DISCUSSION OF RESULTS

Friedlander and Orr[3] determined the L-capture to K-capture ratio in I^{125} by using a windowless proportional counter to compare the ratio of 35-kev gamma rays to K x-rays in an I^{125} source with the same ratio in a Te^{125} source. They reported a transition energy of 80_{-18}^{+160} kev, which is confirmed by our measurement. As an additional point of reassurance, these authors calculated $\log(ft)$ values for the K capture and showed that the energy was consistent with an allowed transition. The $\log(ft)$ for Cd^{109} calculated by means of a formula appearing in Feenberg and Trigg's[9] article, appears in Table I. It also is compatible with an allowed transition. In both cases the classification of the transition as allowed agrees with spin assignments for the initial and final states of the nuclei involved.[10]

The author wishes to express his appreciation to Dr. M. Goldhaber for his interest in this problem and for many helpful suggestions generously offered.

[9] E. Feenberg and G. Trigg, Revs. Modern Phys. **22**, 399 (1950).
[10] M. Goldhaber and R. D. Hill, Revs. Modern Phys. **24**, 179 (1952).

PHYSICAL REVIEW VOLUME 92, NUMBER 4 NOVEMBER 15, 1953

Excitation Function for the Photodisintegration of Beryllium*

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(Received August 7, 1953)

Using filtered betatron bremsstrahlung, the $Be^9(\gamma,n)$ excitation function has been determined from threshold to 24 Mev. The results show two peaks, one due to excitation of the odd neutron and the second to the excitation of the Be^8 core.

THE photoneutron disintegration cross section of beryllium in the vicinity of the threshold (1.6 Mev) has been measured by several investigators,[1] and the results are in substantial agreement with the calculations of Guth and Mullin[2] for $P\rightarrow S$ and $P\rightarrow D$ transitions of a neutron moving in the field of a Be^8 core. The photoproton excitation function,[3] as determined by successive subtractions of yields produced by betatron bremsstrahlung, shows the characteristic dipole resonance found in other elements. Determination of the (γ,n) excitation function from threshold to 24 Mev by this method is of particular interest but is difficult because of the low threshold and the preponderance of low-energy photons in the bremsstrahlung, spectrum when the betatron is run at high energies.

We have measured the neutron yield as a function of betatron energy by the method of direct neutron detection[4] for betatron bremsstrahlung filtered by 30 cm of carbon absorber to flatten the bremsstrahlung distribution. Figure 1 shows the calculated bremsstrahlung curves at 10 and 20 Mev, normalized to 100r, with and without the carbon filter. As a test of the method, the bismuth (γ,n) yield curve[5] was repeated using filtered radiation, and the excitation functions computed therefrom are shown in Fig. 2. The data of reference 5 are drawn for comparison. Aside from a 20 percent discrepency in the absolute values of the cross sections, the data taken with the hardened beam are in good agreement with the previous work.

Figure 3 shows the excitation function for beryllium computed from yield data using the filtered beam. Also shown are the $Be^9(\gamma,p)$ data of reference 3, and

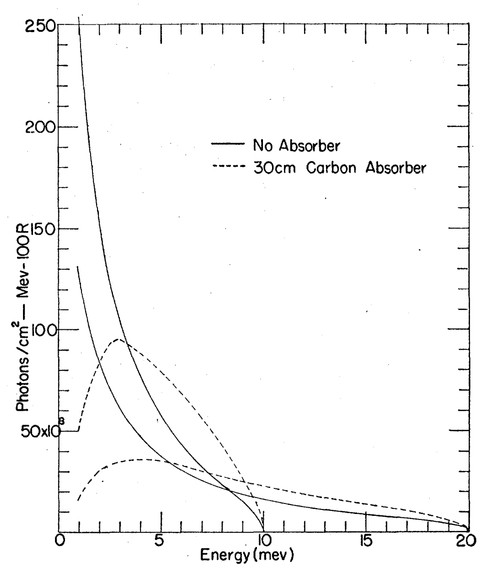

FIG. 1. Theoretical bremsstrahlung distributions for betatron energies of 10 and 20 Mev with and without 30-cm carbon absorber.

* Supported in part by the U. S. Air Research and Development Command and by the joint program of the U. S. Office of Naval Research and the U. S. Atomic Energy Commission.
[1] Russell, Sachs, Wattenberg, and Fields, Phys. Rev. **73**, 545 (1948), B. Hamermesh and C. Kimball, Phys. Rev. **90**, 1063 (1953).
[2] E. Guth and C. J. Mullin, Phys. Rev. **76**, 234 (1949).
[3] R. N. H. Haslam *et al.*, Can. J. Phys. **31**, 210 (1953).
[4] Halpern, Mann, and Nathans, Rev. Sci. Instr. **23**, 678 (1952).
[5] Halpern, Nathans, and Mann, Phys. Rev. **88**, 679 (1952).

