ANGULAR DISTRIBUTION OF 14-Mev NEUTRONS INELASTICALLY SCATTERED ON CARBON, NITROGEN AND SULFUR

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The angular distributions of neutrons inelastically scattered on C, N and S nuclei with excitation of the first excited states of these nuclei are measured. The results are in agreement with calculations according to the direct interaction model.

EXPERIMENTS on angular distributions for inelastically scattered nucleons are of considerable interest in that they clarify the mechanism of reactions. Thus, the first qualitative studies of the angular distributions of inelastically scattered 14-Mev neutrons [1] were not consistent with the compound nucleus theory. The direct interaction model was in considerably better agreement with these experiments.

Experiments involving inelastic scattering for individual nuclear excited states are especially interesting, since the results can be directly compared with various theories.

In the present work a measurement was made of the angular distribution of inelastically scattered 14-Mev neutrons with excitation of the first excited states of the C^{12}, N^{14}, and S^{32} nuclei.

The neutron source was the reaction $T(d,n)He^4$, which was produced in the low-voltage accelerator of the Physics Institute of the Ukrainian S.S.R. Academy of Sciences. The measurements were made in an annular geometry. The scatterers were in the form of toruses of diameter 200 and 330 mm and cross-section diameter of 30 mm. For the measurements on nitrogen, a thin-walled copper container was employed whose double walls permitted the use of liquid nitrogen as the scatterer. A scintillation spectrometer consisting of a photomultiplier (FÉU-14-A), a stilbene crystal, and a 100-channel pulse-height analyzer (AI-100-1) was used to detect the neutrons. The spectrometer had an energy resolution of 3%. A scintillation counter was also used for monitoring.

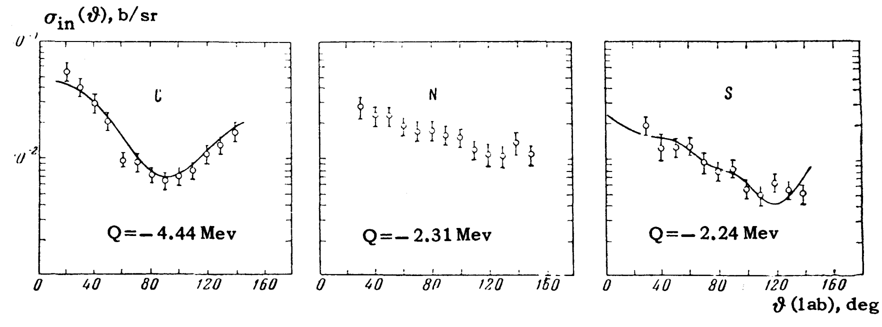
In the experiment the spectra of scattered neutrons, of the background, and of the incident neutrons were measured for each angle.

The ratio between the intensity of inelastically scattered neutrons for the first excited level to the intensity of the incident neutron beam was determined by analyzing the quantity

$$S_m = \left(\sum_{i=m}^{M} N_{si} - N_{bi}\right) / \sum_{i=m}^{M} N_{\text{inc i}},$$

where N_{si}, N_{bi} and $N_{\text{inc i}}$ are, respectively, the number of counts in the j-th channel when measuring scattered neutrons, background neutrons, and the incident beam; M is the number of channels registering the spectrum. Corrections were introduced into S for the energy and angular sensitivity of the detector and for attenuation of the neutron beam in the scatterer. The adjusted spectrum of S values allows us to determine the interaction cross section for groups of inelastically scattered neutrons separated by 1 Mev energy intervals. The energy of the levels is in good agreement with the results of other authors. [2]

The graphs represent the results of measuring the inelastic scattering cross section in which the first excited levels of C^{12}, N^{14}, and S^{32} nuclei have



Angular distribution of inelastically scattered neutrons with excitation of the first excited state of the C^{12}, N^{14}, and S^{32} nuclei respectively. The solid curve represents a calculation from direct interaction theory.

been excited. The results for carbon agree well with those of Anderson et al.[3] The measurements on nitrogen and sulfur are performed for the first time.

The angular distributions measured for carbon and sulfur were compared with calculations performed on the basis of direct interaction theory by Glendenning.[4] In the case of sulfur, the comparison was made with calculations for a nucleus with atomic weight of ~ 30 and the same first excited state characteristics as sulfur.

The large cross section for forward scattering and the good agreement with theoretical curves computed on the basis of the direct-interaction hypothesis allow us to conclude that the excitation of the first levels of these nuclei by 14-Mev neutrons is due to a direct interaction process.

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[3] Anderson, Gardner, McClure, Nakada, and Wong, Phys. Rev. **111**, 572 (1958).

[4] N. K. Glendenning, Phys. Rev. **114**, 1297 (1959).

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