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Fig. 1. Scheme for measuring the cross sections σ_t

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Abstract

Full Text

PHYSICS

M. M. KHALETSKII

MEASUREMENT OF TOTAL CROSS SECTIONS σ_t FOR NEUTRONS $E_n = 14.8$ MeV BY COUNTING (n, α) -COINCIDENCES¹

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

Registration of monochromatic α -particles from the reaction $D^2(T, n)He^4$ makes it possible, with the aid of a coincidence circuit, to select in space a narrow beam of neutrons from this reaction. The use of a beam of neutrons correlated with α -particles for measuring the cross sections σ_t makes it possible to eliminate the background (from other neutrons, in particular from neutrons of the reaction $D^2(D, n)He^3$, and from other causes).

In the present work a thick T–Zr target was used (Fig. 1). A beam of magnetically separated deuterons with energy $E_d = 160$ keV was incident on the target. The α -particles emitted from the target were registered by a NaJ(Tl) crystal of thickness $d = 0.5$ mm with an FEU-19. The window of the α -counter subtended, with respect to the target, a solid angle $\omega_\alpha = 1.8 \cdot 10^{-3}$ steradian. On the other side of the target, at a distance of 75 cm from it, there was a neutron counter—a stilbene crystal 34 mm in diameter with an FEU-19.

Fig. 1. Scheme for measuring the cross sections σ_t

The neutron detector was set into the beam of “correlated” neutrons with an accuracy of $\pm 0.5^\circ$; for this purpose the α -counter was rotated through 1° , first by the angle φ (in the horizontal plane), and then by the angle θ (in the vertical plane), and at each position the (n, α) -coincidences of the n -counter were counted at one and the same α -particle count (Fig. 2).

Fig. 2. Directionality of the beam of neutrons correlated with α -particles. Stilbene neutron counter, $d = 34$ mm at a distance $r = 25$ cm from the target: a —the counter was rotated about the target by the angles φ ; b —by the angles θ

Between the target and the neutron counter, at a distance of 26 cm from the

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target, cylindrical scatterers were placed into the neutron beam, and removed from the beam, by means of a special device. The dimensions of the scatterers were: diameter 25 mm, height 25 mm. The measurement of the total cross sections σ_t consisted in counting (n, α) -coincidences with the scatterer present and without it. From the attenuation of the (n, α) -coincidence count,

$$[T = e^{-n \cdot \sigma_t \cdot d},]$$

where n is the number of nuclei in

1 cm³, σ_t was determined. In the measurements a coincidence circuit with a resolution $\tau = 5 \cdot 10^{-8}$ sec was used. The counting rate of coincidences in the measurements was ~ 30 pulses/sec; simultaneously with the recording of coincidences, neutrons and α -particles were counted channel by channel. The emergence of neutrons from the target was monitored by the α -particle count.

Table 1

Element	Number of nuclei in 1 cm ³ , $n \cdot 10^{22}$	Total cross sections σ_t		
		from our measurements, in barns	σ_t from measurements ⁽²⁾ , in barns	σ_t from Goodman's measurements ⁽³⁾ , in barns
Li	4.59	$1.24 \pm 0.06^*$	1.45 ± 0.03	—
Be	12	$1.46 \pm 0.03^*$	1.53 ± 0.03	1.4 ± 0.1
C	7.72	1.18 ± 0.12	1.32 ± 0.02	1.20 ± 0.04
Mg	4.31	$1.83 \pm 0.05^*$	1.75 ± 0.03	1.8 ± 0.2
Al	5.81	1.75 ± 0.08	1.73 ± 0.03	1.8 ± 0.1
Fe	8.5	2.51 ± 0.06	2.60 ± 0.05	2.4 ± 0.2
Cu	8.38	2.66 ± 0.07	2.96 ± 0.06	2.5 ± 0.1
Pd	6.7	4.0 ± 0.1	—	—
Cd	4.61	4.12 ± 0.06	4.44 ± 0.09	—
Sn	3.51	4.05 ± 0.07	4.68 ± 0.09	4.0 ± 0.4
Pb	3.29	5.28 ± 0.15	5.48 ± 0.11	5.1 ± 0.4
Bi	2.82	5.33 ± 0.08	5.46 ± 0.11	5.2 ± 0.5
U	4.73	5.64 ± 0.1	5.87 ± 0.12	—

* According to the measurements of G. A. Ovsyannikov.

The results of the measurements of σ_t are shown in Table 1; the data of Coon et al. ⁽²⁾ and Goodman ⁽³⁾, obtained by another method for neutrons with energy $E_n = 14$ MeV, are also given there.

The described method of measuring neutron cross sections can be extended to neutrons from the reaction $D^2(T, n)He^4$ for $E_n \gg 14$ MeV and $E_n < 14$ MeV (regardless of whether, at higher deuteron energies, the reaction $D^2(T, n)He^4$ remains a source of monochromatic neutrons ^(4,5) or whether two neutron groups appear in it) and to neutrons from the reactions $D^2(D, n)He^3$ ^(1,6) and $p(T, n)He^3$.

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