Measurement of fast neutron radiative capture cross sections for ^{70}Zn(n,γ)^{71}Zn^{m}reaction using isotopically enriched ^{70}Zn isotope in the incident neutron energy range 0.3 - 1.5 MeV

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Introduction

The radiative neutron capture cross section is important both for reactor physics applications as well as for nuclear astrophysics and hence accurate data are very important. The cross section for the ^{70}Zn(n,γ)^{71}Zn^{m} has not been measured in the past for the energy range above 25 KeV. In the present paper, the neutron radiative capture cross section of ^{70}Zn has been measured using ^{7}Li(p,n)^{7}Be neutron source with the lithium thickness 2 mg/cm^{2}. Above 2.4 MeV the first-excited state of ^{7}Be at 0.43 MeV may be excited, producing a second group of neutrons; however, below 5 MeV the 0^{0} yield of these lower energy neutrons is less than about 10% of the ground-state yield[1]. The activation technique is used and the cross section is measured relative to the reactions ^{197}Au(n,γ)^{198}Au and ^{115}In(n,n')^{115}In^{m}.

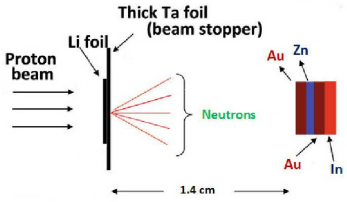

FIG. 1: Schematic diagram of irradiation set up used for neutron irradiation.

Experiment

Experiment has been performed at the FOTIA accelerator at BARC, India, employing stacked foil activation technique. The ^{70}Zn (ENR = 72.4%) is sandwiched between Gold foils. The Tantalum foil of thickness 0.25 mm is used as proton beam stopper. We irradiate the samples with the target combination which is Au - Zn - Au - In. Proton beam energies of 2.25 MeV, 2.6 MeV, 2.8 MeV and 3.5 MeV were used for the irradiation of the stack. The activity induced in each of the samples were counted using a precalibrated lead-shielded 100 cc high-purity germanium (HPGe) detector coupled with a data acquisition system. The ^{152}Eu source of known strengths was used to determine the absolute efficiency of the detector at various gamma energies. The HPGe detector resolution is 1.8 KeV. The detector is equipped with lead shielding and hence the room background is negligible. We irradiate the sample for about 3 times the half - life of the ^{71}Zn^{m}, and then cooled it for about 20 minitues. After cooling, the sample was put inside the HpGe detector for counting the characteristic gamma lines of the product nuclei by using LAMPS 2010 (Linux Advanced Multi Parameter System). The counting has been done till 3-4 times the half-life. The schematic diagram of the experimental set up is shown in Figure 1. The decay data used in the analysis are tabulated in Table - 1 [2].

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TABLE I: List of reactions and decay data of activation products:

Reactions	Half-life	Γ-ray energy (KeV)
^{70}Zn(n,γ)^{71}Zn^{m}	3.96 ± 0.05h	386.28 (91.4%)
^{197}Au(n,γ)^{198}Au	2.6948 ± 0.0012d	411.802 (95.62%)
^{115}In(n,n)^{115}In^{m}	4.486 ± 0.004h	336.24 (45.8%)

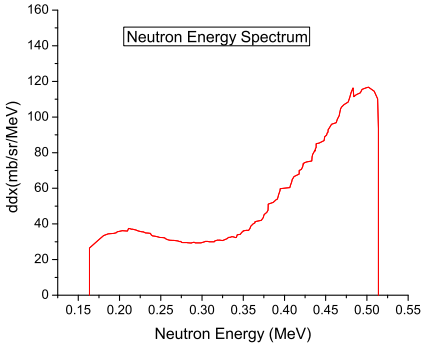

FIG. 2: Neutron spectrum from ^{7}Li(p,n)^{7}Be reaction at E_P=2.25 MeV calculated using the results of EPEN.

Neutron energy spectrum calculation

The neutron energy spectra analysis are carried out using the code EPEN, the code developed by our group. This code is designed by using evaluated data below Ep=4 MeV taken from H. Liskien and A. Paulsen [3] and it will be made available for other users in the future. Typical neutron energy spectra from the code EPEN at proton beam enery 2.25 MeV for the Li thickness used in the present experiment is shown in Figure 2. It can be seen that the neutron energy is quasi-monoenergetic due to the proton energy loss in the Li sample and also due to the angular coverage of the sample in the experiment.

Preliminary results

The observed gamma peaks and the gamma decay curves of our experiment at Ep = 3.5 MeV of Zn, Au and In are shown in the Fig. 3. anf Fig. 4.

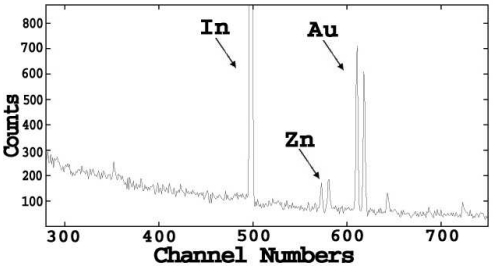

FIG. 3: The gamma-ray spectrum of Au, Zn and In.

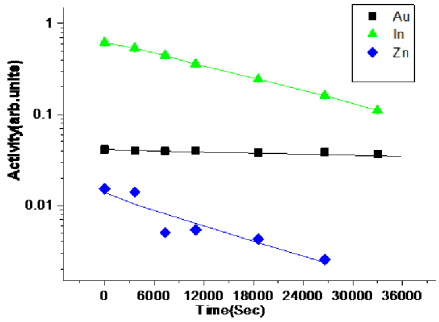

FIG. 4: The gamma decay curves of Au, Zn and In. The symbols are experimental results and the solid lines represent the expected decay lines.

Conclusion

The detail data analysis to determine the neutron capture cross section for the reaction ^{70}Zn(n,γ)^{71}Zn^{m} in the energy range 0.3 to 1.5 MeV is being carried out. The final results will be presented during the symposium.

References

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[3] H. Liskien and A. Paulsen., Atomic Data and Nucl. Data Tables,Vol. **15**, Issue 1, Pages 57-84(1975).