International Atomic Energy Agency

INDC(CPR)-003/L

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August 1985

IAEA NUCLEAR DATA SECTION, WAGRAMERSTRASSE 5, A-1400 VIENNA

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August 1985

85-03918

Nonelastic Scattering Cross Section Measurement on Cu, Si at 14.9 MeV

Nonelastic scattering cross sections for Cu and Si at 14.9 MeV have been measured by using of the sphere trasmission technique. Corrections have been applied to the data with a simpler method, principally for elastic scattering energy loss and multiple scattering. The results have been compared with others.

1. Introduction

Nonelastic scattering cross section are useful not only to the nuclear engineering, but also to the calculation of nuclear reaction cross section with optical model. They are also the basical data on nuclear data evaluation. But nutil present, the measured data of some elements are still sparse, especially at the energy region of above 14 MeV. For instance, at the energy region mentioned above there was only one measurement om Silicon at 14 MeV in 1956 (1). Hence measurements of nonelastic scattering cross section are of significance.

2. Principle and Method of Analysis

Most nonelastic scattering cross section measurements were performed with spherical shell method. According to the reciprocity theorem this work was done with sphere around the detector, while the corrections calculations were made assuming the sphere to be around the source. The principle of the sphere method is that the scattering out of neutrons from the direct beam by the sphere around a source must be exactly compensated for by the scattering in of neutron from other regions of the sphere.

In an actual experiment two of corrections must be taken into account: (a) elastic scattering energy loss, and (b) multiple scattering. There are still other corrections such as the noninfinite distance between the source and the detector; the neutrons source are not monoenergetic and not isotropic; finite detector size. But according to the work of Lu Zuyin et al.(2), the effect of these factors on nonelastic scattering cross section can be negligible in our experiment. Hence only two main corrections i.e., the elastic scattering energy loss and multiple scattering were considered with a simple method introduced by Arun Chatterjee et al.(3).

(1). Correction of multiple scattering

When a absorber thickness is not infinitesimally small compared with the elastic-scattering mean free path, the error due to multiple scattering can not be neglected. In the case of fast neutron, scattering mostly confined to the forward cone. And in this case Bethe et al.[4] have shown that as a first approximation the apparent cross section $\sigma(t)$ is given by

$$\sigma(t) = \sigma_{ne} \left(1 + \frac{1}{2}\sigma_{et}\, t \right) \qquad (1)$$

where σ_{ne} is the nonelastic scattering cross section, σ_{et} is the elastic transport cross section. When the shell thickness is moderately large, the above simple relation breaks down. However, the general form of the above equation should retain its validity even under such conditions, and an extrapolation formula of the form

$$\sigma(t) = \sigma_{ne} \left(1 + at + bt^2 + \ldots\ldots \right) \qquad (2)$$

can be used. In which the constants a, b, etc. are treated as empirical constants.

A. Chatterjee et al.[3] have shown the apparent cross section measured as a function of absorber thickness. It would be seen that the first two terms of Eq.(2) were sufficient to repersent these results within the limits of experiment error.

In this work the measurements with 4 different thicknesses of Si spherical shell have been done and the apparent cross sections are shown in Fig. 1.

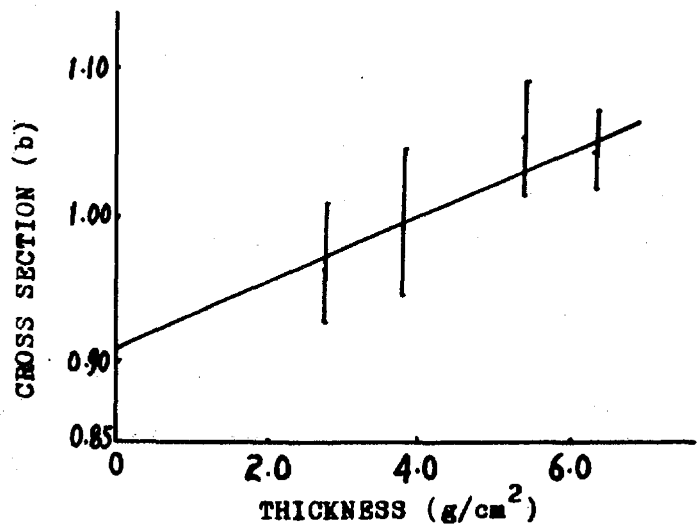

Fig. 1. Apparent nonelastic cross section of Si as a function of absorber thickness

(2). Correction of elastic scattering energy loss

According to A. Charrejee et al.[3], we determined the correction of elastic scattering energy loss by the method of two biases. This method is based on the fact that in the efficiency diagram shown in Fig. 2 the curves for different biases can be transformed from one into another by a simple deformation of the ordinate scale. The principal advantage of this method over conventional methods is that it requires no knowledge about the spectrum of elastically scattered neutrons. The scale factor m calculated by us used in our experiment is shown in Fig. 3. The nonelastic cross section can be related to the experimentlly measured cross section at two different biases b and b' by the relation

$$\sigma_{ne} = \frac{(\sigma_{expt} - m\sigma'_{expt})}{(1 - m)} \qquad (3)$$

Eq.(3) then enable us to measure nonelastic scattering cross section by a method quite independent of the shape of the elastically scattered neutron spectrum.

