Estimation of Neutron Absorption Ratio of Energy Dependent Function for ^{157}Gd in Energy Region from 0.003 to 100 eV by MCNP-4B Code

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Gd-157 material has very large neutron capture cross section in the thermal region. So it is very useful to shield material for thermal neutrons. Futhermore, in the neutron capture experiment and calculation, the neutron absorption and scattering are very important. Especially these effects are conspicuous in the resonance energy region and below the thermal energy region. In the case of very narrow resonance, the effect of scattering is to be more considerable factor. In the present study, we obtained energy dependent neutron absorption ratios of natural indium in energy region from 0.003 to 100 keV by MCNP-4B Code. The coefficients for neutron absorption was calculated for circular type and 1 mm thickness. In the lower energy region, neutron absorption is larger than higher region, because of large capture cross section (1/v). Furthermore it seems very different neutron absorption in the large resonance energy region. These results are very useful to decide the thickness of sample and shielding materials.

Ⅰ. Introduction

Gd-157(Gadolinium) material has very large neutron capture cross section in the thermal region. Since the capture cross-section is large in the lower energy region (thermal neutron capture cross-section: 253,757 barn)[1]. Figure 1 shows the evaluated neutron capture cross section of Gd-157 sample. So it is very useful to shield material for thermal neutrons. Futhermore, in the neutron capture experiment and calculation, the neutron absorption and scattering are very important. Especially these effects are conspicuous in the resonance energy region and below the thermal energy region. In the case of very narrow resonance, the effect of scattering is to be more considerable factor. The neutron absorption and scattering are very important to calculate the thickness of shield and experimental sample. In the present study, the absorption ratios of Gadolinium (Gd-157) were calculated by MCNP(A General Monte Carlo N-Pe vicle Transport Code)-4B Code. The Gadolinium is a promising material for the neutron dosimetry measurement by the activation method[2]. The neutron capture cross section of Gadolinium is for the study of neutron capture mechanism and for the safetr thsign of nuclear reactors. Gadolinium is an useful neutron detector for the reactor dosimetry[3].

Ⅱ. Method and calculation

In the neutron capture cross-section measurement and the study of the neutron shielding effects, the effect of single and multiple neutron scatterings in the capture sample are quite important in determining a thickness of material. This effect, which increases with the effective sample thickness relative to the geometrical thickness in the direction of incident neutrons, must be considered in the capture cross-section measurement in which the total number of capture events in a sample is measured. In the present study, we have made Monte Carlo calculations using the MCNP-4B code[4] to simulate the neutron capture and multiple scattering events in the sample and carry out the corrections

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of the effect of single and multiple neutron scatterings in the capture sample. The scheme of simulation shown in Fig. 2. There are several type of neutron and photon reaction in the sample(material). We can assume that there are one and two reactions in the case of thin sample. The sample size is 18mm x 18mm and Thickness: 1mm. However, there are several type of reactions in the case of thick sample. The sampling(neutron generation number) is 10,000,000 times.

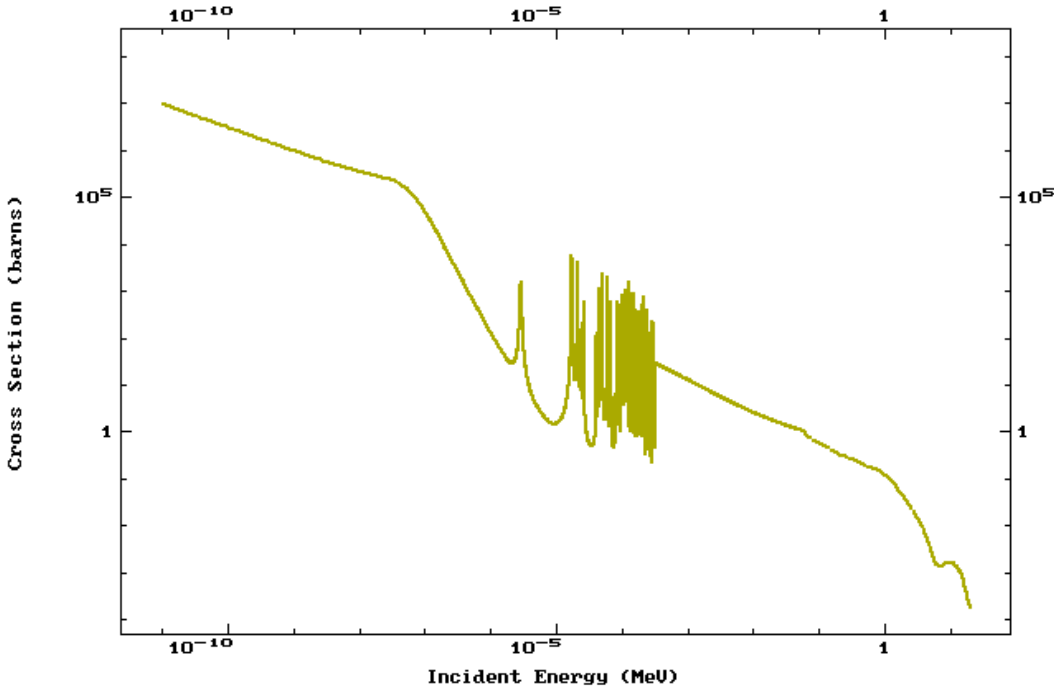

Figure 1. The evaluated neutron capture cross section of Gd-157 isotope. The thermal neutron capture cross section has 253,757 barn that is largest value in the element.

