Measurement of reaction cross-section for ^{197}Au(n,2n)^{196}Au reaction

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Introduction

Studies of neutron capture reaction cross-sections have considerable prominence for fundamental research such as Nuclear Physics, Astrophysics and for practical applications in nuclear technology, medicine and industry [1]. In the present paper, ^{197}Au(n,2n)^{196}Au reaction is chosen as it is used as a reference monitor reaction for the evaluation of neutron flux for the measurement of the reaction cross-sections [2] and it is also very useful as dosimeter standard for higher energy range [3]. The present work accomplished with the measurement of (n,2n) reaction cross-section for ^{197}Au from threshold energy (8.113 MeV) to 13 MeV by Neutron Activation Analysis (NAA) technique and off-line γ - ray spectrometry. The reaction cross-sections are also measured with theoretical nuclear modular code such as TALYS - 1.9 [4] and EMPIRE - 3.2.2 [5] and compared with the present experimental data. The present cross-sections data are also compared with literature data taken from ENDF-B/VII.0 [6], JENDL-4.0 [7] and EXFOR [8].

Experimental Details

The experiment was performed at 14-UD Bhabha Atomic Research Centre-Tata Institute of Fundamental Research (BARC-TIFR) pelletron facility in Mumbai, India. The proton beam of energy 15.0 and 11.0 MeV [9] was bombarded on the ^{7}Li target for the generation of neutron beam by means of ^{7}Li(p, n) reaction (E_{th} = 1.88 MeV). The lithium foil was sandwiched between tantalum foil in front and back to prevent interaction of proton with gold sample. The mass of gold sample was 0.0705 g for both the energies. The gold sample and indium flux monitor were wrapped in aluminum foil to prevent radioactive contamination and placed behind the Ta-Li-Ta stack. The whole arrangement was placed in the 6 meter port of the main beam line of the Pelletron for irradiation. The irradiation was carried out for 7:00 and 16:05 hrs with 15.0 and 11.0 MeV of proton beam respectively to achieve sufficient activity. The irradiated samples of Au and In were cooled for sufficient time to lower the dose rate from the samples. Then, the samples were taken for γ-ray counting to PC based 4K MCA HPGe detector. This detector was pre-calibrated with the help of standard γ-ray ^{152}Eu source. The dead time of the detector was kept < 0.6 % by placing the samples at an appropriate distance from the detector head. The ^{115}In(n, n')^{115m}In reaction was used as monitor reaction for flux measurement.

Data Analysis

The experimental data were analyzed using NAA - technique. This technique is used for the products which are emitting characteristic γ-rays having sufficiently long half-life and gamma branching abundance. The present reaction has half-life of 6.183 days with characteristic γ-line at 355.684 keV and gamma branching abundance is 87 %.

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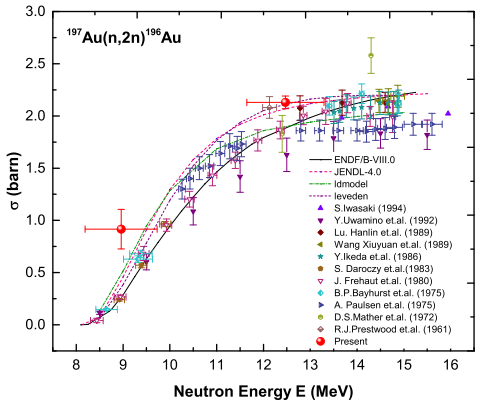

FIG. 1: A comparison of the present data with the literature data library as well as with the theoretical predictions TALYS-1.9 [4] and EMPIRE - 3.2.2 [5] codes.

The reaction cross section of the selected reaction has been calculated with the help of following equation [9].

$$\sigma = \frac{A_\gamma \lambda (t_c/t_r)}{N\phi I\gamma\epsilon(1-e^{-\lambda t_i})(1-e^{-\lambda t_c})e^{-\lambda t_w}} \quad (1)$$

Where, all the symbols have their usual meanings. The activity (Aγ) was measured from HPGe detector for different γ - rays emitted from the product nucleus. The number of atoms were calculated using weight of sample and isotropic abundance. The neutron flux incident on the target was calculated using spectrum averaged neutron cross-sections for monitor reaction with the help of relatively recent available data from EXFOR data library. In ^{7}Li(p,n) reaction, when proton interacts with natural lithium target, various reactions take place which generates neutrons of main peak energy as well as low energy. Therefore, the tailing correction is required to remove the contribution of low energy neutrons. This tailing correction has been performed by using spectral average cross-sections as given in ref. [9].

Results and Discussion

The measured cross-sections of ^{197}Au(n,2n)^{196}Au reaction at average neutron energies 12.47±0.83 and 8.96±0.77 MeV are found to be 2.13±0.061 and 0.916±0.190 barns respectively and are plotted in Fig. 1. It is clearly shown from Fig. 1 that the present cross-section value of 12.47±0.83 MeV neutron energy is in good agreement with the value of EMPIRE - 3.2.2 [5] as well as with JENDL-4.0 data library [7]. However, the cross-section value of 8.96±0.77 MeV neutron energy is slightly higher than the value of theoretical codes and JENDL-4.0 data.

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