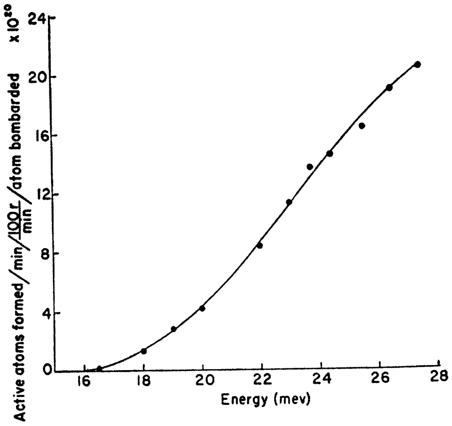

FIG. 1. Activation curve, $Rb^{87}(\gamma, \alpha)Br^{83}$.

viously[6] yields the cross-section curve reproduced in Fig. 2. This curve has a maximum at 22.5 Mev, a half-width of 6.6 Mev, and the integrated cross section is 4×10^{-4} Mev-barn. Presumably the reason that the cross section starts at a finite value is that a threshold has been assumed which is actually too high and consequently, near the threshold, activity which is actually due to photons of lower energy has been credited to photons of energy in the immediate vicinity of the apparent threshold. The observed threshold (16 Mev) may be considerably higher than the actual threshold. The experimental point at 16.5 Mev corresponds to a measured activity of only 1.5 counts/min above background of 32 counts/min over a two-hour counting period. The length of irradiation was 1.5 hr. To obtain points at lower betatron energies would have necessitated much longer irradiations than were thought feasible. The binding energy of the alpha-particle in Rb^{87} calculated from the Feenberg formula[7] in the form given by Stern[8] (with the obvious corrections) is only 5.3 Mev. The discrepancy between this value and the observed value is very large but it may be explained partially by the barrier effect. It should be expected that in order to compete with de-excitation by gamma-emission the half-life for alpha-emission must be of the order of 10^{-13} sec at the most. According to calculations based on the simple one-body theory of Bethe[9] the half-life for alpha-emission from Rb^{87} as a function of alpha-energy is as follows:

α-particle energy (Mev)	4	5	6	8
Half-life (sec)	3.8×10^{-10}	4.8×10^{-13}	2.8×10^{-15}	4.3×10^{-18}

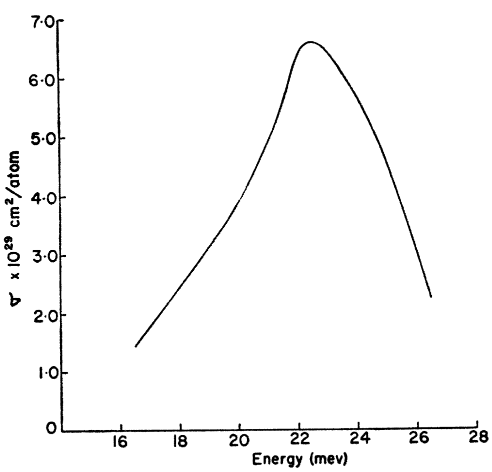

FIG. 2. Cross-section curve for the reaction $Rb^{87}(\gamma, \alpha)Br^{83}$.

It follows on this picture that a threshold energy of the order of 10 rather than 5 Mev would be expected. This is still considerably lower than the observed value. Further, the observation by Cameron and Millar[10] of α-particles ejected by γ-rays from Ag or Br, having an energy distribution which exhibits a peak at about 4 Mev, casts doubt on this simple interpretation.

The falling-off in cross section following the peak may be due to the influence of competing reactions. However, it should be noted that cross-section curves for (γ, n) reactions observed in this laboratory exhibit a similar course. In this case, however, an explanation in terms of competing reactions does not seem feasible and thus some other explanation must be sought.

