Study of neutron-induced fission cross-section of the ^{232}Th(n,f) reaction

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Introduction

A comprehensive understanding of several crucial aspects, such as reactor cores, fuel components and the complex interactions of nuclear waste with other materials, is necessary for the proper design and complete study of nuclear energy systems. Nuclear cross-section data is essential in nuclear energy research. These data sets provide invaluable insight into the behaviour of materials within nuclear reactors and their response to various energy [1–8].

In the field of nuclear engineering, several cutting-edge applications such as the design of fast reactors, Accelerator Driven Subcritical Systems (ADSs), the innovative Advanced Heavy Water Reactor (AHWR), energy amplifiers and future fusion reactors require an even deeper understanding of nuclear cross-section data [9].

Current commercial reactors utilize ^{235}U as its fissile material, which makes only up to 0.72 percent of natural uranium. The most common kind of uranium, ^{238}U, which makes up 99.27 percent of natural uranium, cannot fission in thermal reactors today. The ^{238}U/ ^{239}Pu and ^{232}Th/ ^{233}U fuel cycles are the two primary fuel cycles that are recommended for use in the future in order to make the most use of the resources now available. The fissile component of the ^{238}U/ ^{239} Pu cycle, ^{239}Pu, is created from ^{238}U by neutron capture and two subsequent beta decays. Similarly, in the ^{232}Th/ ^{233}U cycle, ^{233}U, which is transmuted from ^{232}Th via neutron capture and two beta decays, is the fissile material. The ^{232}Th/ ^{233}U cycle has certain appealing qualities, such as the fact that thorium is more abundant in nature than uranium, less waste is generated, and there are fewer transuranic isotopes in the waste. Considering these objectives, we conducted computational calculations to determine the fast neutron-induced reaction cross sections of ^{232}Th(n,f).

Theoretical Studies

Nuclear models serve as indispensable tools for computing nuclear reaction cross-sections and gaining insight into the intricate mechanisms governing these reactions. In our research, we have used the TALYS-1.96 nuclear code to calculate the theoretical cross-section of the ^{232}Th(n,f) reaction. Theoretical analysis for the fission cross-section of ^{232}Th(n,f) reaction was performed using fismodel 5 along with the level density model 5 of the TALYS-1.9 code. The calculated cross-sections agree well with the measured results [10–14] in the 1-40 MeV region as presented in Fig.1. TALYS 1.96 offers a diverse array of level density (LD) models, which play a pivotal role in characterising the distribution of nuclear energy levels. These models are essential for accurately predicting cross-sections and various other reaction-related quantities. The following level density models are mentioned in TALYS: LD Model-1 is the constant temperature and Fermi gas model, LD Model-2 is the back-shifted Fermi gas model, LD Model-3 is the generalized super-fluid model, LD Model-4 is the microscopic level

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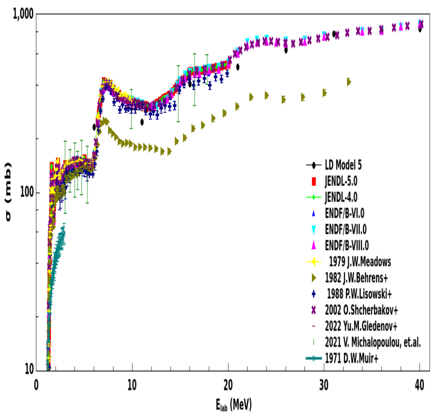

FIG. 1: Comparison of theoretically calculated cross-section and different experimental data [10–14] of ^{232}Th(n,f) reaction.

density (Skyrme Force) from the Gorley table, LD Model-5 is the microscopic level density (Skyrem force) from Hilaire's combinatorial tables and LD Model-6 is the micro-scale density (temperature-dependent HFB, Gogni force). This comprehensive approach aims to enhance our understanding of nuclear reactions, contributing to the precision and reliability of nuclear data essential for a wide range of scientific and practical applications.

Results and Discussions

In the present study, we have compared the cross-section calculated by TALYS with available data up to 40 MeV energy of ^{232}Th(n,f) reaction first time. In this work, we have calculated the fission cross-section of ^{232}Th(n,f) reaction using fismodel 5. The outcomes obtained by theoretical fismodel 5 along with the level density (LD Model) model 5 are compared with cross-section data taken from the IAEA-EXFOR database, JENDL-5.0 and ENDF/B-VIII. From Fig. 1 we can see that the fismodel 5 along with LD Model 5 gives the best result with experimental data.

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