Effect of breakup and transfer coupling on elastic cross-section for ^{9}Be+^{208}Pb below Coulomb barrier

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Introduction

The effect of breakup (BU) of ^{9}Be using a ^{5}He+α cluster model and single neutron transfer coupling on elastic channel at energies near and above barrier have been reported for ^{9}Be+^{208}Pb system [1]. The transfer reaction is known to be a surface phenomena while the break-up process can occur due to both short range nuclear force and long range Coulomb interaction. At well below the Coulomb barrier the effect due to the nuclear force is expected to be negligible and any deviation of elastic cross-section from Rutherford scattering can only be due to coupling of break up channels. In the present work we have carried out a detailed CDCC (continuum discretized coupled channel) calculations for BU couplings and CRC (coupled reaction channel) calculations for one neutorn transfer to understand our previously measured high quality elastic scattering data for the system ^{9}Be+^{208}Pb at below Coulomb barrier energies [2].

CDCC calculations

The continuum discretised coupled channels calculations were performed using the code FRESCO, version FRES 2.3. For the breakup channel we have considered the nucleus ^{9}Be as a cluster structure of ^{5}He (core) and α (valence particle) [3]. The cluster folded potential, obtained by folding the fragment target potentials α+^{208}Pb and ^{5}He+^{208}Pb, was used for calculation of the interaction potential between ^{9}Be and ^{208}Pb. The α+^{208}Pb optical potential was taken from Goldring *et al.* [4], while for ^{5}He+^{208}Pb potential we have used the same parameters with the real and imaginary diffuseness increased by 0.1 fm in order to take into account the larger radial extent of ^{5}He [1]. To get the appropriate bare potential for the entrance channel, the calculations have been done with the cluster folded potential to fit the higher energy (42-75 MeV) elastic scattering data measured by Woolliscroft *et al.* [5]. The real part of the nuclear potential is decreased by a factor of 0.7 to get a good fit to data. The binding potential of ^{5}He+α were taken from Ref.[3]. The potential parameters were r_b=1.115 fm and a_b=0.57 fm and the depth (V_b) was adjusted to reproduce the correct binding energy. The inelastic excitation of ^{9}Be(E$_x$=2.43 MeV, 5/2$^-$) was also included in the calculation. The continum states upto 3.7 MeV were considered in the coupling. The inclusion of states above 3.7 MeV has negligible effects on the elastic cross section. The ^{5}He+α continuum model space was limited to $0\leq E\leq 1.2$ MeV with ΔE=0.15 MeV (beam energy above Coulomb barrier $\sim$40 MeV) and ΔE=0.08MeV (below barrier) in order to obtain numerical convergence of the calculations.

The CDCC results in the energy range 24-34 MeV are shown in Fig.1 along with our measured data. Here the ratio R(E)=$\sigma_{el}(160^o)$ / $\sigma_{Ruth.}(160^o)$ is plotted. By changing the potential of the BU states, the polarizability of ^{9}Be was increased to a maximum value of 0.36 fm^3. With this value a deviation of only 2% is obtained from that of bare

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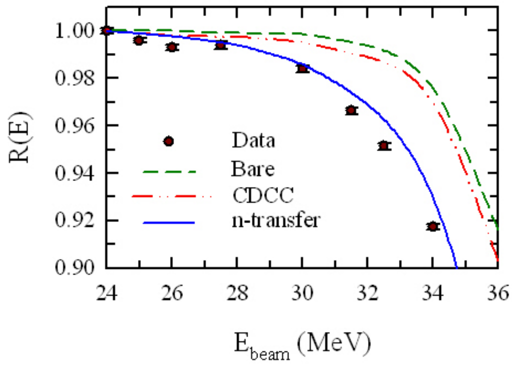

FIG. 1: The measured ratio R(E) of the elastic scattering cross-sections [2]. Calculations with only bare potential, CDCC calculations and one neutron transfer calculations are denoted by dashed, dot-dot-dashed and solid curves respectively.

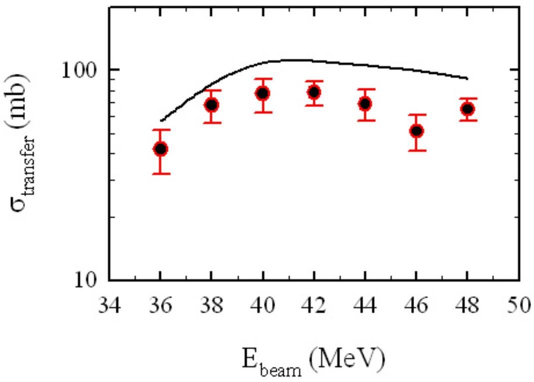

FIG. 2: CRC calulated cross section along with data for the one neutron transfer reaction ^{208}Pb(^{9}Be, ^{8}Be).

potential and still unaccounts the observed deviation. A simple calculation with a potential $V = V_{bare} + V_{pol}$, with the polirazation potential V_{pol} taken from Baur *et al.* [6] it has been observed that inorder to explain our data a value of the polarizability required is $\sim$5 fm^3 which is not physical. This implies that other than BU, effect of additional channels are required to explain the observed elastic data.

Calculations for one neutron transfer

We have carried out one neutron transfer calculations along with elastic channel in the frame work of CRC using the code FRESCO. The following states of ^{209}Pb: ground state ($9/2^+$), 0.78 ($11/2^+$), 1.42 ($15/2^-$), 1.57 ($5/2^+$), 2.03 ($1/2^+$), 2.49 ($7/2^+$) and 2.54 ($3/2^+$) MeV states were included. The spectroscopic factors for all these single particle states of ^{209}Pb were taken from Ref. [7]. The same bare potential, as used in the CDCC calculations, was used. The results are plotted in Fig.2 and are compared with existing data at higher energy [8]. The elastic cross-sections are shown in the Fig. 1 (solid line) and a good agreement with the data is obtained.

Conclusion

The breakup to the continuum and one neutron transfer calculations have been reported here. It is observed that for the present system ^{9}Be+^{208}Pb the effect of transfer coupling is significantly large than that of BU states even at 10 MeV below barrier. It is a surprise to see such a strong effect on the elastic cross section due to transfer coupling at below barrier energies and need further investigation.

References

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