Coupled Channel Calculations for Multinucleon Transfer in Ca Induced Reactions using FRESCO Code

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Introduction

In the last three decades, the renewed interest in transfer reactions has been mainly due to the realization that multi-nucleon transfer reactions could be used to populate nuclei moderately rich in neutrons [1].

In explaining experimentally observed fusion cross-section enhancement in the sub-barrier energies, transfer play a prominent role [2]. The first suggestion was made by Broglia et al. [3], that two neutron transfer with transfer Q-values are positive should enhance sub-barrier fusion. Coupled channel(CC) calculations with including only inelastic excitations of projectile were able to explain fusion enhancement in many cases [4]. However, in some other cases, where Q > 0, one has to include transfer as a part of the reaction [4].

Coupled Channel Calculations

In the coupled channel approach the various reaction channels such as elastic, inelastic, transfer etc. are treated as not independent of each other. The effect of other channels have to be considered in order to obtain information about a particular channel. We have performed the coupled channel calculations using the FRESCO code [5] for Ca induced multi-nucleon transfer reactions listed in Table I, were experimental measurements exists.

We have treated the multinucleon transfer via a successive transfer of single nucleons for all the considered reactions. To find the optical model potential parameters, we have fit the experimental elastic scattering data for the reaction ^{40}Ca+^{208}Pb, and for the reactions ^{40}Ca+^{124}Sn and ^{48}Ca+^{124}Sn, the parameters were taken from Ref. [7] and Ref. [8] respectively.

TABLE I: A list of reactions for which calculations performed in this work.

System	Energy ($E_{c.m.}$) (MeV)	Reference
^{40}Ca+^{208}Pb	149.8	[6]
^{40}Ca+^{124}Sn	106.9	[7]
^{48}Ca+^{124}Sn	110.4	[8]

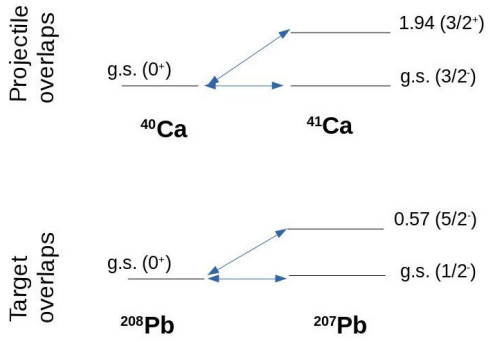

FIG. 1: Coupling diagram showing various transfer path used in the CC calculations for one neutron pickup channel in the system ^{40}Ca+^{208}Pb at $E_{c.m.}$=149.8 MeV.

The coupling scheme used for ^{40}Ca+^{208}Pb reaction is given in Fig. 1, which include the ground state and first excited state of ^{40}Ca nucleus. Fig. 2 shows the total transfer cross sections for ^{40}Ca+^{208}Pb, ^{40}Ca+^{124}Sn and ^{48}Ca+^{124}Sn reactions. Also, we compare our results with other theoretical models such as GRAZING [9] and complex WKB method [10].

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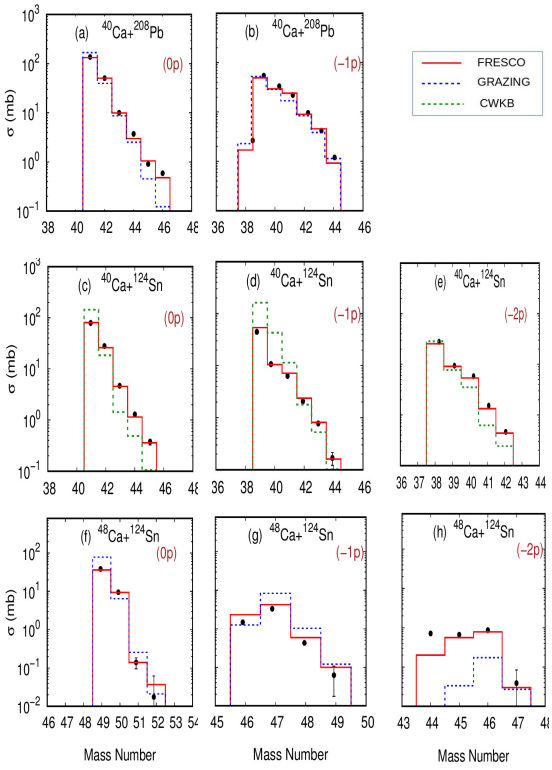

FIG. 2: The transfer cross sections for ^{40}Ca+^{208}Pb, ^{40}Ca+^{124}Sn and ^{48}Ca+^{124}Sn reactions in comparison with FRESCO, GRAZING and CWKB calculations.

In the case of ^{40}Ca+^{124}Sn and ^{48}Ca+^{124}Sn reactions, we have included the ground, first and second excited states of ^{40}Ca and ^{48}Ca nuclei. The second excited state will not make any appreciable effect in total transfer cross sections for the reaction ^{40}Ca+^{208}Pb. In Fig. 2(a) and 2(b), ^{40}Ca+^{208}Pb transfer reactions for $0p$ and $-1p$ cases are compared with experiment and GRAZING calculations [6]. Our calculations are in reasonable agreement with experiment. For the case of ^{40}Ca+^{124}Sn reaction, as the number of transferred protons increases (*0p* to *-2p*), the cross sections in the CWKB results show a drift from the experiment, whereas our calculations are very well describe the experimental results in all these cases (*0p*, *-1p* and *-2p* in Fig. 2(c), 2(d) and 2(e) respectively). Corradi et al. [8], suggested that the experimental data and their calculations supports the idea of cluster degrees of freedom for the case of *-2p* channel in ^{48}Ca+^{124}Sn reaction. However, calculations shown here do not involve any cluster degrees of freedom. Our calculations including coupling between $\frac{9}{2}^+$, $\frac{3}{2}^-$ and $\frac{1}{2}^-$ states of ^{48}Ca and $\frac{11}{2}^-$, $\frac{3}{2}^+$ and $\frac{1}{2}^+$ states of ^{124}Sn are very well describe the experiment. One could appreciate the good agreement between our calculations and experiment if one consider $-2p$ case as shown in Fig. 2(h).

Conclusions

Coupled channel calculations using FRESCO performed for Ca induced multi-nucleon transfer reactions give a good agreement with experiment. Also our calculations give a good representation to the experiment compared to GRAZING and CWKB calculations.

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