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Reaction cross section calculation of some alkaline earth elements

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Abstract: Reaction cross section knowledge is crucial to application nuclear physics such as medical imaging, radiation shielding and material evaluations. Nuclear reaction codes can be used if the experimental data are unavailable or are improbably to be produced because of the experimental trouble. In this study, there action cross sections of some target alkaline earth elements have been calculated by using pre-equilibrium and equilibrium nuclear reaction models for nucleon induced reactions. While these calculations, the Hybrid Model, the Geometry Dependent Hybrid Model, the Full Exciton Model, the Cascade Exciton Model for pre-equilibrium reactions and the Weisskopf-Ewing Model for equilibrium reactions have been used. The calculated cross sections have been discussed and compared with the experimental data taken from Experimental Nuclear Reaction Data library.

1 Introduction

Beryllium (Be), magnesium (Mg), calcium (Ca), strontium (Sr), barium (Ba) and radium (Ra) are alkali earth metal that is located at 2A group of periodic table. These elements are usually shinny and silver in their pure forms are rarely pure. Alkali metals are used in many areas and the use of these metals is increasing as a result of research. These metals are used in nuclear reactors, computer parts, lighting tubes, and rocket fuel, military purposes, our life cycle, health, strength of bones and teeth and plays fundamental role on our body.

In this study, we aim to investigate equilibrium and pre-equilibrium effects of some alkaline earth elements for nucleon induced reactions. For this purpose, ALICE/ASH [1], CEM 95 [2] and PCROSS [3] computer codes are used. The calculated cross sections have been discussed [10] and compared with the experimental data takenfrom Experimental Nuclear Reaction Data library [4].

2 Material and Methods

In this paper, we have calculated reaction cross section of several alkaline earth elements. While these calculations, the Hybrid Model [5], the Geometry Dependent Hybrid (GDH) Model [6], the Full Exciton Model [7], the Cascade Exciton Model [8] for pre-equilibrium reactions and the Weisskopf-Ewing (WE) Model [9] for equilibrium reactions have been used.

By neglecting angular momentum according to WE model equilibrium emission is calculated. Binding energies, inverse reaction cross-section, the pairing, and the level density parameters are the basic parameters of this model. According to the exciton model, after the first interaction between the incoming particle and the target nucleus, the excited system can reach the balance after a series of successive steps of increasing complexity, it may be possible to publish each of these steps. Hybrid and GDH models were modified using Pauli and surface correctionsthat were based on exciton model initially. The Cascade Exciton Model (CEM) accepts that reactions occur in three phases. The first phase is a transition in nuclear levels. The second phase corresponds to the pre-equilibrium state, and the third phase corresponds to the equilibrium state. These three components contribute to the experimentally measured values. Detailed description of this model can be found in their references.

3 Results and Discussion

Comparison of calculated cross sections ^{44}Ca(p,n) ^{44}Sc reaction with EXFOR are given in Fig. 1. PCROSS code calculations do not good fit experimental values after 12 MeV energy. CEM 95 model results are good harmony with Exfor data after 20 MeV energy region. WE Model have same geometry with experimental data up to 20 MeV. GDH and Hybrid Model calculations are best options for this reaction.

As can be seen in Fig. 2., all calculated results have a same geometry with EXFOR values, however, CEM follow experimental data from below. Hybrid and GDH model calculations are best options for these reactions.

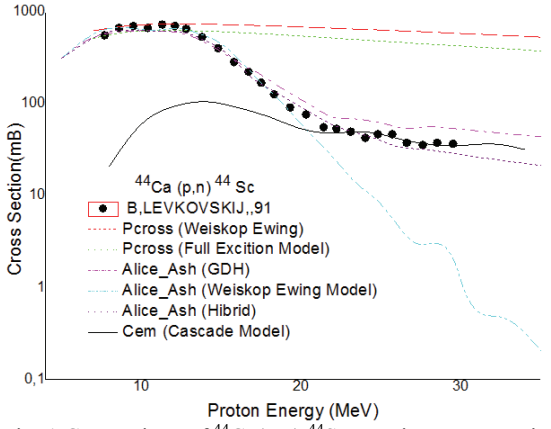

Fig. 1 Comparison of ^{44}Ca(p,n) ^{44}Sc reaction cross section calculations with EXFOR

