Transactions of the Korean Nuclear Society Autumn Meeting
Gyeongju, Korea, November 2-3, 2006

Evaluation of Charged Particle Induced Reaction Cross sections

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1. Introduction

The importance of different emission channel production cross sections induced by charged particles like protons, deutrons and alphas are increasingly recognized by nuclear data community. An effort to improve often unsatisfactory situation with these data was quite under progress. Methods to be used are both experimental and theoretical, the latter having important advantage in low cost and broader availability.

The purpose of this is to study considerable detail, by applying suitable theoretical approaches, for charged particle induced reactions. Since for these reactions, fairly complete and internally consistent experimental data are available for different emission channels, we intend to analyze them with the statistical model code TALYS, and learn more about the predictive power of this model. These new calculations could allow to solve the discrepancies exist among the literature data. Precise measurement of charged particle induced reactions in high energy domain serve the purpose of testing and recommending the input parameters required in model-based evaluations of cross-sections at high energies which are essential to support new nuclear energy systems. The TALYS code [1] has opened up options for calculating cross sections for various nuclear reaction channels.

With this in view, in the present work, we considered the reactions $^{nat}Cu(\alpha, x)^{66,67}Ga, ^{65}Zn$, etc. We have calculated the cross sections of different radio isotopes produced in deuteron and alpha induced reactions. For experimental cross-section values we always refer to the original publications [2-3] if they were available. In the case when the original sources were not available, the data were taken from earlier compilations [4] (compilations of charged particle reactions in EXFOR data base of the International Atomic Energy Agency, Vienna, Austria.)

Figure 1 and 2 shows the comparison of measured data with our present calculations using TALYS code, for the reactions $^{nat}Cu(a,X)^{66}Ga$ and $^{nat}Fe(d,X)^{56}Co$. The natural contains two isotopes, ^{63}Cu and ^{65}Cu, with abundance 69% and 31% respectively. Similarly, natural Iron has four isotopes, ^{54}Fe(6%), 56Fe(91.7%), 57Fe(2%) and 58Fe(0.3%). In the present example of alpha induced reaction, shown in figure 1, the outgoing particles include neutron (n) emission and 3n emission channels. Whereas, in case of deuteron induced reaction, shown in figure 2, X includes compound nucleus and 2n, 3n and 4n emission channels.

2. Discussion

In analyzing the results of our present model calculations (and those ones which were available in the literature) it can be concluded that the calculations could reproduce the shape of experimental excitation functions more or less properly. There are no general tendencies in the results of individual model code calculations in either over- or underestimating of the existing experimental data. There are, however, differences among the calculations, but it would require further evaluations of model parameters to find the reason for the individual deviations.

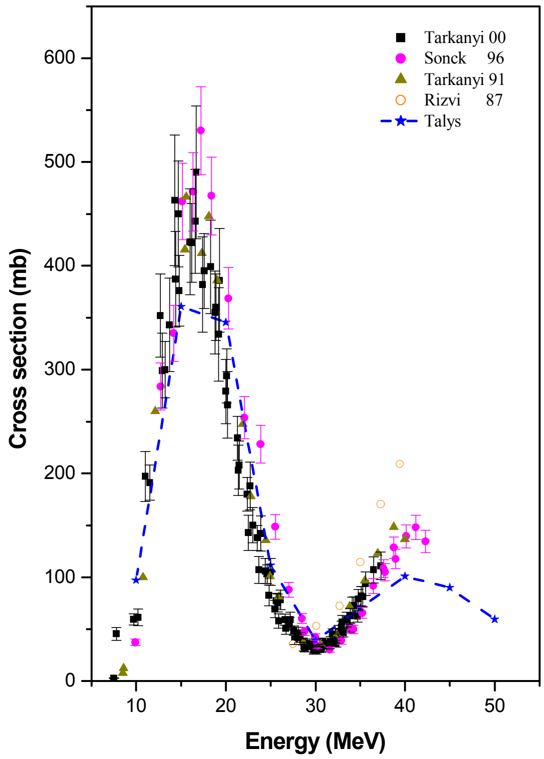

Figure 1. $^{nat}Cu(\alpha,X)^{66}Ga$

The comparison makes it evident that, with exception of few cases, the deviations both in magnitude and in shape are so significant that they could not predict or describe the cross-sections of the investigated alpha induced reactions with the required reliably. Due to the deviations in shape of the theoretical curves there is also a problem with their use even for interpolation and fitting of the existing experimental data. Consequently, at the present stage of calculations the recommended cross-sections data can be based only on well measured experimental ones.

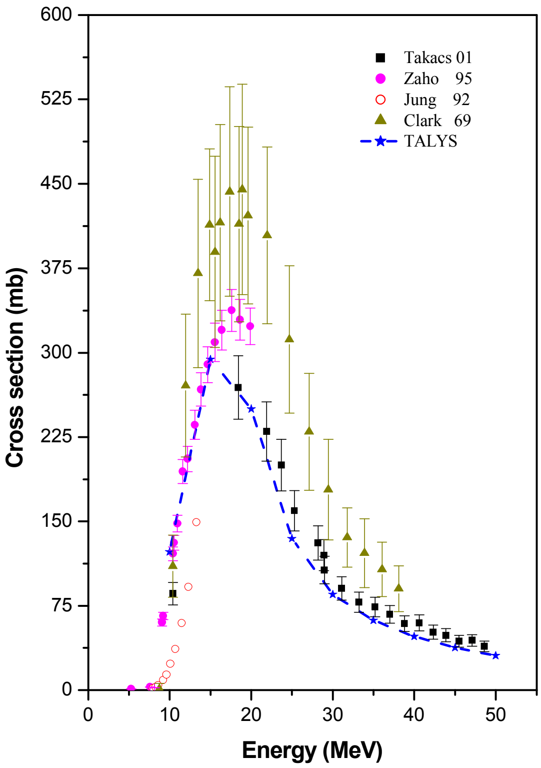

Figure 1. $^{nat}Fe(d,X)^{56}Co$

3. RESULTS

These experimental cross-sections have been compared with the corresponding cross-section obtained using TALYS code, which is a most recent and versatile code. These theoretical calculations have been performed within the frame work of Hauser-Feshbach statistical model theory with pre equilibrium cross-sections. The required inputs like nuclear masses, discrete energy levels and level densities of the nuclides involved in the calculations have been taken care in a proper way during the calculations. Especially, in case of alpha induced reactions, we optimised the input parameters like asymptotic level density, adjustable constant for spin cut-off factor. By fixing these input parameters in the input data of TALYS code, we successfully reproduced the measured cross sections in case of alpha induced reactions on natural Copper targets and for some other reactions as well.

Acknowledgements

This work has been performed under the Nuclear Research and Development program by the Ministry of Science and Technology (MOST) of Korea.

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