Neutron induced reaction cross section measurement for silver with detailed uncertainty quantification

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Introduction

➢ ^{109}Ag is used for the production of ^{109}Cd, ^{110m}Ag, ^{110}In radioisotopes which are used in X ray fluorescence analysis, radiation sources and life sciences. It can also be used as flux monitors.

➢ ^{110m}Ag is produced by ^{109}Ag which undergoes β-decay into ^{110}Cd. ^{110}Cd is used for the production of ^{110}In, ^{113m}In radioisotopes which have imperative role in health care, medical applications and pharmaceutical industries, also for production of helium-cadmium lasers.

Experimental Details

- The experiment was performed using the 6-MV Folded Tandem Ion Accelerator (FOTIA) facility, BARC, Mumbai, India.
- The neutrons were produced by the reaction ^{7}Li + p → n + ^{7}Be . The proton beam of energies 2.5, 3.0, 3.6 MeV were bombarded on Lithium target producing neutrons of average energies 0.53, 1.05, 1.66 MeV.
- To obtain spectrum averaged neuron energies at the three proton energies, we have used EPEN code [1].
- The neutron beam impinged on indium (monitor foil) and silver (target foil). ^{115}In(n,n'γ)^{115m}In reaction cross section was used as reference monitor reaction cross section.
- The current during irradiation was ~30nA. The target was irradiated for 24 hours for all three energies.
- We have used offline gamma ray spectroscopy technique for counting purpose [2]. The gamma-ray activity was measured using a pre-calibrated lead-shielded High-Purity Germanium (HPGe) detector.