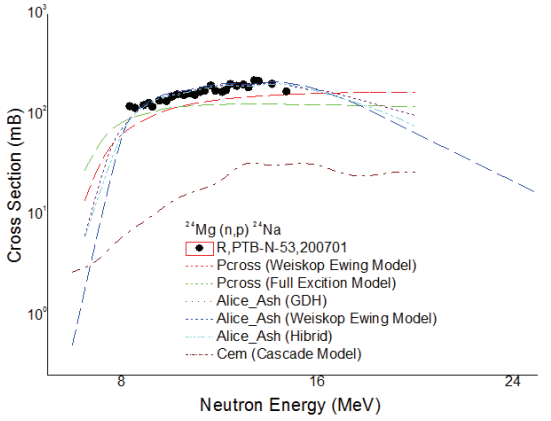

Fig. 2. Comparison of ^{24}Mg(n,p)^{24}Na reaction cross section calculations with EXFOR

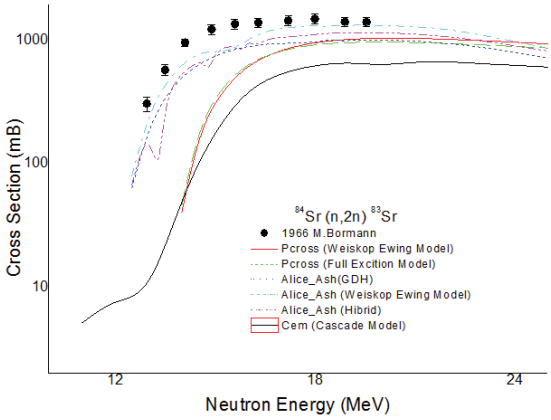

Fig. 3. Comparison of ^{84}Sr(n,2n) ^{83}Sr reaction cross section calculations with EXFOR

Comparison of ^{84}Sr(n,2n)^{83}Sr reaction cross section calculations with EXFOR are given in Fig. 3. All model calculations have a same shape with experimental data but Cascade Exciton Model and PCROSS code calculations follow from below. ALICE/ASH results gave close results with each other. They are good harmony with EXFOR values. ALICE/ASH WE Model are the best option for this reaction.

As can be seen in Fig. 4. ALICE/ASH WEModel and PCROSS code calculations are good harmony with experimental data up to 18 MeV energy. CEM 95 code results have a good harmony experimental data but follow them from below up to 23 MeV energy. ALICE/ASH pre-equilibrium calculations fit experimental data perfectly.

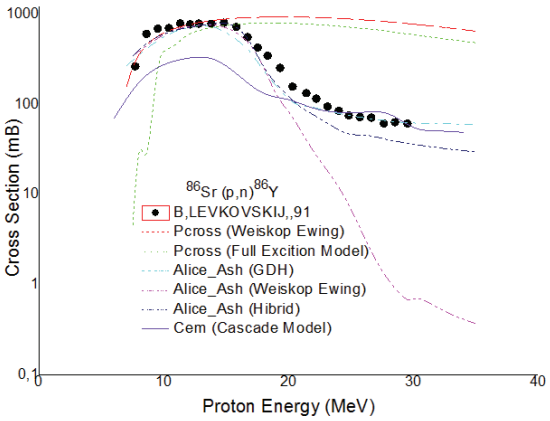

Fig. 4. Comparison of ^{86}Sr(p,n)^{86}Y reaction cross section calculations with EXFOR

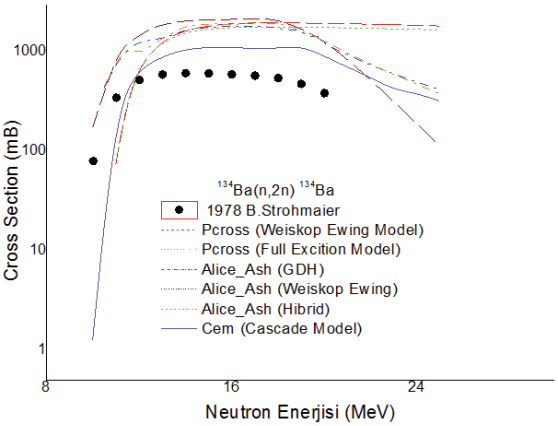

Fig. 5. Comparison of ^{134}Ba(n,2n)^{134}Ba reaction cross section calculations with EXFOR

Comparison of ^{134}Ba(n,2n)^{134}Ba reaction cross section calculations with EXFOR are given in Fig. 5. All model calculations are good harmony with experimental data but follow EXFOR values from above. As can be summarized;

1. Generally PCROSS code calculations are harmony with EXFOR values up to 18 MeV nucleon energy.
2. Cascade Exciton Model calculations have a same geometry shape with experimental databut follow them from below.
3. ALICE/ASH WE Model calculations are in good harmony with EXFOR values up to 18-20 MeV energy region.
4. Pre-equilibrium calculations from ALICE/ASH code can be chosen if the experimental data are unavailable.

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