Measurement of neutron induced reaction cross-sections for ^{86}Sr at different neutron energies

Nidhi Shetty, Rajnikant Makwana[1], Mayur Mehta[1,2], N.L. Singh[1], S. Mukherjee[1], S.V. Suryanarayana[3], Siddharth Parashari[1], Ratan Kumar[1], Sai Akhil Ayyala[4], Chandani Menpara[1]

1. *Department Of Physics, Faculty Of Science. The M. S. University of Baroda, 390002, India.*
2. *Institute for Plasma Research, Gandhinagar-382428, India.*
3. *Nuclear Physics division, Bhabha Atomic Research Centre, Trombay, Mumbai-400085.*
4. *G.B Pant University of Agri. & Tech., Pantnagar, Uttarakhand-263145*

Introduction

The cross-sections of ^{86}Sr (n, 2n) ^{85}Sr are measured at neutron energies of 19.4 MeV and 16.7 MeV wherein there is a scarcity of data. The measurements and analysis of the data were done using standard neutron activation analysis and offline gamma-ray spectroscopy and then compared to EXFOR database [1]. The method of tailing correction is used to remove the contribution of the low energy neutrons from the primary neutrons which is adapted from literature [2]. The theoretical predictions were incorporated using nuclear modular codes TALYS 1.8 and EMPIRE 3.2.2. The LD models of TALYS 1.8 and LevDen models of EMPIRE 3.2.2 have been successfully tested to predict the cross-section data which is also supported by the experimental data [1]. A detailed study and comparison of experimental results with the theoretical model is discussed.

Experimental Details

The neutrons required to carry out this experiment were produced from ^{7}Li(p, n)^{7}Be reaction at the BARC-TIFR Pelletron facility in Mumbai, India. A natural lithium foil of thickness 3.4 mg/cm^2 was wrapped with a Tantalum foil of 4 mg/cm^2 in the front and 0.1 mm on the back and was irradiated with a proton beam of energies 22 and 19 MeV. The distance of the sample from the Li foil was kept 10 cm in the forward direction. For each irradiation, ^{115}In(n, n')^{115m}In reaction was used as a flux monitor. After irradiation and a suitable cooling time, the activity produced in the samples were measured using a pre-calibrated High Purity Germanium detector.

Data Analysis

The standard neutron activation analysis technique was employed to analyze the experimental data. In this technique, nuclei are irradiated with neutrons which activate the isotope and the product nuclei formed emits characteristic gamma rays having adequately long half lives and gamma branching abundances. Here, the number of target nuclei available and the neutron flux incident on the target determines the rate of production of daughter nuclei or the nuclear reaction rate. The cross-section of the selected reactions can be determined using the following equation:

$$\sigma = \frac{A_\gamma \cdot \lambda \cdot (t_c/t_r)}{N \cdot \emptyset \cdot I_\gamma \cdot \varepsilon \cdot (1-e^{-\lambda \cdot t_i}) \cdot (1-e^{-\lambda \cdot t_c}) \cdot e^{-\lambda \cdot t_w}}$$

where all the symbols have their usual meanings as mentioned in reference – [3]. An HPGe detector was used to measure the activity Aγ for gamma rays of various energies.

A suitable γ-ray counting plan was devised based on the half-lives of the nuclei of interest and several rounds of counting were done. The dead time was kept less than 5% during the entire process. The isotopic abundances and weight of the sample were used to calculate

the number of target nuclei. A γ-ray spectrum of an irradiated In foil was used to calculate the neutron flux.

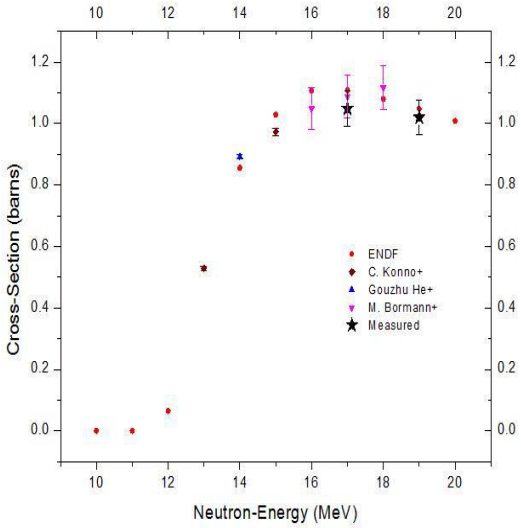

Fig. 1: Comparison of the measured data with ENDF and EXFOR data

Other standard parameters of the reaction were referred from the literature. In order to accurately measure the cross-section, it is necessary to make corrections due to the contribution from the lower energy neutrons. The method of tailing correction is used to remove the contribution of the low energy neutron from the primary neutrons which is adapted from literature [2].

Result and Discussion

The cross-section for ^{86}Sr (n, 2n) ^{85}Sr at 19 MeV and 17 MeV is measured to be 963.206±48 mb and 1048.55±54 mb respectively. The results are well in agreement with the data in ENDF and EXFOR as can be seen in Fig.1. Moreover, they are also comparable to the LevDen models of EMPIRE and LD models of TALYS 1.9. However, it has been observed that the cross-section predicted by TALYS 1.9 is lower in reference to the above considered data.

References

[1] EXFOR, Experimental Nuclear Reaction data, https://www-nds.iaea.org/exfor/.

[2] D. L. Smith et al., Corrections for Low Energy Neutrons by Spectral Indexing,https://www.oecdnea.org/science/docs/2005/nsc-wpec-doc2005-357.pdf.

[3] Rajnikant Makwana et al., Phys. Rev. C 96,024608 (2017).

[4] A J Koning et al., NRG-1755, ZG PET-TEN, The Netherlands, (2015).