ANGULAR ENERGY DISTRIBUTION OF NEUTRONS AT AN INTERFACE

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Spectra of scattered neutrons emerging at various angles from a flat slab of graphite in which a source of fast neutrons of mean energy 3.9 MeV is placed 20 cm from the interface were measured in the work described in this note. The results obtained in the angular range 20-70° and energy range 1.3-3.9 MeV are in essence a solution of the kinetic equation at the interface between two media (graphite-water interface) for the given geometry.

The layout of the experimental set-up is seen in Fig. 1. The $H^2(H^2, n)He^3$ reaction at deuteron energy 900 keV provided the neutron source. Neutrons were singled out at a specific angle by means of a conical collimator giving an angular resolution of ~5°. The neutrons emerging from the graphite in the neighborhood of point A at angle θ could not be scattered in the water since an air cavity was established at the interface.

The neutrons were recorded with a single-crystal fast-neutron scintillation spectrometer discriminating against gamma rays [1]. The amplitude distributions of the pulses were measured with an AI-100 analyzer. The energy scale of the spectrometer was checked periodically against measured spectra of unscattered neutrons.

The large size of the tank filled with a solution of 2% boric acid provided a low-level neutron background. The neutron background was measured when the collimator cavity was filled with water. The relationship of the background and the effect for neutrons emerging at various angles are tabulated. This table shows the relationships between neutron flux and gamma emission. The same flux relationships made it possible to set the spectroscopic threshold of the spectrometer at no higher than 1.3 MeV. The γ-emission discrimination at this threshold was $(6\text{-}8)\cdot 10^{-4}$ at a gamma count rate no higher than $1.3\cdot 10^3$ pulses/sec.

It is clear from the table that even at 70° the measured neutron amplitude distributions contain not more than 4% pulses due to gamma emission, since the background is primarily due to gamma emission, and the gamma emission load in the effect and background, and separately in the background, is approximately the same. The amplitude distribution was measured three or four times for each angle. Each amplitude distribution was converted to the neutron energy spectrum by means of a numerical matrix based on [1]. The use of this numerical matrix to convert amplitude distributions to energy spectra is described in detail in [2]. The use of a differentiation technique in processing these amplitude distributions yielded findings which differed by not more than 20%, even in the 1.3-2.0 MeV neutron energy range. Figure 2 gives the angular distributions of neutron energy groups. Root mean square errors are indicated.

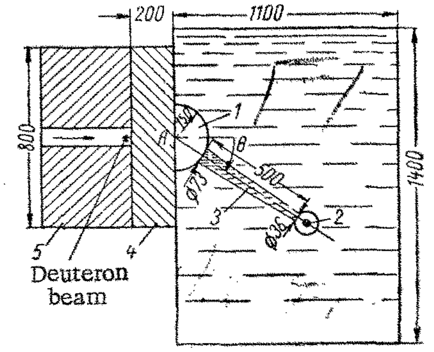

Fig. 1. Design of experimental arrangement. θ) angle of scattering; 1) air cavity; 2) detector; 3) collimator; 4) graphite; 5) target.

Relationship between Neutrons and γ-Emission

Scattering angle, θ	Neutrons		Neutrons and γ-emission		Relation between neutrons and γ-emission
	effect and background	background	effect and background	background alone	effect and background
20°	27	0,2	1000	560	0,03
70°	3	0,5	650	500	0,005

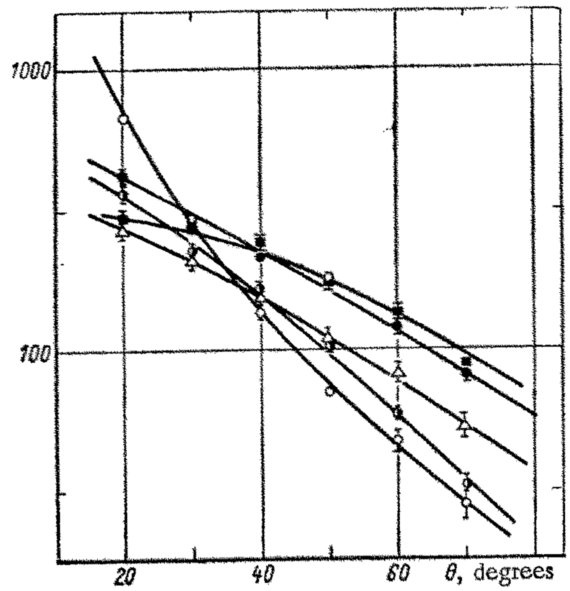

Fig. 2. Angular distributions of neutron energy groups as a function of energy, MeV. ○) 3.5-3.9; ◑) 3.0-3.5; △) 2.5-3.0; ●) 2.0-2.5; ■) 1.3-2.0.

