperduto, Phys. Rev. **82**, 248 (1951).
[7] Pauli, Ahnlund, and Mileikowsky, Arkiv. Fysik. (to be published).