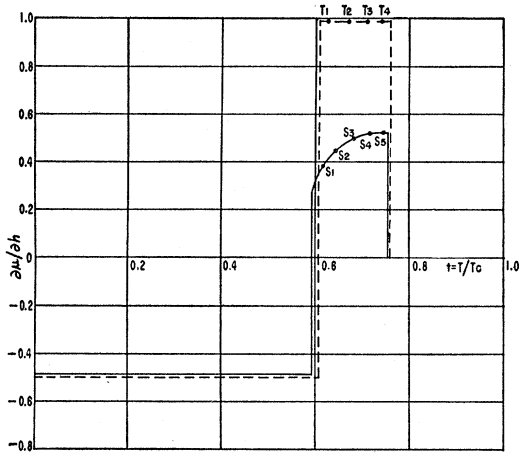

FIG. 3. Differential susceptibility as a function of temperature.

process were isothermal one would get a differential susceptibility given by the dashed line in Fig. 3. It is noted that the shape of the solid curve in Fig. 3 is a function of the applied field h. This should reflect itself in a change in the warm-up curves (Fig. 1) as the fields are varied.

Preliminary experiments performed at this laboratory in studying the critical magnetic field curves for ruthenium and cadmium have revealed warm-up curves which are considerably different from that shown in Fig. 1. Since the metal particles used for these experiments were much smaller than those of previous workers, the difference in warm-up curves may be associated with size effects in the superconductors. This supposition is made plausible in terms of the suggested explanation given above when one examines the isothermal magnetization curves of small superconducting spheres.[2] In fact one can utilize the warm-up curves obtained for small particles to construct the magnetization curves. Such data would be useful in the study of penetration depths for those elements having transition points below 1°K. Such a program is now in progress at this laboratory.

The author wishes to thank M. F. M. Osborne for profitable discussions relating to this problem.

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Cross Section for the Reaction $Br^{81}(\gamma,\alpha)As^{77}$

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(Received July 30, 1952)

THE cross section for the (γ,α) reaction in Br^{81} has been found by counting forty-hour As^{77}. Arsenic was separated from sodium bromide which had been irradiated with the University of Saskatchewan betatron. Ten ninety-gram samples of reagent NaBr were irradiated at betatron energies from 16.0 to 25.4 Mev. Arsenic was precipitated from solutions $3N$ in HCl and obtained for counting as As_2S_3. The usual counting corrections were applied. The chemical yield determined gravimetrically was 100 percent. It was assumed that exchange of active and carrier ions was complete.

X-ray doses were recorded by tantalum monitors mounted at the front of each sample, appropriate corrections being made for inverse square attenuation and x-ray absorption in the sample.

The yield curve is shown in Fig. 1. No attempt was made to determine yields at energies lower than 16 Mev on account of the very long irradiations that would have been necessary. From the yield curve the cross section, Fig. 2, was computed by the photon difference method.[1] This cross section has a peak value of 270 microbarns at 21.5 Mev. The integrated cross section is about

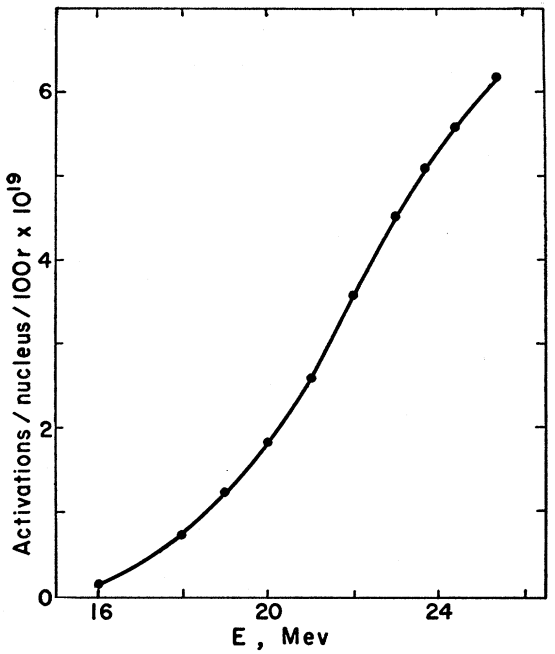

FIG. 1. Yield curve for $Br^{81}(\gamma,\alpha)As^{77}$. The number of activations/Br^{81} nucleus/100 roentgens is plotted against the maximum betatron energy in Mev.