The observed activity might be due to the reaction $Rb^{85}(\gamma, 2p)Br^{83}$. This is thought to be unlikely for several reasons. The calculated threshold energy (apart from the barrier effect) is 17.7 Mev which is 12.4 Mev higher than the calculated alpha-particle binding energy. Further, it seems unlikely that the $(\gamma, 2p)$ reaction would occur to any appreciable extent for energies near the threshold, since the first proton emitted might be expected, for a large percentage of potential $(\gamma, 2p)$ occurrences to have more than one-half the available energy and thus the second proton not enough energy to escape. An attempt was made to detect the corresponding reaction in the neighboring isotope, $Rb^{87}(\gamma, 2p)Br^{85}$. Evidence of a possible 3-min Br^{85} activity after a rapid chemical separation was obtained first at 27.4 Mev. Thus it seems unlikely that Br^{83} would be produced by a $(\gamma, 2p)$ reaction in Rb^{85} with a threshold at 16 Mev.

Work on (γ, α) reactions leading to unstable product nuclides is continuing.

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The First Excited State of Be^7 from the $Li^7(p, n)Be^7$ Reaction*

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THE existence of an excited state in Be^7 at about 430 kev has been confirmed by several methods: (a) the reaction[1-3] $B^{10}(p, \alpha)Be^7$, (b) the reaction[1] $Li^6(d, n)Be^7$, (c) scattering of neutrons from a $Li^7(p, n)Be^7$ source[4] by He, (d) photographic plate analysis of recoil protons from a $Li^7(p, n)Be^7$ neutron source.[5-8] Of these methods, (a) and (b) are the most accurate, the results[1] being 429±5 kev from γ-ray measurements, and from magnetic analysis of α-particles,[2,3] 434±5 and 431±5 kev. Method (d) has shown the presence of a low energy neutron group with about ten percent of the total neutron intensity at bombarding energies $E_p=2.7$ to 4.0 Mev (well above the expected threshold for the second group at 2.38 Mev).

With a thin target and a neutron counter subtending a small angle on the beam axis, the yield curve just above threshold shows a "geometrical peak"[9] due to forward concentration of neutrons in the laboratory reference frame. By taking advantage also of the greater sensitivity of a bare BF_3 counter for the low energy second group neutrons, it should be possible to detect the group at its threshold unless its relative intensity is very small. We are not aware that this has been done previously.[10]

Protons from the MIT Rockefeller electrostatic generator were used to bombard a thin Li target. The beam was bent magnetically and analyzed by slits. The magnetic field was stabilized and its magnitude H at one point measured by a proton resonance method which permits a reading accuracy on a standard oscillator of one part in 10^4. The $Li^7(p, n)Be^7$ threshold[11] at $E_p = 1.882$ was taken as a calibration point and it was assumed that the proton energy $E_p \propto H^2$. This relation has been checked so far only by measuring the $B^{11}(p, n)C^{11}$ threshold, which agreed within 2 kev with Richards' value[12] of 3.015 Mev.

Figure 1 shows a plot of the ratio of the counts from a one-

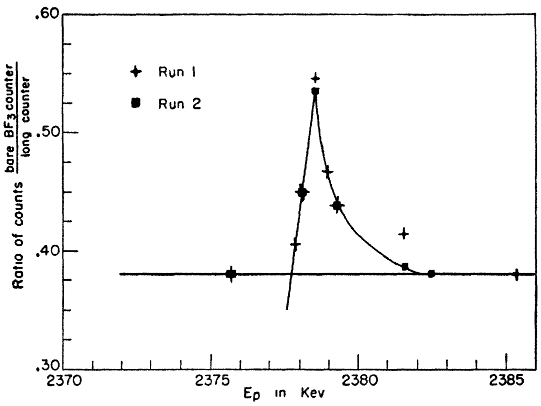

FIG. 1. Ratio of counts from a BF_3 counter to those from a "long counter."

inch diameter BF_3 counter, on the beam axis eight inches from the target and shielded by ½ inch of B_4C, to those from a paraffin moderated "long counter" whose efficiency is nearly independent of neutron energy.[13] The curve is flat in the neighborhood of the expected threshold except for the peak shown, which is attributed to the second neutron group. The measured threshold is 2.378 Mev and the Q value 2.081 Mev. From the ground state $Q = 1.647$ Mev, the excited state in Be^7 is at 434 kev. The statistical and reading errors appear to be within ±1 kev, but the extent of possible systematic errors in the calibration has not been explored. It is satisfactory to note that the eight determinations in the papers referred to above, as well as an additional photographic determination (unpublished) by P. Stelson of our group, all agree with this value within the authors' stated errors. The ratio of the height of the "geometrical peak" of the second group (above "background") to that of the corresponding first group peak is about 0.03.

