Estimation of the total neutron-nucleus cross section using GEANT4.

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Introduction

Studies of total cross-section for neutron-nucleus collisions in the vicinity of the reactor domain are of interest in a number of fields of study in basic science as well as many of applied nature [1–5]. Moreover, the lack of experimental data for measuring the fast neutron cross section for medium nuclei must be compensated by an estimation by simulation calculations. Many studies have been done for neutron shielding abilities for various shielding materials [6]. The total neutron cross section for Fe^{56} is estimated using GEANT4 with a Cf^{252} source avaliable in reference physics lists. The High Precision (QGSP BERT HP) neutron model is used for the hadronic interactions of low-energy neutrons below 20 MeV.The neutron flux with and without the iron foil for three different thicknesses is recorded on the scoring mesh volume using the primitive scorer named flatSurfaceFlux. The results are compared with a nuclear reaction TALYS 1.96 code, and it is found that the GEANT4 results describe the cross section well. This study leads to useful insights into the mechanisms of neutron-induced reactions.

Model

The high-precision neutron model QGSP BERT , which is used as a reference physics list that uses the quark-gluon model for low-energy interactions below 20 MeV . GeneralParticleSource (GPS) is used to generate the incident neutrons as an energy distribution. flatSurfaceFlux: The neutron flux with and without the iron shield for three different thicknesses is recorded on the scoring mesh volume, which acts as a detector, and using the primitive scorer named flatSurfaceFlux, In the present work, Cf^{252} is taken as the neutron source for neutrons below 20 MeV and defined as a planar source to get standard emission in a particular direction. The neutron flux is in the (0, 0, 1) direction. The scoring mesh volume acts as a detector and is used to record the neutron flux, and the primitive scorer is named flatSurfaceFlux, which is a surface-based flux scorer and is used to record the number of tracks that pass through the given scoring volume. The iron foil with area $2cm^2$ and different thicknesses 3mm, 4mm, and 15 mm are used as shield samples and placed at a distance of 26 cm from the source and 100 cm from the scoring mesh scoring mesh volume, which is located much closer to the neutron source than the traditional position" halfway between the source and the detector" Fig. 1,

Results and discussion

The neutron-nucleus total cross-section depends on the nuclear potential transparency for neutron. This transparency increases slowly with increasing incident wave energy and decreases sharply with increasing incident neutron orbital angular momentum. This means that there are finite numbers of partial waves that contribute to the neutron-nucleus interactions. Whereas, the remaining number will pass without interaction. Fig. 2 shows the total cross-section as a function of the incident neutron energy within the range of 0.12 MeV to 9 MeV for an iron target nucleus with a thickness of 3mm. The estimated results are compared with Talys 1.96 code, and good agreement is noticed. It is found that the neutron cross section is a strong function of the incident neutron energy and depends,

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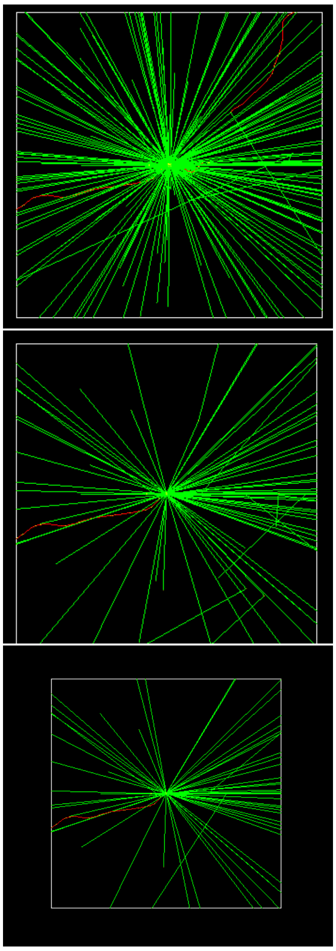

FIG. 1: The neutron flux trajectory through 3 mm ,4 mm, and 15 mm thicknesses of iron.

relatively, to a lesser extent, on the form of initial spectrum. Fig. 2 shows the oscillating behavior of the mass attenuation coefficient for 3 mm, 4 mm and 15 mm thicknesses with respect to neutron energy, as it decreases sharply with increasing energy up to 1.2 MeV, then increases sharply between 1.2 MeV and 2.5 MeV, and then begins to be approximately stable up to 6 MeV. Finally, it decreases slowly with increasing energy up to 9 MeV. This behavior is due to the fluctuation of the transmission value of the neutron flux through a specific thickness of the iron material, which

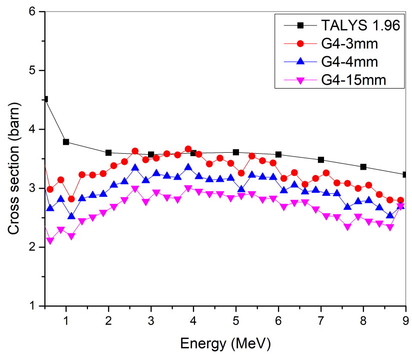

FIG. 2: The neutron cross-section for the 3 mm, 4 mm and 15 mm thicknesses of iron foil as a function of incident neutron energy.

depends on random events in the model used for the simulation. The neutron cross section for iron has been estimated using the Monte Carlo code GEANT4 with the High Precision (QGSP BERT HP) neutron model. It is found that the neutron cross section strongly depends on neutron energy due to different interaction mechanisms dominating within this energy range. It depends, relatively, to a lesser extent, on the thicknes of the target.

References

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