1.5 Mev-millibarns. In shape this cross section is quite similar to those found for $Cu^{65}(\gamma,\alpha)Co^{61}$,[2] and $Rb^{87}(\gamma,\alpha)Br^{83}$,[3] while in magnitude it lies between them, the cross sections declining with increasing atomic number. This trend is similar to that observed for photoproton yields from middle-weight nuclei.[4]

It is of interest to compare our result with measurements of alpha-tracks arising from the photodisintegration of bromine and silver in nuclear emulsions.[5–7]

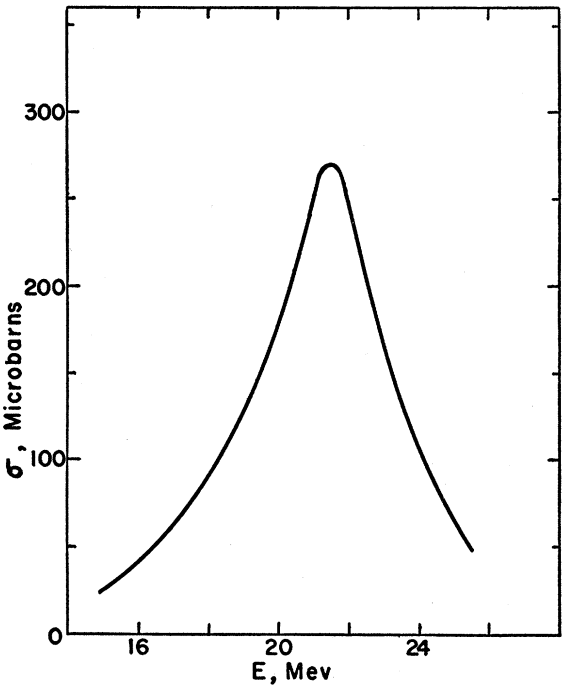

FIG. 2. Cross section for $Br^{81}(\gamma,\alpha)As^{77}$. The cross section in microbarns is plotted against photon energy.

Nabholz, Stoll, and Wäffler[5] have investigated the energy distribution of α-particles ejected from heavy nuclei in photographic emulsions by lithium γ-rays. They estimate that the contribution of silver to the spectrum at its peak is negligible but find close agreement between the observed spectrum and that calculated from statistical theory for bromine. Accordingly they calculate the average $Br^{79,81}(\gamma,\alpha)$ cross section at 17.6 Mev to be $(1.2\pm0.5)\times10^{-28}$ cm^2. For Br^{81} at this energy we find the cross section to be 0.80×10^{-2} cm^2. Making the same assumptions as Nabholz *et al.* regarding the cross-section ratios for the two isotopes we obtain 1.3×10^{-28} cm^2 as the average cross section for bromine at 17.6 Mev, in agreement with the above value.

It might be noted that the small number of α-particles with energies higher than the theoretical spectrum for bromine in Fig. 1 of reference 5 might arise from silver and would in no way affect the good agreement noted above.

Haslam, Cameron, Cooke, and Crosby[6] made no attempt to separate the effects of silver and bromine since their observed α-spectrum did not agree closely with theoretical distributions for either element. The methods described in their paper, while suitable for investigation of the general features of photo-alpha processes, are not well adapted to accurate determination of cross sections at a particular energy. Statistics in photographic emulsion work are poor, and the effect is aggravated by the use of a continuous rather than a discrete photon spectrum. If silver is assumed to make a negligible contribution at 17.6-Mev excitation, a cross section of 3×10^{-28} cm^2 for an average bromine nucleus is obtained, but this value is open to considerable doubt due to the steepness of the cross-section curve in this energy region.

We wish to thank Dr. K. J. McCallum of the Department of Chemistry for helpful advice and Mr. L. H. Greenberg for valuable discussions. This work was supported by the National Research Council of Canada.

