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Experimental Corroboration of the Theory of Neutron Resonance Scattering

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DETAILED theoretical investigations have been made on the variations of the cross section with energy near a neutron scattering resonance.[1,2] In particular, the phenomenon of destructive inteference between resonance and potential scattering has been predicted. Until now, however, there has been no definite experimental evidence of this effect. While measuring the total cross section of sulfur, a resonance was observed which shows the effect predicted by theory particularly clearly.

Cross sections were determined from transmission measurements using monoenergetic neutrons from the Li(p,n) reaction. The width of the neutron energy distribution was estimated at 7 kev for measurements made at an angle of 115° with respect to the incident proton beam, and 11 kev for points taken in the forward direction. Measurements were made over an energy range from 16 kev to 250 kev using a procedure similar to that previously described.[3]

The cross section is assumed to represent almost entirely elastic scattering since it is improbable that inelastic scattering will be appreciable at the low energies involved. Further, measurements of the total cross section of sulfur at low energies[4] indicate that neutron capture will probably account for less than 0.1 b at the energies used here.

Figure 1 shows a sharp peak at 111 kev preceded by a dip which is interpreted as caused by destructive interference between resonance and potential scattering. At this energy less than 2 percent of the potential scattering will be due to neutrons of more than zero angular momentum.[5] Therefore, it must be concluded that the resonance is caused by S-neutrons forming a state of S^{33} with spin $\frac{1}{2}$. This compound nucleus is formed from S^{32} which has an isotopic abundance of 95 percent and zero spin.

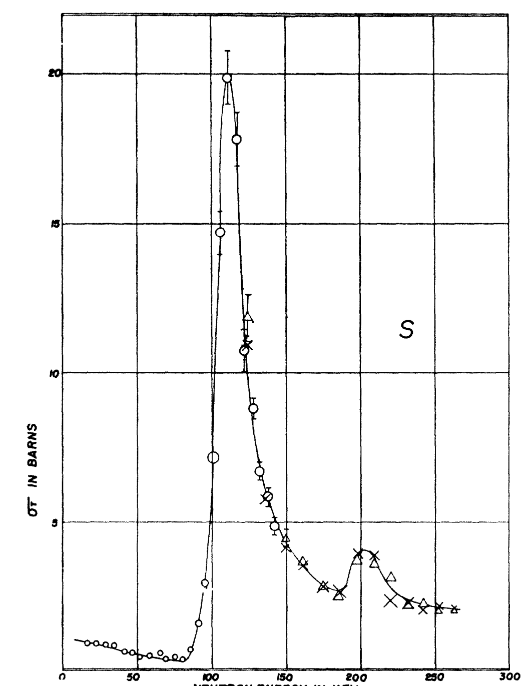

FIG. 1. The total cross section of sulfur as a function of neutron energy. The circles represent data taken at an angle of 115° with respect to the protons incident on the Li target. Other symbols show data taken in the forward direction. The height of the symbols is a measure of the statistical error.

For S-neutrons interacting with a target nucleus of spin zero the Breit-Wigner single level formula, including potential scattering, is expressed by Feshbach, Peaslee and Weisskopf[6] as:

$$\sigma=\frac{4\pi}{k^2}\left|\frac{\Gamma_n/2}{E-E_r+i(\Gamma/2)}+e^{ika}\sin ka\right|^2,$$

where k is the neutron wave number in the center of mass system, a is the nuclear radius $1.4\cdot 10^{-13}A^{\frac{1}{3}}$ cm,[7] E_r the resonance energy, and E the energy of the incident neutrons. Γ_n, the elastic scattering width, is taken to be equal to the total width Γ according to the preceding arguments.

The experimental width of the peak is about 19 kev which, by taking into account the effect of the neutron energy spread, yields a natural width of 18 kev. When this value is used for Γ, and E_r is taken as 108 kev, the experimental curve is found to be in good agreement with the theory. The correction for instrumental resolution increases the observed maximum cross section of 19.9 ± 0.9 b at 111 kev to 21.5 ± 1 b, which agrees with the theoretical value of 21.4 b at 111 kev. The theoretical minimum is zero at an energy of 82 kev. The position of the experimental minimum does not contradict this value, and the residual cross section of 0.3 b can be attributed to radiative capture and to the cross section of the other isotopes.

For 1-ev neutrons sulfur has a total cross section of 1.1 b, of which not more than 0.1 b is due to absorption.[4] Neglecting absorption, the potential scattering at low energies should be equal to $4\pi a^2$ or 2.4 b. The low value of the observed cross section can be explained by the effect of the resonance at 108 kev, since destructive interference reduces the theoretical value to 1.1 b at low energies.

There is evidence of a further resonance at 205 kev. The width of this peak is presumably quite small and its effect on the resonance at 108 kev should be negligible.

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Scintillations Produced by α-Particles in a Series of Structurally Related Organic Crystals

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WE are currently investigating the scintillation properties of a series of structurally related organic crystals, and in view of the fact that one of these crystals possesses a much higher conversion efficiency (number of photons per unit α-particle energy loss) than any other crystal previously reported, we considered it worth while to make a preliminary report of some of our results.

The series under investigation is 1,2-diphenylethane, 1,2-diphenylethylene (stilbene) and diphenylacetylene. The scintillation crystals were prepared by crystallization from a slowly cooling molten mass of the organic material. For purposes of comparison all crystals that were used were of approximately equal thicknesses