Calculation of p-capture rates for ^{92}Mo and ^{106}Cd

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Introduction

The formation of the chemical elements and understanding their abundance has been one of the most puzzling problems. The subject gained initial momentum from remarkable work of E. M. Burbidge, G. R. Burbidge, W. A. Fowler, F. Hoyle, and A. Cameron. Majority of chemical elements heavier than iron are expected to be formed by neutron capture reactions in s- or r- process. Still, there exist about 35 proton rich nuclides, which are heavier than Iron (lying between ^{74}Se and ^{196}Hg), occurring naturally, can not be produced by s- or r-process. Abundance of these p-nuclei is 10-1000 times lesser in comparison to s or r-isotopes (nuclei formed through s and r process) in the solar system. There are thousands of nuclear reaction involving stable and unstable nuclei, needed for the detailed modelling of p-process nucleosynthesis.

There are number of ongoing experiments to study capture reactions via differernt type of technique. Particularly, the number of nuclear reactions that can be studied experimentally are limited in the case of γ- induced reactions where the higher coloumb barrier results in cross sections typically well below the Gamow window. Hence, it is still rare to find experimental values of nuclear reaction rates at the energies needed as inputs to stellar models, as these energies are almost always below the Coulomb barrier. Hence, theoretical methods become necessary tool to extrapolate the available data to the energy region of interest.

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Mathematical Formalism

Relativistic mean field (RMF) model which contain the spin-orbit naturally, has been successfully used to understand and explain many nuclear features of nuclei such as binding energy of ground states, various excited states, charge radii etc. Here, NL3* paprmeter set has been used for solving the standard RMF Lagrangian[1] and we have used RMF nuclear densities to calculate the potential which is used to find the cross section [2] of reactions with the help of Talys 1.6. The charged particle cross section has been found on the basis of statistical model calculations, the input parameters for the statistical model calculations are the level density of excited states and $\gamma-$ transmission coefficients.

Results and Discussion

We have performed the detailed nuclear structure study for the nuclei relevant to the proton capture reactions. In order to ensure the model prediction reliability regarding shape and density, we have studied ground state properties, (binding energy, and rms charge radii), coherently with nuclear reaction rates. In Table 1, we have presented the calculated values along with experimental values.

Table 1. Comparison of calculated ground state properties for nuclei.

Nucleus	B.E./A (in MeV)		r_{charge}(in fm)	
	Calc.	Expt.	Calc.	Expt.
^{92}Mo	-8.65	-8.65	4.31	4.31
^{106}Cd	-8.52	-8.53	4.52	4.53
^{93}Tc	-8.62	-8.65	4.34	4.31
^{107}In	-8.48	-8.53	4.54	4.53

In the present work, we have calculated proton capture rates for ^{92}Mo and ^{106}Cd using the

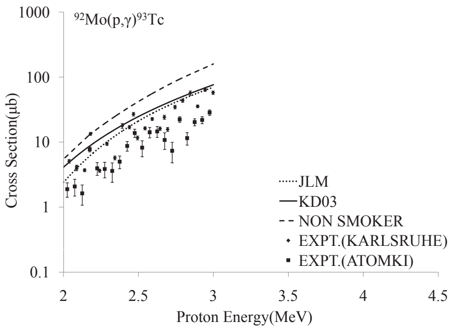

FIG. 1: Comparison of cross section rates(as function of energy) for ^{92}Mo(p,γ) reaction.

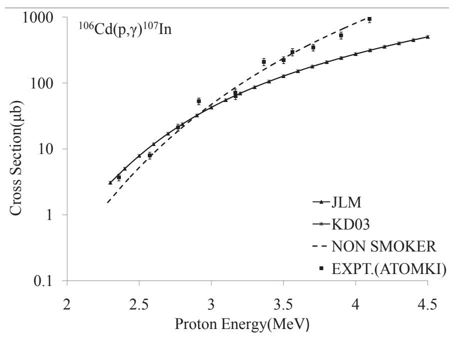

FIG. 2: Same as Fig. 1, but for ^{106}Cd.

optical potential with relativistic mean field densities through TALYS [3] i.e. microscopic JLM potential and KD03 potential, these nuclear densities were added to TALYS source files manually for calculating the potential and reaction rates.

In Fig.1 and Fig.2, we have shown the results of our calculations and compared with experimentally available values for reaction rates. Experimental results of Cross section for ^{92} Mo are taken from [4] and [5] respectively, and for ^{106}Cd taken from [6]. To have a qualitative check on our results, we have also compared the same with the reaction rates available from NON-SMOKER database, which has compilation of all relevant reaction rates calculation for the Gamow energy window.

Conclusion

Proton-capture reactions are necessary for our understanding in the context of formation and abundance of various elements. In the present work, cross-sections for (p,γ) reactions for ^{92}Mo and ^{106}Cd have been calculated. Present study clearly demonstrates that RMF densities, starting from nucleon meson interaction, can be successfully employed to calculate the nuclear reaction rates relevant to astrophysical processes and understanding the abundance of nuclei.

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