Theoretical study of ^{109}Ag(α, n) reaction from the threshold up to 20 MeV

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Introduction

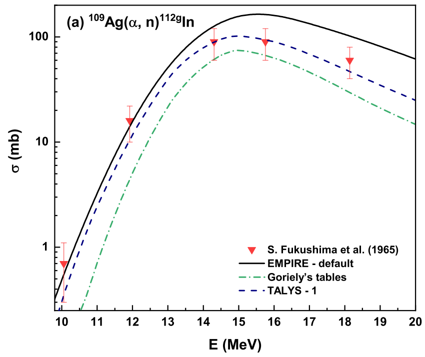
The α induced reactions are important to study due to the breakup problem of the projectile as its binding energy is large [1].

The study of α-induced reactions and their possible isomeric cross-section ratio (ICR) have significant importance for testing nuclear models. The cross section production of isomeric states is more difficult to be predicted than for the total reaction channels due to the detailed structure of the residual nucleus has been taken into consideration. The ^{109}Ag(α, n)^{112}In reaction has been studied theoretically in the present work. As the product nucleus ^{112}In populates to the ground state ($J^{\pi} = 1^{+}$) and the isomeric state (E_{level} =0.156 MeV, $J^{\pi} = 4^{+}$), the cross sections have been measured for both the populated state of the reaction along with ICR (σ_m/σ_g).

Theoretical calculation

The theoretical calculations were performed using EMPIRE-3.2.3 [2] and TALYS-1.95 [3] statistical model codes. The purpose of using different codes is to determine the optimum parameter for the reaction. In both the codes, a variety of theoretical models are implemented to study three major reaction mechanisms, including direct, pre-equilibrium and compound nucleus ones. The codes utilize the RIPL data library for input parameters.

EMPIRE calculations were performed using the default nuclear level density (NLD) model (i.e., EMPIRE-specific level densities) whereas TALYS results were obtained using the NLDs of Goriely's tables, the optimum NLD for the present case and shown in Figs. 1-(a), (b), (c) & (d). Further, it is assumed that nuclear reactions depend on the NLDs, γ-strength functions (γ-SF), and optical model potentials (OMPs). Therefore, the calculations were performed using the possible combinations and the best fit was adopted for the present study. The combination of NLD of Goriely's tables + Brink-Axel Lorentzian γ-SF + Avrigeanu *et al.* α-OMP is used to reproduce reported data. This combination is referred as TALYS-1.



Results & Discussion

The theoretical cross sections were obtained for the ^{109}Ag(α, n)^{112g,m,total}In reaction from threshold to 20 MeV of energy using TALYS and EMPIRE codes, the results are plotted in Figs. 1-(a), (b), & (c), respectively along with experimental data retrieved from the EXFOR database [4].

It is observed from Fig. 1-(a) that the ground state cross sections of EMPIRE are in good agreement with EXFOR data for lower energies whereas the data of TALYS-1 repro-

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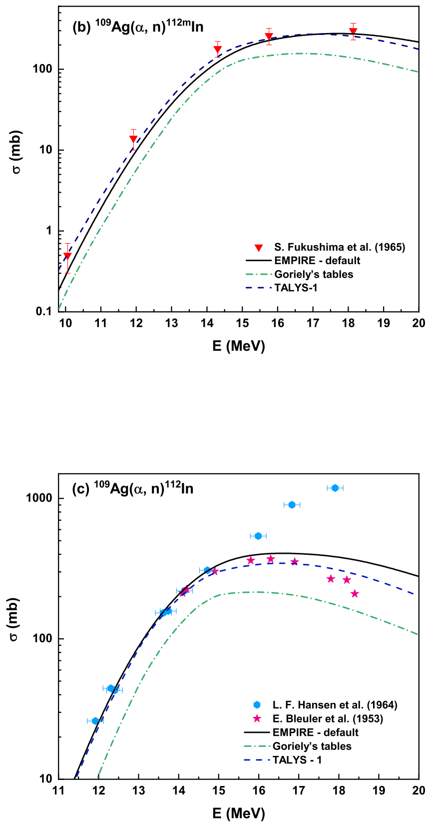

FIG. 1: Cross sections obtained from EMPIRE and TALYS, with available experimental data.

duce the experimental data from threshold to 20 MeV.

Fig. 1-(b) concludes that the isomeric cross sections are in good agreement with the results of EMPIRE and TALYS-1. Fig. 1-(c) shows that the total reaction cross sections obtained from the EMPIRE and TALYS-1 complement the experiment data. However, the discrepancy is observed in the previously reported experimental data at higher energies. Overall, the theoretical predictions follow the trend of experimental data.

The ICR was obtained and plotted in Fig. 2. The ratio using EMPIRE is under-predicted than other data. Also, it is observed from

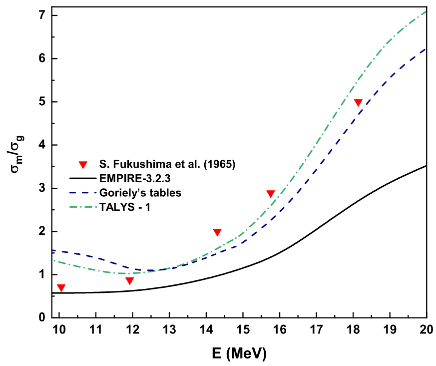

FIG. 2: The isomeric cross section ratio σ_m/σ_g calculation.

Fig. 2 that the ratio is low in the low-energy region and rises at higher energies, following the rise in the population of high spin levels of the compound nucleus, by the increase of the incident alpha energy. This ratio helps us to identify the reaction mechanism.

Conclusion

The present work describes the scarcity of experimental data. More measurements are needed for this reaction channel to validate the theoretical calculations.

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[4] IAEA-EXFOR database at `https://www.nds.iaea.org/exfor`