time. (b) The "missing" isotope, Tc^{98}, has been observed and hence must be long-lived. (c) The occurrence of a long-lived isomer of Tc^{100} seems to be excluded. (d) The relative abundance of the 60-day Tc^{95m} found suggests that as little as 5×10^{-9} g of technetium can be estimated by mass spectrometry.

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[6] Thanks and appreciation are expressed to Dr. S. K. Allison and Dr. B. C. Cook for making the University of Chicago betatron available for these irradiations. These experiments were assisted by J. W. Cobble.
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Fine Structure in the Photoproton Spectrum of Oxygen

SVEN A. E. JOHANSSON AND BENGT FORKMAN
Department of Physics, University of Lund, Lund, Sweden
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IT has been known for some time that the excitation curves for (γ,n) reactions show pronounced breaks.[1,2] These breaks have been explained as due to sharp resonances in the cross-section curves. If this is true, one should expect the energy spectra of the emitted particles to be composed of peaks. In general, the number of peaks would be so great that it would be extremely difficult to resolve them. Under certain conditions, however, the peaks may appear. When the maximum bremsstrahlung energy is set fairly close to the threshold, only a limited number of levels are excited. Furthermore, if the level density of the residual nucleus is low, only transitions to the ground state will be of any importance.

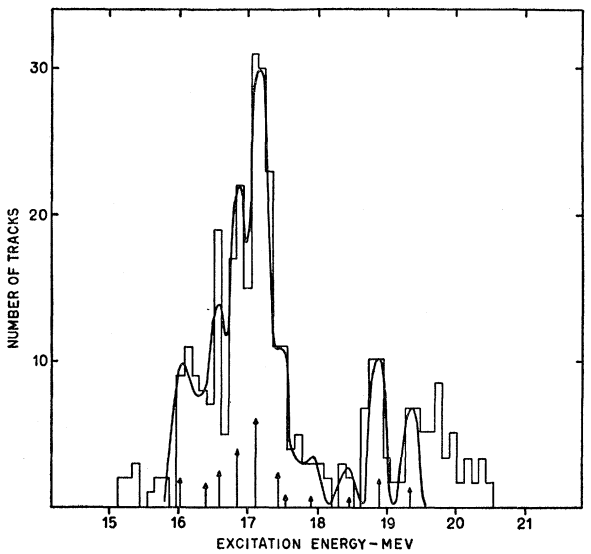

FIG. 1. Histogram showing the energy distribution of photoprotons from oxygen. The curve gives the distribution calculated from the breaks in the (γ,n) activation curve. The arrows indicate the position of the breaks.

In order to test the feasibility of this method, the photoproton spectrum of oxygen was investigated. The maximum bremsstrahlung energy was 21 Mev. The first excited state in N^{15} is at 5.28 Mev;[3] hence the ground-state transitions will be predominant. The proton energy was measured with nuclear plates mounted in a camera filled with oxygen at 2 atmos. The collimated beam from the University of Lund synchrotron was sent through the camera. The proton tracks in the plates were measured in the usual way. Great care was taken to make the energy measurements as accurate as possible. A correction was applied for the energy loss in the gas. There is a certain background from the (n,p) reaction in oxygen. It was determined by blocking the hole in the collimator by a lead cylinder. The background, which has been subtracted from the spectra, amounted to about 20%. The background tracks were all of low energy so that they have very little influence on the photoproton spectrum.

The energy spectrum is shown in Fig. 1 as a histogram. The curve has been obtained in the following way. At the position of each break in the excitation curve[1,2] (shown by arrows in Fig. 1) a peak has been placed. The width of the peaks is determined by the resolution of the experimental arrangement and has been calculated. The height of the peaks has been chosen to give the best possible fit to the histogram. The peaks are then added to give the curve in Fig. 1. The agreement with the measured spectrum is surprisingly good. This agreement strongly supports the assumption of sharp resonances in the cross-section curve. It should perhaps be mentioned that the relative height of the peaks (indicated by the height of the arrows) is about the same as calculated from the breaks, when the shape of the bremsstrahlung spectrum is taken into account.

The proton spectrum gives further information about the character of the photonuclear cross-section curve. The fact that the width of the peaks agrees so closely with the calculated values, sets an upper limit for the width of the resonances. A conservative estimate is 75 kev. Another interesting fact is that the sharp resonances can account for the whole spectrum below 19.5 Mev. Hence there is no continuous component in the cross-section curve. The part above 19.5 Mev may correspond to breaks not seen in the excitation curve or possibly to the onset of a continuous cross-section component. When the angular distribution of the protons is plotted separately for the strongest peaks, in-

formation is obtained about the spin values of the excited states in oxygen.

