Isomeric states of ^{113,115}In in radiative proton–capture reactions at energies of astrophysical interest

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NUSTRAP Nuclear Structure, Reactions & Applications

EMMI

Introduction & Motivation

- Isomeric states in the neutron–deficient nuclei around $A \sim 100$ are important for astrophysical processes, as these states are often involved in vast reaction networks taking place at astrophysical sites
- ^{113}In is generally considered a p nucleus known to be significantly underproduced in most astrophysical models
- For ^{115}In an older set of isomeric cross sections is reported in [4], while a more recent work was focused on its production for medical applications [5], at beam energies well outside the Gamow energy window for the reaction
- Measurements of reaction rates and cross sections in this mass regime provide stringent tests to the theoretical models
- Measurements of cross sections inside the Gamow window ($\sim$ 1.6–4.8 MeV, corresponding to $T_9 \sim 1.7$–3.3 GK) are expected to provide data for better understanding the p process in this mass region

Experimental Details

- Experiments were carried out at the 5.5 MV T11 Tandem Van de Graaff accelerator of NCSR "Demokritos", Greece
- Radiative proton capture reactions were studied at proton beam energies $E_p = 3.0$–4.0 MeV
- Array of 3 HPGe detectors, placed at 55^o, 90^o and 155^o, respectively
- Isotopically enriched ^{112,114}Cd targets were used
- De–excitations to the g.s. were measured in–beam
- The activation method was employed for the measurement of the isomeric cross section, σ_{is}
- σ_{is} was also measured via the in–beam method, by measuring decays to the isomeric state in the in–beam spectra

Results

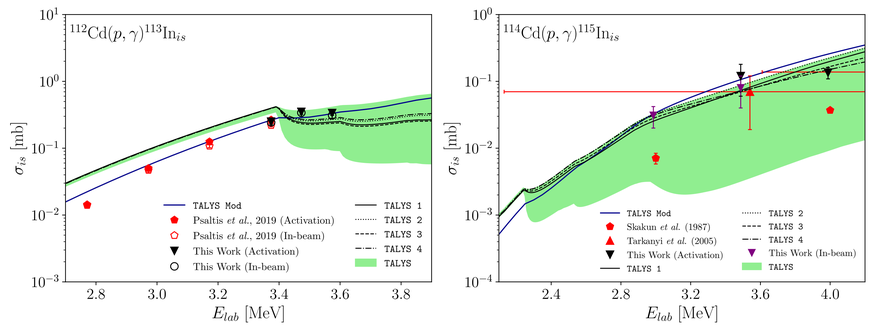

Figure 1: Isomeric cross sections for the reactions ^{112,114}Cd$(p,\gamma)^{113m,115m}$In. The shaded areas correspond to the full range of calculated values with every combination of models employed [6]. The lines correspond to the best data matching calculations [1]. The results are compared to experimental data, previously published from our group [3].

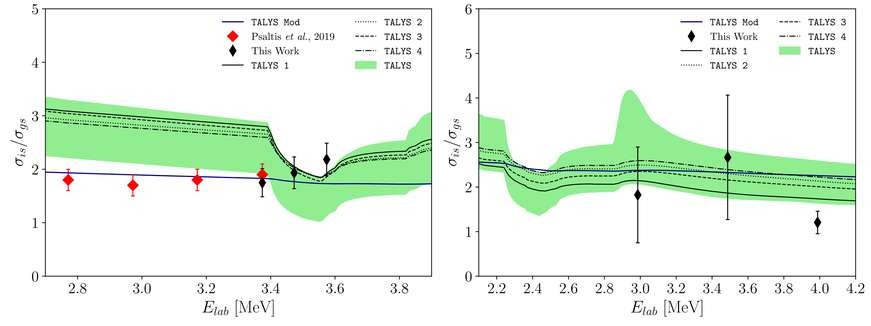

Figure 2: Isomeric to ground state ratios for the reactions ^{112,114}Cd$(p,\gamma)^{113m,115m}$In

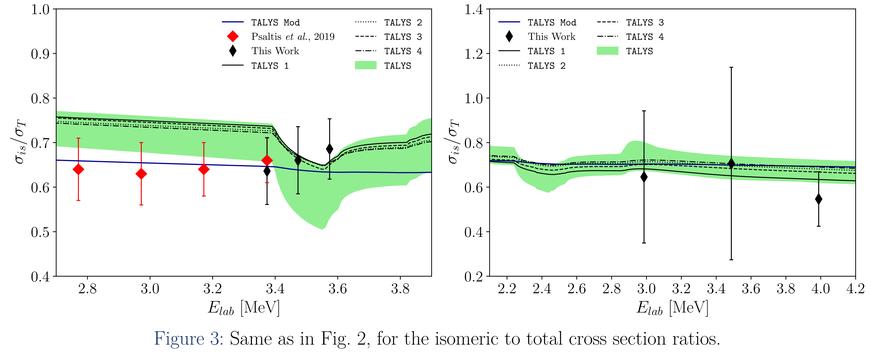

Figure 3: Same as in Fig. 2, for the isomeric to total cross section ratios.

Overview & Conclusions

- Excellent agreement with the data from the earlier work of Ref. [3], and extension to energies above the neutron emission threshold ($E_{th} = 3.397$ MeV), while still inside the Gamow energy window of astrophysical importance [1, 2]
- Better agreement with the data of Ref. [5] than Ref. [4], improving on the large uncertainties.
- Experimental results are compared to theoretical predictions using every possible combination of OMP+NLD+γSF provided by the TALYS v1.95 code [6] (green shaded area in figures) [1, 2]
- The best set of OMP+NLD+γSF model parameters was determined, in an effort to achieve a good description of the experimental data for each reaction channel in a simultaneous fashion [1, 2]
- Further experimental and theoretical work required for a firm insight at the driving mechanisms behind the p process nucleosynthesis, in an energy region where the experimental data are scarce

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References

[1] P. Vasileiou *et al.*, https://doi.org/10.1016/j.nuclphysa.2021.122298

[2] P. Vasileiou *et al.*, https://doi.org/10.1051/epjconf/202226011030

[3] A. Psaltis *et al.*, https://doi.org/10.1103/PhysRevC.99.065807

[4] E. Skakun *et al.*, Yad. Fiz. **45** (1987) 614–618

[5] F. Tárkányi *et al.*, Radiochim. Acta **93** (2005), 561–569

[6] A. Koning *et al.*, www.talys.eu