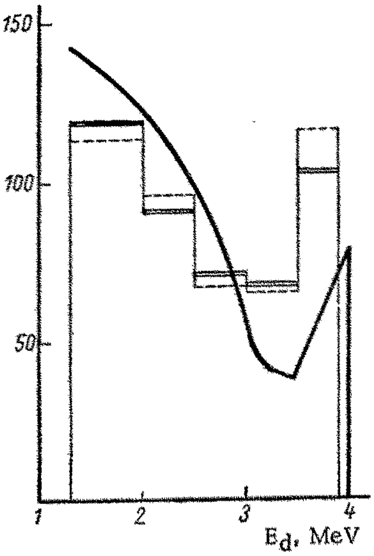

Fig. 3. Energy distribution of neutrons at graphite-water interface: ---) angle range from angular distribution; ═) energy distribution at interface; —) theoretically predicted spectrum [3].

The energy distribution of the neutrons at the graphite-water interface, obtained by integrating the angular energy distributions over the 0-180° angular interval, appears in Fig. 3. Here the energy distribution of neutrons measured at the graphite-water interface when the spectrometer was placed in the air cavity is plotted (as histograms). All three spectra are area-normalized. The difference in the shape of the measured spectrum and the theoretically computed spectrum is due to the different geometry.

Figure 4 shows the angular distributions of the energy groups 1.3-3.9 and 3.5-3.9 MeV, and the results of calculations in an approximation of single scattering with and without taking energy losses into account. The angular dependence of the 1.3-3.9 MeV group is excellently fitted by the exponential law $\exp[-\theta/\theta_0]$ where $\theta_0 = 28.0 \pm 1.0°$.

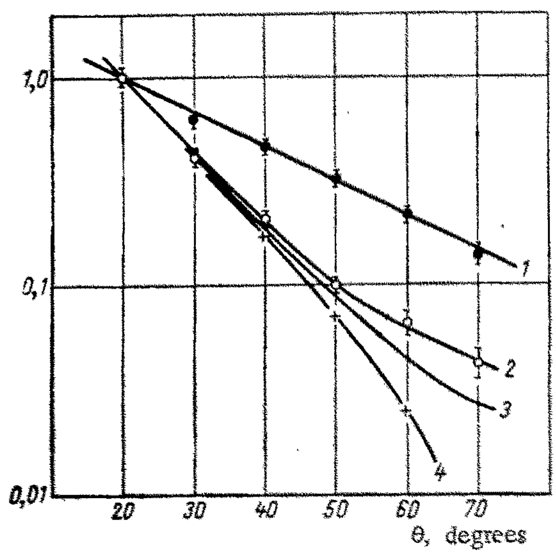

Fig. 4. Comparison of angular distributions of energy groups: 1) 1.3-3.9 MeV; 2) 3.5-3.9 MeV; 3) calculated with energy losses ignored; 4) calculated with energy losses taken into account.

Calculations based on a formula for single scattering with scattering with energy losses taken into account to 3.5 MeV for a given graphite thickness fail to coincide with experimental findings in the case of the 3.5-3.9 MeV group, attesting to an appreciable contribution of multiple scattering, even in the case of such a hard neutron group at large scattering angles. The differential scattering cross section on carbon at 3.65 MeV neutron energy was used in the calculations [4].

Calculations based on the single-scattering formula with energy losses disregarded constituted, in a certain sense, a manner of treating multiple scattering. The theoretically predicted curve was in satisfactory agreement with experimental findings.

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All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. *Some or all of this periodical literature may well be available in English translation.* A complete list of the cover-to-cover English translations appears at the back of this issue.