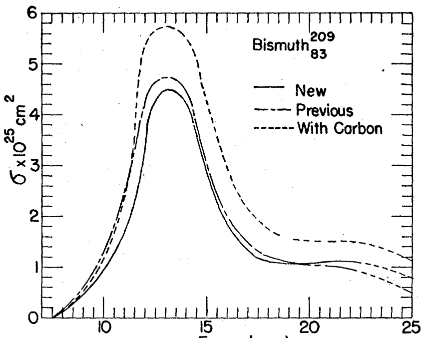

FIG. 2. Bismuth (γ,n) excitation functions constructed from yield curves taken with and without carbon absorber.

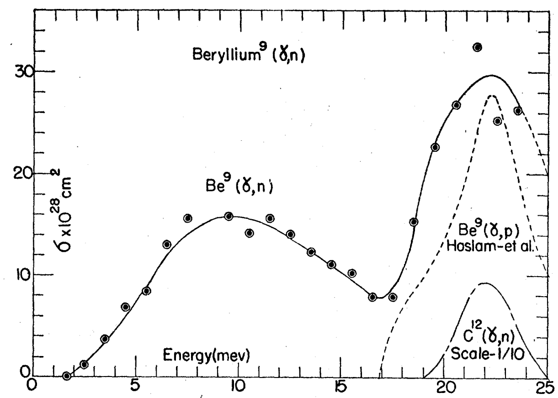

FIG. 3. Beryllium (γ,n) excitation function.

the (γ,n) excitation function of carbon. The method of constructing cross section from yield curves does not permit detailed check with Guth and Mullin near threshold, but the general behavior of the first portion of the beryllium excitation function is in agreement with their model for the $P\rightarrow D$ transitions. In fact, our measured maximum value of 15.8×10^{28} cm^2 for the cross section is in remarkable agreement with the calculations. The coincidence of the second peak with the (γ,p) curve and the (γ,n) excitation in carbon suggests the excitation of the Be^8 core as the photon energy increases and indicates the onset of the large dipole resonance for the core.

The integrated (γ,n) cross section in beryllium up to 25 Mev. is measured to be 0.037 Mev-barns. The (γ,p) integrated cross section of 0.013 Mev-barns[3] is not sufficient to bring the total to 0.187 Mev-barns as calculated[6] from the dipole sum rules. Thus, in beryllium as in other light elements, other modes of disintegration are important or there are large contributions to these reactions at energies above 25 Mev.[7]

[6] J. S. Levinger and H. A. Bethe, Phys. Rev. **85**, 577 (1952).

[7] Jones and Terwilliger [Phys. Rev. 91, 699 (1953)] report a large high-energy tail on the Be$^9(\gamma,n)$ excitation function above 25 Mev.

PHYSICAL REVIEW VOLUME 92, NUMBER 4 NOVEMBER 15, 1953

Resonant Effects and Spin Dependence in Potential Scattering of Slow Neutrons*

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(Received July 24, 1953)

The potential scattering of a nucleus can be considerably different from $4\pi R^2$, where R is the size of the nucleus, if the potential well parameters happen to give an appreciable resonance effect. Strong resonance effects are expected to be accompanied by strong spin dependence. The potential scattering of beryllium shows an appreciable resonant effect but very small spin dependence in the scattering cross section. From an examination of the numerical parameters involved it is concluded that the small spin dependence in the cross section does not preclude a moderate amount of spin dependence in the potential wells for the two spin states—the close equality of the two scattering lengths involved may be the result of a coincidental combination of well depths and ranges.

THE "potential" scattering cross section of most nuclei for slow neutrons, especially of heavier nuclei, is of the order of $4\pi R^2$, where the nominal nuclear radius R is given by $r_0A^{\frac{1}{3}}$ with $r_0\sim1.5\times10^{-13}$ cm. Some nuclei, however, show "potential" cross sections considerably different from this value.

These differences can be accounted for by "potential-well resonances." These are purely scattering resonances, associated with resonant values of the scattering phase shift on the potential-well model, and are to be distinguished from resonances of the compound nucleus. These potential-well resonances will have a "width" given roughly by $ka\sim1$, where k is the neutron wave number and a is the magnitude of the scattering amplitude $(\sigma_{\text{scat}}/4\pi)^{\frac{1}{2}}$ for $k\rightarrow0$.

In the case of nuclei with nonzero spin, strong potential-well resonant effects are likely to be accompanied

* Supported by the U. S. Atomic Energy Commission, and written while the author was at the Brookhaven National Laboratory, summer 1953.