The present investigation indicates that this method gives considerable information about the levels in an energy interval, several Mev wide, above the (γ,p) threshold. It should be possible to increase the resolution by a factor of 2 or 3. It would then be possible to resolve the peaks with great certainty, especially if the statistics is improved by measuring a great number of tracks.

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Size Distribution of Neutron Widths*

D. J. Hughes and J. A. Harvey
Brookhaven National Laboratory, Upton, Long Island, New York
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In the program of work carried out with the Brookhaven fast chopper[1] on total cross sections of heavy elements, various regularities have been observed[2] with regard to the widths and spacings of energy levels. In contrast to the near-constancy of Γ_γ ($\sim$20 percent variation from level to level in a given nuclide), the neutron widths were found to have an extremely large variation in size; the reduced neutron widths, Γ_n^0 (given by $\Gamma_n/E_0^{\frac{1}{2}}$ with E_0 the neutron energy at resonance), differed by factors as high as several hundred.

In the work of Harvey *et al.*,[2] in which several hundred neutron widths were measured, it was found that within experimental error the neutron widths had an exponential distribution in size for each nuclide that was investigated. When the number of resonances in a given energy range with widths larger than a given value were plotted as a function of the latter, the resulting distribution was consistent with an exponential distribution, implying that the differential distribution, that is, the number of levels as a function of neutron width, was also exponential. It was difficult to draw any definite conclusion, however, from individual nuclides because the number of levels observed in each case was rather small, of the order of ten levels. In order to investigate the distribution in more detail it is obviously desirable to combine the data from many nuclides to attain greater statistical accuracy.

The combination of data from various nuclides has been accomplished by plotting the reduced neutron widths relative to the average value for each nuclide rather than in terms of actual widths. This process normalizes the distributions for different nuclides so they can be plotted together, but some distortion of the final distribution results because the average neutron widths are not accurately known for individual nuclides.

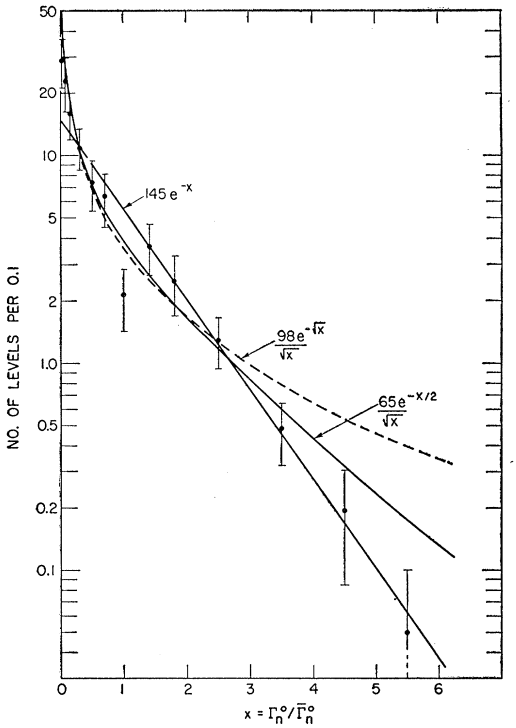

FIG. 1. Distribution (per 0.1 in Δx) of 145 reduced neutron widths relative to the average value for each nuclide. The curves are various suggested distribution laws described in the text.

Fortunately, it is possible to compute the distorting effect rather easily and the experimental points were corrected for it before plotting.

The distortion just described would of course add to a similar one already present in the distribution for the individual nuclides, which is a result of the presence of levels of two spin values. In computing the neutron widths from experimental transmission data the statistical factor, g, was assumed to be $\frac{1}{2}$, except for zero-spin target nuclei, where it is known to be unity. As a result, the distribution obtained for a given nuclide actually consists of two sets of levels, each with a different g value.[3] The spurious curvature in the distribution arising from the uncertainties in $\overline{\Gamma}_n^0$ and in g was computed and the experimental points were corrected before being plotted in Fig. 1. The distortion arising from the error in the average widths is much larger than that arising from the g uncertainty; the total correction is less than 10 percent for $x<3$ but reaches a factor of one half for the highest x value.

In plotting the points of Fig. 1, a careful attempt was also made to investigate other possible experimental distortions of the distribution, particularly the loss of very small levels simply because of their small size, as well as the loss of levels by failure to resolve them at high energy. One method that was used to investigate the failure to observe levels was to determine for each nuclide a neutron energy below which it was felt that