ANGULAR DISTRIBUTION OF ELASTICALLY SCATTERED NEUTRONS

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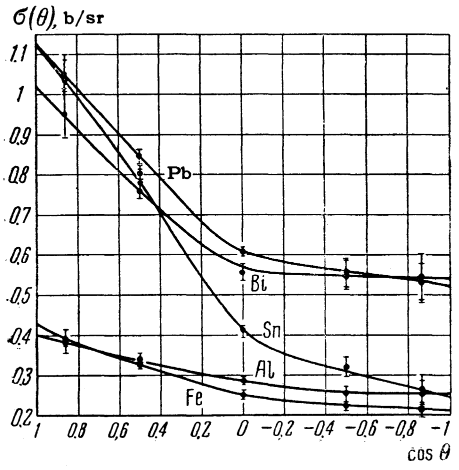
The differential cross sections for the elastic scattering of neutrons from a $Na^{24}(\gamma,n)D_2O$ source by Pb, Bi, Sn, Fe, and Al nuclei have been measured over the range of angles from 30° to 150°. The total elastic cross section, the transport cross section, and the mean value of the cosine of the scattering angle were obtained from the measured angular distributions.

WE have studied the angular distributions of neutrons elastically scattered from Bi, Pb, Fe, Sn, and Al nuclei. A $Na^{24}(\gamma,n)D_2O$ photoneutron source was used for this purpose. The γ rays were emitted from a thin-walled nickel capsule with an internal diameter of 29 mm, containing compressed sodium fluoride. This source was placed in another nickel capsule consisting of two halves filled with heavy water to a layer thickness of 8 mm. The mean energy of the neutrons from a source with this same thickness of heavy water, according to Wattenberg's results,[1] was 220 kev. A proportional counter with an active volume 80 mm in length, filled with BF_3 and surrounded with layers of paraffin and boron carbide, served as the detector. Rings of various diameter and thickness, according to the scattering angle, were used as the scattering samples.

In reducing the experimental data, it was kept in mind that the sensitivity of the counter circuit was different for neutrons which arrived directly and those which had been scattered from the sample. Allowance was made for the fact that the direct and scattered neutrons fall on the detector at different angles to the detector — source symmetry axis. The angular sensitivity of the detector was determined experimentally; the corresponding corrections were applied. Allowance for the effects of attenuation and multiple scattering was made in the course of the calculation by the method of Turchin.[2] A measurement was also made of the effect of the shielding screen on the number of neutrons scattered from the sample. Throughout the work, elaborate checks were carried out on the influence of γ radiation on the results.



Angular distribution of elastically scattered neutrons.

To provide a correction for the decay of the source, and also as a check on the stability of the operation of the apparatus, the half-life of the Na^{24} source was measured and found to be 14.93 ± 0.08 hours.

The differential cross sections for elastic scattering of neutrons, measured by the method described above, are shown in the figure. They are given as functions of the cosine of the scattering angle in the laboratory system of coordinates. The mean-square statistical errors are different for different angles, and lie between the limits of 2% and 7%. At 150° (reversed geometry) they are somewhat larger, amounting to about 10% on the average. The statistical errors of the measured corrections are very small, and amount to less than a percent each. On the average, the total error of the results, for all values of cross sections, did not exceed 15%.

The elastic scattering was measured every 30° over the range of angles from 30° to 150°. The average angular resolution was ± 10°. The variation of the scattering angle θ was accomplished by varying the distance

Values of elastic, transport, and total cross sections (in barns)

Element	σ_e	σ_{tr}	σ_t	$\overline{\cos\theta}$	Element	σ_e	σ_{tr}	σ_t	$\overline{\cos\theta}$
Al	3.75	3.43	3.76	0.086	Pb	8.79	7.62	8.80	0.134
Fe	3.49	3.10	3.50	0.116	Bi	8.23	7.37	8.23	0.104
Sn	6.80	4.90	6.85	0.285					

between the source and the detector, and also by the use of rings of different diameters. In order to increase the scattering effect, thicker rings were used at 30° and 150° than at the other angles.

Since no inelastic scattering is observed in the elements studied at the neutron energies used, the differential cross sections are the cross sections for the elastic scattering only.

In the table are shown the total elastic cross-sections σ_e, the transport elastic cross sections σ_{tr}, the total cross sections including the decay cross section (σ_t), and also the mean value of the cosine of the scattering angle. The decay cross section is taken for the same neutron source from the work of Belanova.[3]

The total elastic scattering cross section was obtained by integrating the differential cross-section curve over the total solid angle. In a case where there is no inelastic scattering, the formula

$$\sigma_{tr} = \sigma_t (1 - \overline{\cos\theta}).$$

was used in calculating σ_{tr}.

[1] A. Wattenberg, Phys. Rev. **71**, 497 (1947).

[2] V. F. Turchin, Атомная энергия, (Atomic Energy) **4**, 244 (1958).

[3] T. S. Belanova, JETP **34**, 574 (1958), Soviet Phys. JETP **7**, 397 (1958).

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