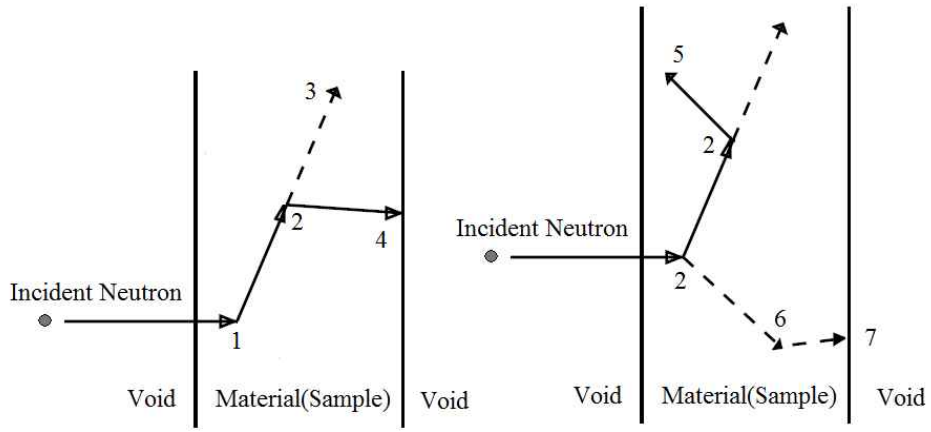

Figure 2. Incident neutrons have several type of reaction as follows (1). Neutron elastic scattering, (2), Neutron inelastic scattering and photon production, (3). Photon absorption(capture), (4). Neutron leakage, (5). Neutron capture, (6). Photon scattering, (7). Photon leakage

Ⅲ. Result

In the present study, neutron absorption ratio function was estimated by Monte-Carlo method. The correction factor of the Gadolinium sample is shown in Fig. 3. In the thermal energy region, the correction factors were remarkably depend on the incident neutron energy. In this case of thermal region, the factor is about 100 times than above 1eV energy region. Furthermore it seems very different correction factor in the neutron capture resonance. However in small and sharp resonances above several neutron energy, the difference is small. It seems constant factor above 1 keV neutron energy because of low of low of low of low of low o. In keV energy region, negative absorption ratio found because of neutron scattering effect by very closed and narrow neutron capture resonances. From these results we have to consider the neutron capture effects in the thermal energy region and large neutron capture region.

Reference

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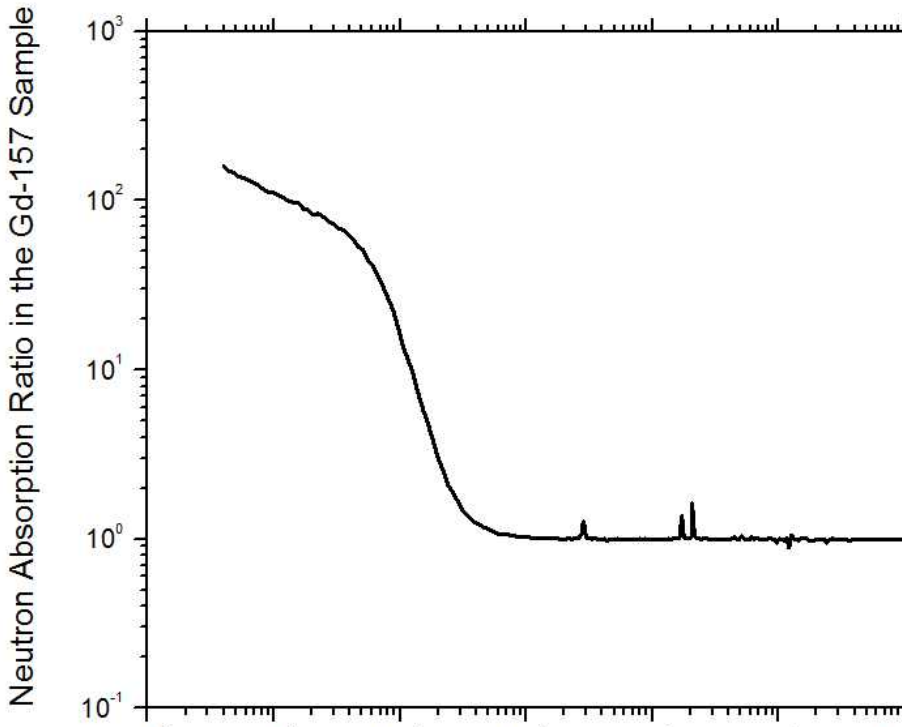

Figure 3. The correction factor of Gd-157 sample