Determination of the Efficiency of Neutron Detectors in the Experiment of Inelastic Neutron Scattering on ^{12}C

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Information about neutron-nuclear interactions is extremely important for applied and fundamental physics. Since the neutron has no electric charge, it has a high penetrating power, which can be used, in particular, to research the structure of matter.

As part of the TANGRA collaboration, an experiment is being conducted to study the reaction of inelastic neutron scattering on a carbon nucleus $^{12}C(n, n')^{12}C^{*}$ using the method of labeled neutrons. It is planned to obtain the values of the differential neutron scattering cross sections of 14.16 MeV in the angle range from 0 to 2π.

The method of labeled neutrons implies registration of events (in our case, inelastic collision of neutrons with carbon nuclei ^{12}C), in coincidences with α–particles formed in a neutron generator in the reaction of deuterium and tritium synthesis:

$$d + t \rightarrow n(14.1\ \text{MeV}) + \alpha(3.5\ \text{MeV})$$

The reaction products scatter in opposite directions in the center-of-mass system, so that knowing the direction of departure of the α-particle, it is easy to determine the direction of departure of the neutron. The "marking" of the neutron is carried out by a pixel α-detector located in body of the neutron generator [1].

The installation is a neutron generator with a carbon C12 screen located in front of it, surrounded by detectors at different angles with a increments of 15°.

An important part of data analysis is to determine the efficiency of the detectors used in the experiment. This is important both for determining the sensitivity limits of measuring instruments and for estimating the total neutron flux for each detector. Efficiency estimates can be made using different methods, in particular, for a similar experiment V. Valkovich's group used the following equations [2]:

$$\varepsilon(0thr) = \frac{N_H\sigma_H}{N_H\sigma_H + N_C\sigma_C}\left(1 - e^{-d(N_H\sigma_H + N_C\sigma_C)}\right)$$

$$\varepsilon(E_{thr}) = \varepsilon(0thr)\left(1 - \frac{E_{thr}}{E_{neutron}}\right), \qquad (1)$$

where, N_H is density of hydrogen atoms, N_C is density of carbon atoms, σ_H and σ_C – total cross sections for scattering of neutrons having energy $E_{n'}$ on H and C, d = 8cm.

As a result of this work were obtained estimates for the efficiency of neutron detectors, performed their calibration, and constructed dependences for efficiency on the energy of the incoming neutron were.

Literature

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2. V. Valkovic. 14 MeV Neutrons. Physics and Applications. CRC Press, New York. 2015.