PHYSICS

M. M. KHALETSKII

1957

SovietRxiv

Fig. 1. Measurement scheme for $\sigma(\theta)$: 1—shield of Fe; 2—scintillating torus; 3—FEU-19; 4—scatterer; 5—target; 6—α-counter; 7—reflector

Figure 1: Fig. 1. Measurement scheme for $\sigma(\theta)$: 1—shield of Fe; 2—scintillating torus; 3—FEU-19; 4—scatterer; 5—target; 6—α-counter; 7—reflector

Abstract

Full Text

PHYSICS

M. M. KHALETSKII

DETERMINATION OF THE DIFFERENTIAL CROSS SECTIONS OF ELASTIC SCATTERING OF NEUTRONS WITH ENERGY $E_n = 14.8$ MeV FROM THE COUNT OF (n, α) COINCIDENCES (1)

(Presented by Academician V. N. Kondrat' ev, 13 XI 1956)

The source of neutrons was the reaction $D^2(T, n)He^4$. The α-particles emitted from the target at an angle of 135° to the deuteron beam were recorded by a FEU-19 with a thin NaJ(Tl) crystal. On leaving the target, the neutrons correlated with the α-particles passed through a narrow channel drilled in an iron shield of thickness $d_1 = 260$ mm (Fig. 1). The shield reduced the count from random (n, α) coincidences. Immediately behind the shield, cylindrical scatterers of diameter 25 mm and height from $d = 22$ mm to $d = 25$ mm were placed. During measurements the scatterers were introduced into the neutron beam and removed from the neutron beam by means of a special device. The neutrons were recorded by a liquid scintillation counter, which had the form of a torus. The torus was made from a thin-walled glass tube (inner diameter 20 mm). The mean diameter of the torus was 18 cm. A 2% solution of terphenyl in m-xylene was poured into the torus. The scintillating torus was placed in an aluminum reflector; the narrow base of the reflector was turned toward the cathode of the FEU-19. To change the angle θ at which neutron scattering was studied, the torus was displaced relative to the scatterer.

Fig. 1. Measurement scheme for $\sigma(\theta)$: 1—shield of Fe; 2—scintillating torus; 3—FEU-19; 4—scatterer; 5—target; 6—α-counter; 7—reflector.

Fig. 2. Measured cross sections $\sigma(\theta)$ for Pb. Errors are indicated only for points at which measurements were carried out repeatedly.

The resolving time of the coincidence circuit was $\tau = 2 \cdot 10^{-8}$ sec; simultaneously

Fig. 2. Measured cross sections $\sigma(\theta)$ for Pb. Errors are indicated only for points at which measurements were carried out repeatedly

Figure 2: Fig. 2. Measured cross sections $\sigma(\theta)$ for Pb. Errors are indicated only for points at which measurements were carried out repeatedly

Fig. 3. Measured cross sections $\sigma(\theta)$ for Sn and Fe

Figure 3: Fig. 3. Measured cross sections $\sigma(\theta)$ for Sn and Fe

with the coincidences, the circuit recorded α-particles and neutrons channel by channel. In the n-channel of the circuit, the pulse cutoff corresponded to the neutron counting threshold $E_n \approx 11.5$ MeV. The change in neutron flight time when the torus was displaced relative to the scatterer was corrected by connecting appropriate sections of coaxial cable into the α-channel of the circuit.

The measurement of the cross section $\sigma(\theta)$ consisted in taking readings of: 1) (n, α)-coincidences in the presence of the scatterer (N_p); 2) (n, α)-coincidences without the scatterer (Φ (background)); 3) neutrons incident from the target onto the torus for the given position of the latter (N_n). To measure N_n, the neutron counter was rotated around the target away from the iron shield.

The investigation showed that the background in the coincidence counting is, by $90 \pm 10\%$, due to the fact that the FEU-19 cathode itself counts 14-MeV neutrons. Special experiments showed that the attenuation of the background in the presence of the scatterer follows the dependence $\Phi e^{-n\sigma_t d}$, where σ_t is the total cross section

Fig. 3. Measured cross sections $\sigma(\theta)$ for Sn and Fe

Fig. 4. Measured cross sections $\sigma(\theta)$ for Al and C

for neutrons $E_n = 14$ MeV, n is the number of nuclei in 1 cm^3 of the scatterer.

The cross sections $\sigma(\theta)$ were calculated from the formula

$$\sigma(\theta) = \frac{N_p - \Phi e^{-n\sigma_t d}}{aN_n} \cdot \frac{r^2}{r_0^2} \cdot \Pi(\theta).$$

(The formula is valid under the assumption that the scatterer dimensions $d \ll r$.) Here r is the scatterer–torus distance; r_0 is the distance from the torus to the center of the target; $a = k_1 k_2 n \omega_\alpha d$; k_1 is the fraction of "correlated" neutrons incident on the scatterer; k_2 is the ratio of the intensity of the α-particle flux (per steradian) at the angle of the α-counter with respect to the deuteron beam,

Fig. 4. Measured cross sections $\sigma(\theta)$ for Al and C

Figure 4: Fig. 4. Measured cross sections $\sigma(\theta)$ for Al and C

$\varphi_\alpha = 135^\circ$, in the laboratory coordinate system, to the intensity of the α-particle flux in the center-of-mass system at the corresponding angle $\varphi_{\text{c.m.}}$; ω_α is the solid angle of the α-counter with respect to the target.

The correction $\Pi(\theta)$ takes into account the absorption of direct and elastically scattered, at angle θ, neutrons in the volume of the scatterer v:

$$\Pi(\theta) \sim \int e^{-x/\lambda} e^{-r(\theta)/\lambda}\, dv \qquad \left(\lambda = \frac{1}{n\sigma_t}\right).$$

In this work an approximate calculation of $P(\theta)$ was carried out by replacing $r(\theta)$ with $r_{\text{av}}(\theta)$, under the assumption that $r_{\text{av}}(\theta) < \lambda$, where $r_{\text{av}}(\theta)$ is the mean path of neutrons in the volume v scattered through the angle θ.

In the measurements, the coincidence counting rate was $\sim$ 1 pulse/sec; the background Φ amounted to from 30 to 50% of the total count, depending on the angle θ and the material of the scatterer. To reduce the background Φ, a Pb rod was inserted into the reflector (Fig. 1) (at present the method has been improved in that scintillations in the thorium are simultaneously recorded by two FEU-19 photomultipliers).

The cross sections $\sigma(\theta)$ measured for Pb, Sn, Fe, Al, and C are shown in Figs. 2–4. Where measurements were carried out several times, the measurement errors are shown in Figs. 2–4. The statistical error of an individual measurement is $\sim$ 15%. Our measurements agree with the results of works [2,3], which were obtained using a different measurement method.

The author thanks Academician V. N. Kondrat' ev for his attention to this work and N. M. Meleshin for his participation in the measurements.

Institute of Chemical Physics
Academy of Sciences of the USSR

Received
2 XI 1956

REFERENCES

1. M. M. Khaletskii, Report of the Institute of Chemical Physics, Academy of Sciences of the USSR, 13 III 1953.
2. I. O. Elliot, Phys. Rev., **101**, 684 (1956).
3. G. Culler, S. Fernbach, N. Sherman, Phys. Rev., **101**, 1047 (1956).

Note: Figure translations are in progress. See original paper for figures.

Source: Math-Net.Ru and CyberLeninka. Machine translation. Verify with the original.