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The Angular Distribution of Fission Fragments in the Photofission of Thorium*

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MEASUREMENTS of the angular distribution of photofission fragments from thorium have been made using the x-ray beam of the MIT linear accelerator. They were performed by counting the β-activities of the fragments which were emitted from a thorium foil and caught at various angles to the x-ray beam. The observed angular distribution has a maximum at right angles to the beam and the amount of the anisotropy decreases with increasing photon energy.

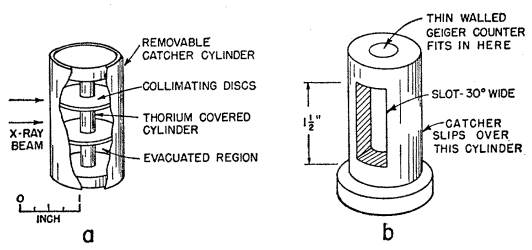

FIG. 1. The arrangements for exposure and counting of the cylindrical fragment catcher. After exposure the catcher is slipped over the cylinder in *b* and rotated so as to expose (to the counter inside) the activities caught at various angles to the x-ray beam.

With the accelerator running at about 16 Mev, the set-up shown in Fig. 1(a) was exposed at 6 inches from the x-ray target. It consists essentially of two concentric cylinders; the inner one is covered with thorium foil which is thick to fission fragments and the outer one serves as the fragment catcher. The activities of 30°-wide strips of this catcher cylinder (each strip corresponding to a different angle of fragment emission with respect to the beam) are measured after the exposure by means of the arrangement of Fig. 1(b).

A number of runs have been made at 16 Mev with this arrangement, and the results are given in the following table normalized

θ	0°	45°	90°	135°	180°	270°
Measured activity for slot 30° wide	1.00	1.14 ±0.06	1.34 ±0.03	1.22 ±0.07	1.00 ±0.06	1.31 ±0.07

to the activity at 0° with respect to the x-ray beam. It is seen that the distribution is peaked at 90° and is symmetrical from front to back. These facts and the amount of activity measured at 45° and 135° suggest that the angular distribution can be written in the form $a+b\sin^2\theta$. When the data in the table is corrected for the

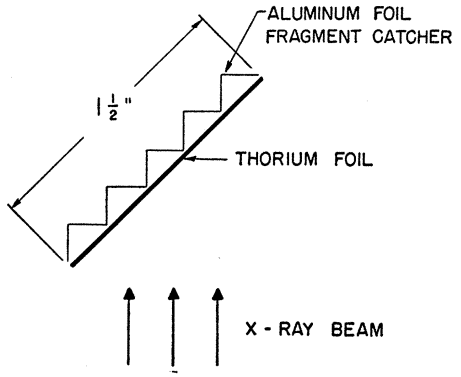

FIG. 2. The exposure geometry used in the energy-dependence runs.

finite angular resolution of the exposure and counting arrangements,[1] the ratio b/a is 0.41 ± 0.09. Some small corrections have been made for x-ray flux variations over the target, and it was established that a negligible fraction of the observed fissions are caused by fast neutrons.

It is conceivable that the measured asymmetry might involve not only different numbers of fragments at 90° and 0°, but also different types of fragments. To check this possibility, the exposure time in the experiment was varied. No dependence of the angular asymmetry on exposure times (from 6 minutes to 3 hours) or on the counting time was found. This would seem to imply that the same fragments are emitted in all directions. The question of a possible connection between the angular distribution and the fragment mass distribution is being investigated more carefully at the present time by means of a technique involving chemical separations.

In order to examine the energy dependence of the angular distribution it was necessary to use the arrangement of Fig. 2. This arrangement sacrifices angular resolution in order to keep the intensity up at the lower energies, where the photofission yield is small. A sheet of one-mil aluminum foil folded into a step-like shape serves as the fragment catcher; it is exposed next to a thorium foil set at 45° to the x-ray beam. Thus alternate faces receive fragments emitted mainly at 90° and 0° to the beam. After exposure the foil is flattened out and counted under a brass mask covering either set of faces. Checks were made to show that flux non-uniformities and the counting geometry introduced no serious errors in the results.

The geometrical corrections for angular resolution are necessarily rather large in this arrangement. At 16 Mev the measured activity ratio was 1.09 ± 0.03 for the 90° faces to the 0° faces. This