Effect of breakup and transfer in ^{9}Be+^{124}Sn reaction

V. V. Parkar[1],* V. Jha[2],† S. K. Pandit[2], S. Santra[2], R. Palit[3], and S. Kailas[2]
[1] *Departamento de Física Aplicada, Universidad de Huelva, E-21071 Huelva, SPAIN*
[2] *Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai - 400085, INDIA and*
[3] *Department of Nuclear and Atomic Physics, Tata Institute of Fundamental Research, Mumbai - 400005, INDIA*

Introduction

We have recently measured the complete fusion (CF) cross-sections for ^{9}Be+^{124}Sn reaction [1] by online gamma-ray spectroscopy method. We observed that these CF cross-sections show suppression at above barrier energies compared to the coupled channels as well as 1DBPM (One Dimensional Barrier Penetration Model) calculations. This loss of flux, causing the suppression in CF, can be because of the incomplete fusion (ICF) as well as due to one neutron (1n) transfer channel.

Here we have attempted more rigorous calculations by means of the Continuum Discretised Coupled Channels (CDCC) method to see the effect of couplings due to ^{9}Be breakup and also Coupled Reaction Chennels (CRC) calculations for studying the effect due to 1n-transfer couplings. It should be mentioned that, ideally the CDCC calculated cross sections are better compared to be the total fusion, but in the absence of ICF data for this system, we have compared them to the measured complete fusion data to gain insights.

CDCC calculations

The CDCC calculations have been performed using the code FRESCO, version frxy.18 [2], to see the effect of breakup couplings in the ^{9}Be+^{124}Sn reaction. The ^{9}Be is assumed as having a cluster structure of ^{5}He as core and ^{4}He as valence particle. The binding potential for ^{5}He+^{4}He cluster has been taken from Ref. [3]. The required optical potential for ^{4}He+^{124}Sn at 4/9 of the ^{9}Be energy have been taken from the global set of Potentials from Averigenu *et al.*[4]. The depth of real part has been normalised by a factor 0.5. Similarly for ^{5}He+^{124}Sn, the same potentials were used with the real and imaginary diffuseness increased by 0.1 fm. The coupling details are same as in Ref. [5]. The CDCC results are shown in Fig. 1 and 2. Two methods have been employed to deduce the fusion cross sections from the calculations. In Fig. 1, the dotted line is the fusion from cumulative absorption method and dashed line is the fusion calculated from the 1DBPM using the effective potential generated from the breakup couplings. There is reasonable agreement with the 1DBPM results while the absorption method overpredict the measured complete fusion data. The 1DBPM fusion calculated using the bare potential found to be similar to that calculated using the effective potential due to breakup, implying that the coupling ef-

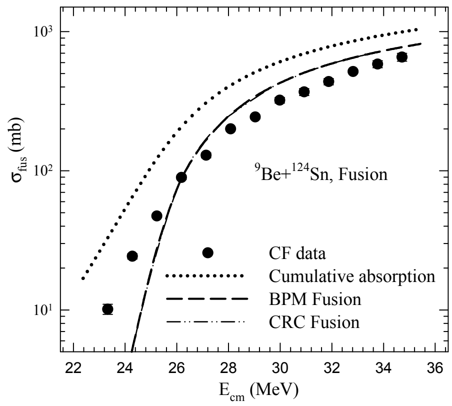

FIG. 1: Experimental complete fusion cross-sections for ^{9}Be+^{124}Sn reaction have been compared with the CDCC and CRC results.

*Electronic address: parkarvivek@gmail.com
†Electronic address: vjha@barc.gov.in

fects due to the breakup in the ^{5}He+^{4}He cluster mode on ^{9}Be+^{124}Sn fusion is quite small.

CRC calculations

In addition to the breakup couplings, the effect of 1n-transfer couplings on the near barrier elastic scattering and fusion have been studied. The ^{124}Sn(^{9}Be,^{8}Be)^{125}Sn has a Q-value of +4.068 MeV and can be expected to play a significant role at near barrier energies. We have considered the 1n-transfer to following states: 0.0 MeV $11/2^-$, 0.026 MeV $3/2^+$, 0.0232 MeV $1/2^+$, 1.377 MeV $7/2^+$, 1.509 MeV $5/2^+$, 2.84 MeV $7/2^-$, 3.43 MeV $3/2^-$ and 4.76 MeV $9/2^-$. These states were assumed to be with a pure single particle configurations as given in Ref. [6]. The 1n-transfer CRC calculations are plotted in Fig. 1 and 2 by dash dot dot lines. While the coupling effects of the single neutron transfer reaction have negligible effect on the fusion, it has a large effect on the near-barrier elastic scattering of ^{9}Be by ^{124}Sn. Unlike the coupling to transfer channels with negative Q values, the ^{124}Sn(^{9}Be,^{8}Be)^{125}Sn reaction with large positive Q value has a effect on the elastic scattering angular distribution that is qualitatively similar to that induced by breakup. Both transfer and breakup couplings lead to reduction of elastic cross sections at lower energy (E_{lab} = 26 MeV), while at higher energy (E_{lab} = 32 MeV) the elastic cross sections are enhanced at back angles with respect to the uncoupled calculations. These aspects of transfer coupling effects on the elastic scattering cross sections, showing the breakup like bahaviour and change in nature of couplings around the barrier [7] are quite interesting, but data is required to confirm these predictions.

Summary

The effect of breakup and 1n-transfer couplings have been studied for ^{9}Be+^{124}Sn reaction. The measured fusion data shows reasonable agreement with the 1DBPM results generated from CDCC effective potential and 1n-transfer couplings. In the elastic scattering angular distributions, it is observed that the transfer couplings have major role to play along with the breakup couplings. We plan to measure the elastic scattering angular distributions at around Coulomb barrier energies to confirm these predictions.

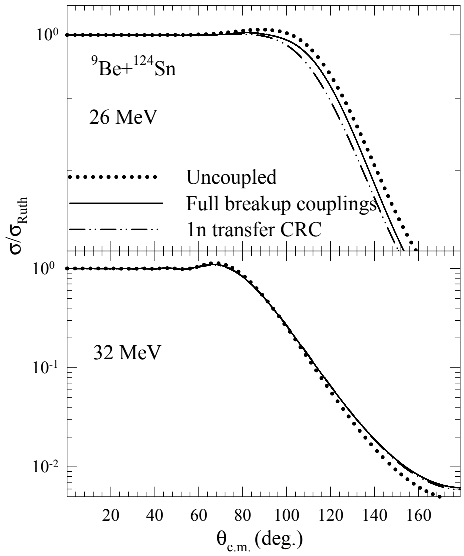

FIG. 2: Calculated elastic scattering angular distributions for ^{9}Be+^{124}Sn reaction. The dotted lines are calculations with bare potential while the dash dot dot and thick solid lines are results from only 1n-transfer and full breakup couplings respectively.

References

[1] V. V. Parkar *et al.*, Proceedings of the International Symposium in Nucl. Phys. **54**, 320 (2009).

[2] I. J. Thompson, Comput. Phys. Rep. **7**, 167 (1988).

[3] N. Keeley *et al.*, Phys. Rev. **C 71**, 014611 (1994).

[4] V. Avrigeanu, P. E. Hodgson, and M. Avrigeanu, Phys. Rev. **C 49**, 2136 (1994).

[5] S. Pandit *et al.*, Proceedings of the International Symposium in Nucl. Phys., **54**, 240 (2009).

[6] C. R. Bingham and D. L. Hillis Phys. Rev. **C 8**, 729 (1973).

[7] V. Jha and S. Kailas Phys. Rev. **C 80**, 034607 (2009).