* This work was jointly supported by the ONR and Bureau of Ships.
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Inelastic Scattering of Deuterons by C^{12}

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A HEAVY-PARTICLE magnetic spectrometer has been used to determine the momentum distribution of deuterons scattered by thin carbon targets. The spectrometer produces a uniform field within an annular region which has approximately 84 cm mean diameter and 7 cm width. Charged particles which emerge from the target in a direction perpendicular to the incident beam are focused magnetically (180°) and fall at grazing incidence upon Ilford C-2 nuclear emulsions. Rapid and positive identification of particles is based on a combination of measured track lengths and experimental momentum ($H\rho$) values. A series of successive exposures with different magnetic fields permits examination of any desired range of momenta up to a maximum of about 6.5×10^5 gauss-cm.

Two types of carbon target were used. One was a 0.2-mil foil of Nylon, which contains mostly hydrogen and carbon, together with some nitrogen and oxygen. The other was a very thin foil of aluminum on which carbon is unavoidably deposited during bombardment. This carbon deposit apparently results from the use of oil diffusion pumps, despite the presence of a liquid nitrogen cold trap. A comparison of the proton spectra from the two targets indicates that little or no nitrogen or oxygen is included in the built-up deposit on the aluminum foil. No signs of $O^{16}(d, p)$ or $N^{14}(d, p)$ reactions were found for the aluminum target.

The carbon targets were bombarded by a collimated beam of 10-Mev deuterons from the Washington University cyclotron. Figure 1(a) shows the spectrum of deuterons scattered from the Nylon target. Three closely spaced groups at high momenta are deuterons scattered elastically by C^{12}, N^{14}, and O^{16}. The relative intensities of the three groups correspond roughly to the 6:1:1 atomic ratio (approx.) of these elements in Nylon. A fourth group of deuterons appears with momenta in the vicinity of 3.7×10^5 gauss-cm. These deuterons have been inelastically scattered by C^{12}, leaving the carbon nucleus in an excited state. It is evident from the width of this peak that the Nylon target is a "thick" one for the inelastic deuterons, whose energy (at 90°) is about 3.3 Mev. Poor resolution results from the rather large energy losses suffered by these slow deuterons as they emerge from the foil.

The inelastic peak was restudied using the aluminum-borne carbon deposit as a target. Figure 1(b) compares results from the two targets for this group. The momentum scale has been expanded for clarity. Some improvement in resolution has been produced through use of the thinner target, so that the inelastic peak now displays a low energy "tail" and somewhat resembles thick-source internal conversion peaks in beta-spectroscopy. If we assume the maximum intensity corresponds to scattering events

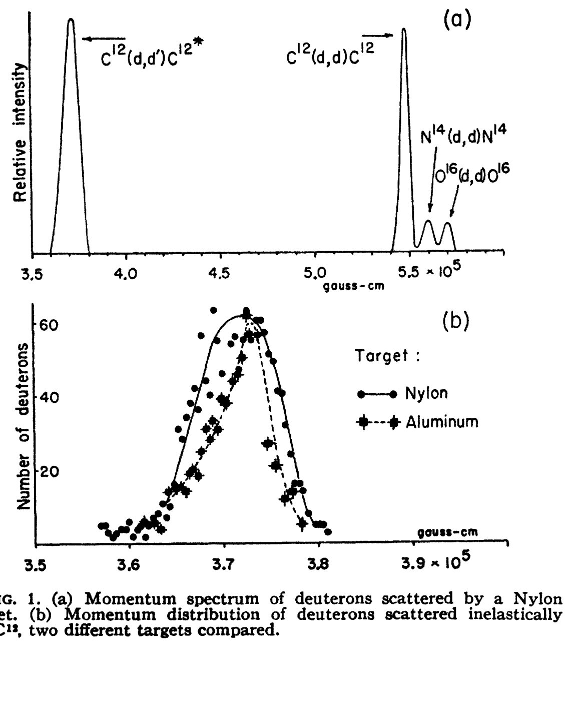

FIG. 1. (a) Momentum spectrum of deuterons scattered by a Nylon target. (b) Momentum distribution of deuterons scattered inelastically by C^{12}, two different targets compared.