Cross-section measurements of the reaction ^{107}Ag(p,n)^{107}Cd at energies inside the Gamow window

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Introduction and Motivation

Nuclear reactions are of fundamental importance in Nuclear Physics, as they provide both direct and indirect information on the interactions occurring between the subatomic particles. In recent years, reactions of light projectiles with heavy ions at low-beam energies have proven particularly useful to understand the dynamics inside the inner core of massive astrophysical objects, such as neutron stars or explosive supernova [1].

A recent study of the radiative proton-capture reactions with silver isotopes ^{107,109}Ag(p,γ)^{108,110}Cd have provided information on the p-nucleus ^{108}Cd for the first time [2]. In the present work, we step on these results to study experimentally the sister reaction ^{107}Ag(p,n)^{107}Cd aiming to provide data for the total reaction cross sections and enrich the scarce information in the mass regime of the nuclear chart, where the astrophysical p process is known to be prominent.

Experimental details

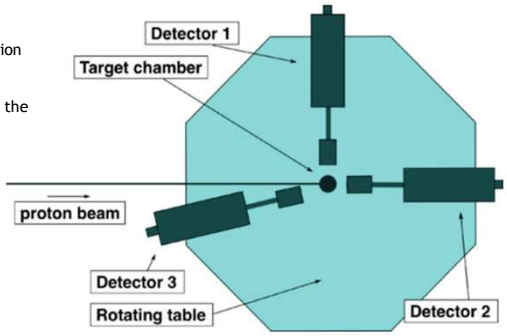

Fig.1 Schematic presentation of the experimental setup with three detectors placed on the rotating table

- The in-beam method was used to measure cross sections
- Proton beams were delivered from 5.5 MV Tandem Accelerator at INPP, NCSR "Demokritos" (Fig. 1)
- Beam energies: 2.2, 3.5, and 4 MeV
- Target: ^{nat}Ag (51.839% ^{107}Ag, 48.161% ^{109}Ag). It was placed at 30° with respect to the beam to avoid emitted γ-rays interacting with the aluminum target holder. The effective thickness was measured via XRF and RBS and found equal to δ= 529 μg·cm^{-2}
- The γ radiation emitted was detected by a set of three (3) high-purity HPGe detectors (100% rel. eff.) placed around the chamber at angles 0°, 90°, 165° and at distances 30 cm, 20 cm and 20 cm from the target, respectively
- Data were recorded in singles and the spectra (Fig. 2) were analyzed using SpectrW [3]

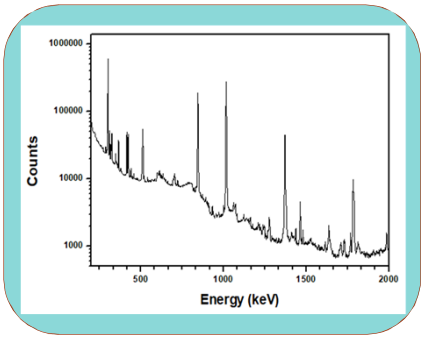

Fig. 2 Typical spectrum of a HPGe detector at beam energy 4 MeV

References
[1] C.A. Bertulani and T. Kajino, doi: 10.1016/j.ppnp.2016.04.001
[2] A. Khaliel et al, doi: 10.1103/PhysRevC.96.035806
[3] C.A. Kalfas et al., doi: 10.1016/j.nima.2016.05.098

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Detector Efficiencies

- Efficiency curves for each detector had been carefully extracted using a standard ^{152}Eu source (Fig. 3)
- A Debertin function was used to fit the experimental points.

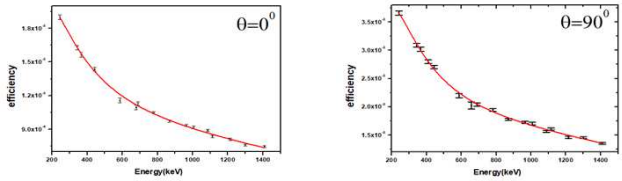

Fig.3 The efficiency curves of the detectors at 0° and 90° along with the experimental data.

Angular Distributions

Angular distributions are necessary for extracting the reaction yields, Y, before evaluating cross sections. Despite the limited number of points, angular distributions were measured (Fig. 4)

$$Y_{tot}(\theta_i, E_j) = \sum_k Y_k = \sum_k \frac{N(E_k)\omega}{e_{abs} Q}$$

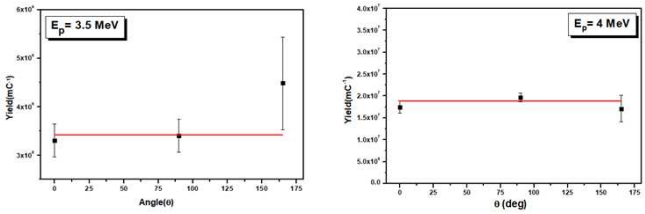

Fig 4. Experimental yields at beam energies 3.5 MeV (left), 4 MeV (right) corresponding to a flat distribution.

Results

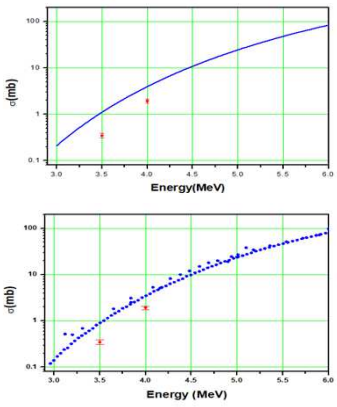

Fig. 5 Experimental cross sections compared with the bibliography data (bottom) and the results from TALYS code (top).

Cross sections have been evaluated using the following equation:

$$\sigma = \frac{AY_{mean}}{QN_A\delta} e$$

- A is the mass number of the ^{107}Ag.
- Y_{mean} is the total number of photons emitted by the ^{107}Cd nuclei.
- e is the electron charge.
- Q is the total charge of the beam
- N_A is the Avogadro number
- δ is the thickness of the target

The experimental cross sections were compared to existing experimental data in EXFOR and to TALYS calculations (Fig. 5)

Conclusions

Reaction cross sections were found experimentally at 3.5 and 4 MeV. Both results seem to be lower than the existing literature data of 50 years ago and TALYS calculations by a factor of ~2-3. A known issue in the present analysis is the missing strength of the first excited (isomeric) state in ^{107}Cd which due to its long lifetime (0.71 ns) was critically suppressed in the spectra. The application of the activation technique could potentially offer a resolution to this issue.

Acknowledgments
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