Measurement of the cross-section ^{107}Ag(n,2n)^{106}Ag reaction on neutron energy 13 MeV and 22 MeV

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Introduction

The present paper contemplates the cross-section data for isotopes of Ag for (n,2n) reaction. Nuclear reactor technology is the field where nuclear reaction cross-section possess prime importance. Silver plays very significant role in nuclear reactor, establishing itself in the form of control rods as it is capable enough to absorb neutrons without undergoing fission. It is well known fact that control rods is one of the key component of nuclear reactor to control the fission rate of uranium and plutonium for the sustain operation of reactor. As the composition of control rods must be designed according to reactor's neutron spectrum, knowledge of interaction probability of composition material with energy range of neutron is quite important. Apart from this, theoretical predictions for nuclear reactions may help us to understand the nuclear reaction mechanisms and in general nucleon-nucleon interactions. Therefore neutron cross sections are playing a significant role in nuclear model developments [1]. Here we have calculated neutron induced reaction cross-section for ^{107}Ag (n,2n)^{106}Ag at two energy points by Neutron Activation Analysis (NAA) and offline-γ ray spectrometry technique. These cross sections were calculated by nuclear model codes TALYS, EMPIRE and ALICE as well as compared with already available data on the EXFOR data libraries. The experimental details and theoretical calculations are discussed here.

Experimental details

The experiment was performed using the BARC-TIFR Pelletron facility in Mumbai, India. The neutrons were produced by bombardment of proton beam on natural lithium foil having thickness 3.4 mg/cm2. The foil was sandwiched between Tantalum with 4 mg/cm^2 in front and 0.1 mm on back. The neutron beam was produced by reaction ^{7}Li(p,n)^{7}Be. The interested proton energies were 13 MeV and 22 MeV. The Ag samples were prepared in pellet form having weight 485.5 mg for 22 MeV and 493.3 mg for 13 MeV proton bombardments. In irradiation, Al and In was used as flux monitor. The gamma ray spectrum was recorded using high resolution HPGe detector. A Baltic manufactured HPGe was used with 4K channels MCA to measure gamma ray spectrum from the irradiated sample. The detector was calibrated using standard ^{152}Eu multi γ-ray source. The calculation of neutron flux was done using γ-ray spectra of irradiated Al and In. Other standard parameters of the reaction were taken from literature [2, 3].

The experimental data was analyzed using NAA technique which is taken under consideration after neutron irradiation, when product nuclei emits characteristic gamma radiation having sufficiently long life time and gamma branching abundance. The cross-section of this (n,2n) reaction was calculated from the measured peak counts using the following activation equation[4] .

$$\sigma = A_i A_\Gamma \lambda / (N_T N_P I_g \varepsilon).(1-e^{-\lambda..ti}).(1-e^{-\lambda..tc}).(e^{-\lambda..tw})$$

Where,

Ai = Gram atomic weight of the target

A_Γ = Peak counts of gamma energy

λ = Half life of the product isotope

t_i = Irradiation time

t_c = Counting time

t_w = Cooling time

N_T = Number of target nuclei

N_P = Incident neutron Flux

I_g = Gamma intensity

ε = Efficiency of gamma detector at chosen gamma

Table:1 Comparison of measured cross-section with EXFOR data library

Energy (MeV)	Cross-section (barn)	
	Measured	TENDLE
13	0.8132±0.179	1.224
22	0.6159±0.122	0.5918

Theoretical Calculations

The theoretical nuclear modular calculations have been performed in order to extract out cross-section using nuclear model codes- EMPIRE-3.2.2, TALYS-1.8 and ALICE. Illustrative example is given in figure-1.The needed parameters for input file for example level density parameters, discrete energy levels, nuclear mass, were taken from Reference Input Parameter Library (RIPL-3).

Conclusion

The cross section for ^{107}Ag(n,2n)^{106}Ag was measured at 13MeV and 22 MeV energy points using activation technique. The measured cross section is compared with nuclear modular codes-ALICE, EMPIRE-3.2.2 and TALYS-1.8. The experimentally measured data resembles with the theoretically calculated cross-section. The best resemblance is with ALICE at lower energy and for higher energy better agreement is with TALYS-1.8.

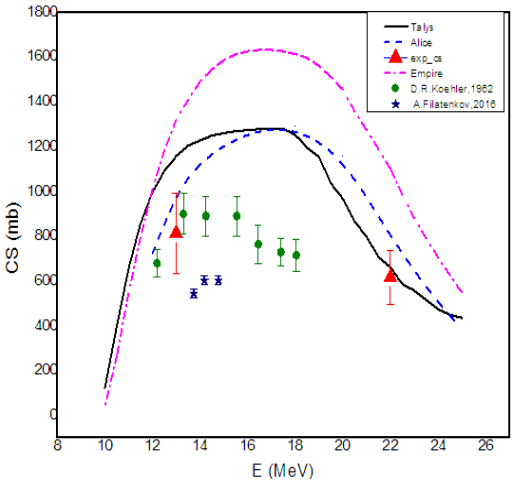

Figure.1: Comparison of our measured cross-section of ^{107}Ag(n,2n)^{106}Ag with ALICE, EMPIRE-3.2.2, TALYS-1.8.

References

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