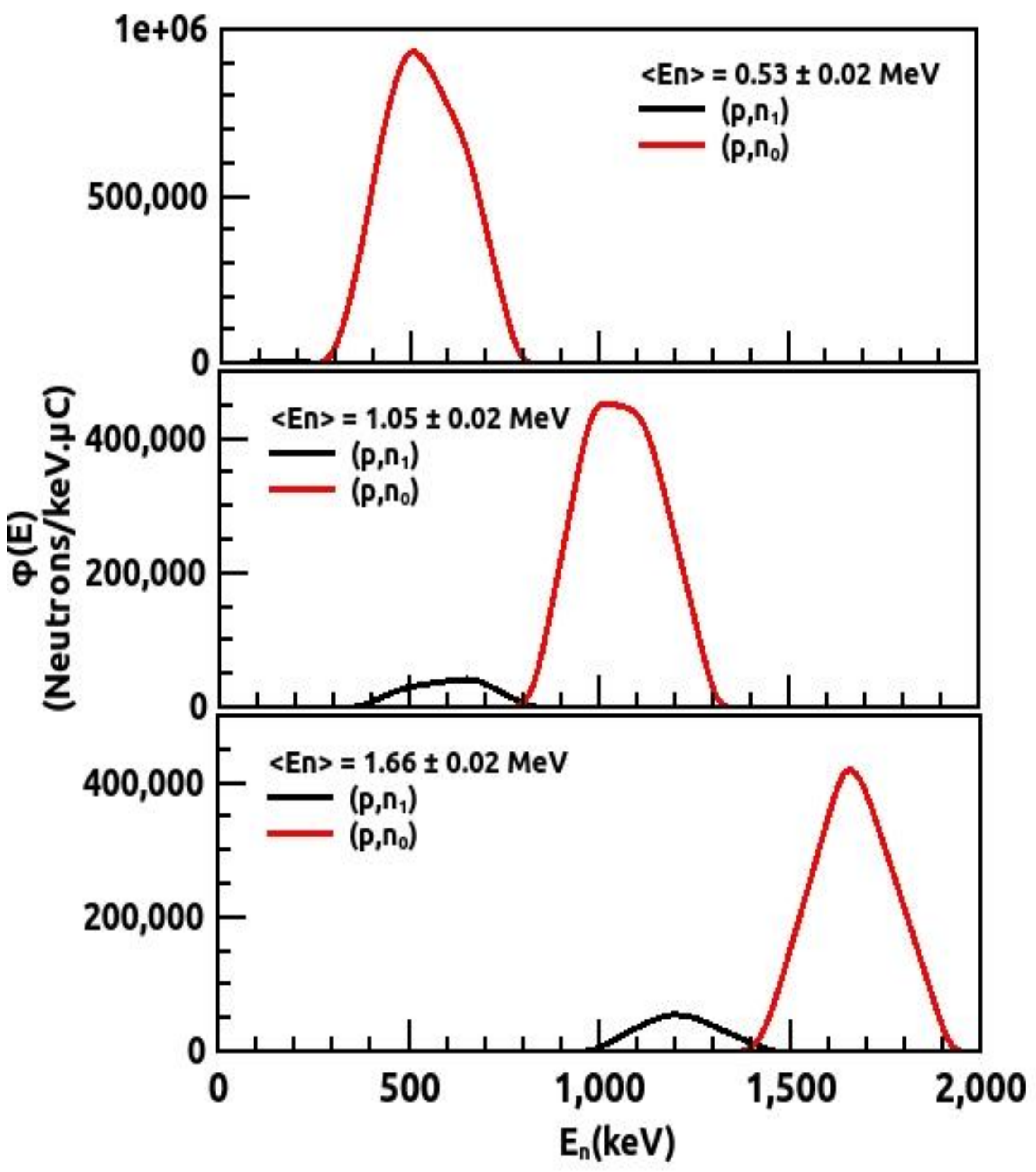

Fig.1. Neutron flux energy spectrum corresponding to Ep = 2.5, 3, 3.6 MeV obtained from the EPEN code.

Data Analysis

➢ The efficiency calibration was done using the ^{152}Eu point source.

➢ We used following formula to calculate the cross section [3].

$$\sigma_s = \sigma_m \times \eta \times \frac{C_s N_m I_{\gamma(m)} f_m}{C_m N_s I_{\gamma(s)} f_s} \times \frac{C_{attn.(s)} \times N_{low(s)}}{C_{attn.(m)} \times N_{low(m)}}$$

➢ We have used the statistical nuclear model code TALYS-1.96 for the theoretical calculations of the reaction.

➢ The present experimental data has been compared with the existing cross sections data available in the TENDL-2019, IRDFF-II, JENDL/AD and IRDF-2002G. Different level density models were used to rationalize the result

Results and Discussions

➢ The ^{109}Ag(n,γ)^{110m}Ag reaction cross sections measured at neutron energies 0.53, 1.05, and 1.66 MeV are presented in Fig.2.

➢ The theoretical results predicted by TALYS by using ldmodel-6 is in good agreement with the present data.

➢ The present experimental cross sections are consistent with the evaluated libraries.

Table 1. The ^{109}Ag(n,γ)^{110m}Ag cross sections measured in the present experiment with associated uncertainties and correlation coefficients.

Energy (MeV)	Cross-section (mb) (σ ± Δσ)	Correlation Matrix		
0.53 ± 0.15	4.1063 ± 0.2941	1.0000		
1.05 ± 0.16	5.7196 ± 0.3555	0.3018	1.0000	
1.66 ± 0.14	4.2812 ± 0.5204	0.1387	0.1543	1.0000

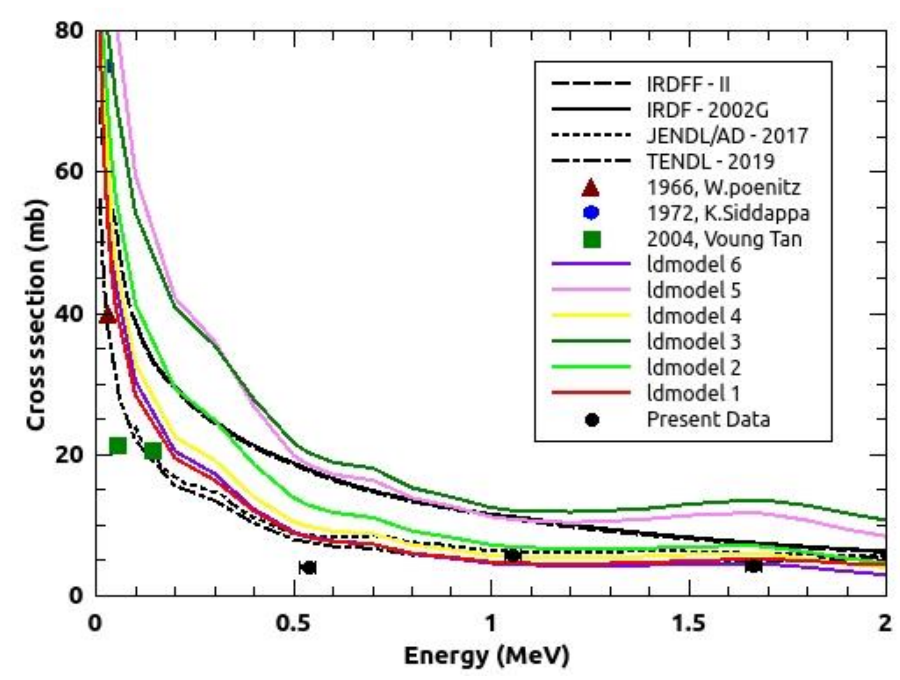

Fig.2. Cross sections measured in present work and its comparative studies

Acknowledgements

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References

[1] A.Gandhi *et al.*, The European Physical Journal A **57**, 1 (2021).
[2] M. Choudhary *et al.*, The European Physical Journal A **58**, 95 (2022).
[3] A. Gandhi *et al.*, The European Physical Journal Plus **136**, 1 (2021).