3. Experimental Arragement

The $T(d,n)^4He$ neutron source on a 400 kV Cockcroft-Walton accelerator was used in this experiment. The detedtor was placed at 45°, and the monitor at 135° with respect to the deuteron beam. The neutron energy is 14.9 MeV in the direction of the detector.

The plastic scintillater (ST-401) detector was in cylinderical shap (φ1.4cm × 1.4cm) with a semi-spherical top. The optical coupling between the scintillater and the pipe was made with the help of silicone oil of high viscosity. The whole assembly was then coated with aluminium foil. The dimension of the detector was such

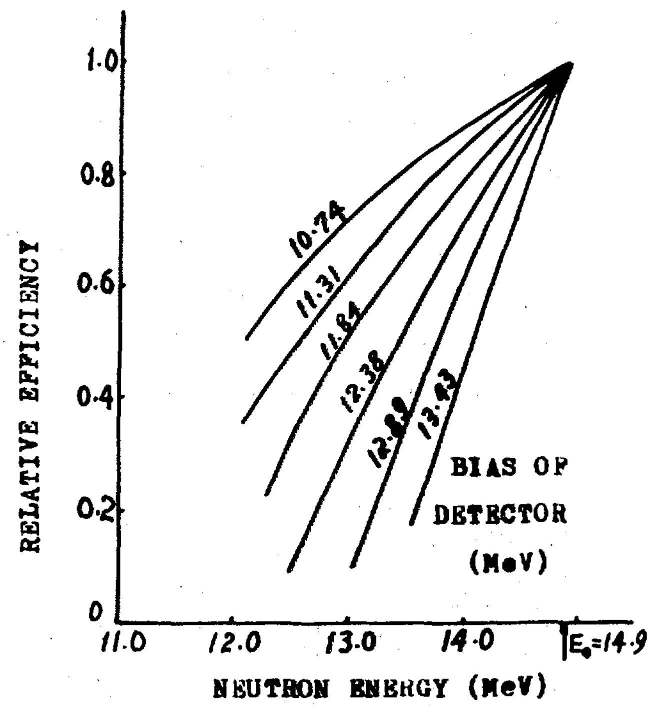

Fig. 2. Relative efficiency curve of a spherical plastic scintillator as a function of neutron energy for different biases

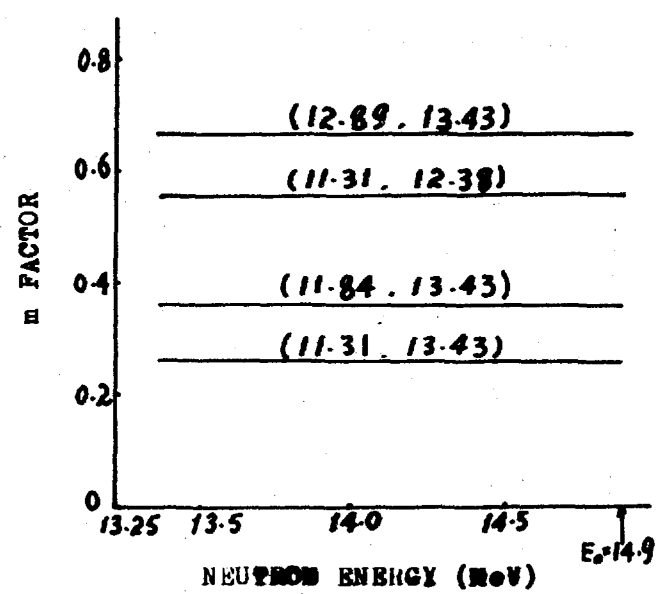

Fig. 3. Variation of the scale factor m with energy (by calcution)

that the γ-ray pulses heigh were confined to the lower-bias portion of the pulse- height spectrum. Hence, the high-bias portion of the spectrum, which is of interest in our experiment, did not contain any pulses from γ-rays and from background neutrons.

The metallic copper samples (99.999% in purity) and powdered silicon samples (99.95% in purity) in thin-walled aluminium shells were used in different thicknesses. These samples were radiograghed to ensure that no casting voids were present in them. Their thicknesses and densities are shown in table 1.

Table 1. Thickness and Density of Samples

SEQUENCE	Cu					Si			
NUMBER	1	2	3	4	5	1	2	3	4
THICKNESS(cm)	1.786	2.340	2.906	3.410	3.883	2.040	2.845	4.250	5.100
DENSITY(g/cm^3)	8.937	8.933	8.918	8.810	8.786	1.378	1.361	1.284	1.256
MASS THICKNESS ($\times 10^{23}$ Atomic number/cm^2)	1.512	1.981	2.456	2.847	3.234	0.603	0.831	1.170	1.373

4. Results

The measured nonelastic scattering cross sections of Cu and Si in our experiment are shown in table 2 with previous measurements. Within the experiment errors our results are agreeable to the previous measurements.

Table 2. Comparison of Nonelastic scattering cross section for Cu, Si at 14 MeV neutrons

author	neutron energy (MeV)	nonelastic scattering cross section (barns)	
		Si	Cu
Флеров [1]	14.1	1.02 ± 0.06	1.48 ± 0.06
MacGregor et al. [5]	14.2		1.49 ± 0.02
Lu Zuyin et al. [2]	14.5		1.44 ± 0.02 1.45 ± 0.02
Chatterjee et al. [3]	14.8		1.46 ± 0.03
Pal et al. [6]	14.2		1.49 ± 0.03
Present work	14.9	0.93 ± 0.04	1.49 ± 0.02

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