Quasi-elastic excitation functions for ^{16,18}O + ^{206}Pb systems

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Introduction

Despite its simplicity, the elastic and quasi-elastic processes in nucleus-nucleus collisions are rich source of information for the underlying reaction mechanisms and the internal structure of the colliding nuclei. The coupling effects that arise primarily due to the inelastic excitation and the nucleon(s) transfer processes are manifested in terms of enhancement or reduction of fusion cross sections in the heavy-ion collisions at energies around the Coulomb barrier. The interaction potential between the colliding nuclei gets modified and it is also reflected in change of the large angle behaviour of quasi-elastic excitation spectra and barrier distribution [1]. In addition, these coupling effects can be utilized to extract the structure information of the nuclei involved in the collisions. Recently, it has been argued that the measured barrier distribution can provide the estimate of optimum incident energy for the synthesis of new superheavy element formation through the hot fusion reaction [2].

Quasi elastic scattering

The quasielastic scattering represents the sum of all direct processes such as, elastic and inelastic scattering and transfer processes. Often quasielastic processes measured at backward angles have been utilized for extracting the barrier distribution which is analogous and similar to the fusion barrier distributions. In heavy ion collisions where fusion is a dominant process as compared to other processes such as, inelastic scattering and transfer processes this is true. In this case, fusion represents the transmission through the interaction barrier, while the quasielastic scattering is related to the to the reflection at the barrier and both are complementary processes. However, if their are other processes such as deep inelastic processes or multinuicleon transfer which contribute significantly, the sum of elastic and inelastic backscattering processes provides only the total reaction threshold distribution and it differs from the fusion barrier distribution. Therefore it is not clear to what extent the multinucleon transfer such as 2n transfer and α-transfer should be included while calculating the quasielastic barrier distribution such that it corresponds to the fusion barrier distribution.

Calculation results

In the present work, we use the data measured for ^{16,18}O + ^{206}Pb systems [5] for exploring the features of quasi elastic scattering. It is expected that for the ^{18}O + ^{206}Pb system, the role of single neutron stripping with a Q-value of -1.308 MeV and 2n transfer with a Q-value of +1.917 MeV may be significant. We perform the coupled-channels (CC) calculations for the elastic and quasi elastic excitation functions. The fusion barrier distribution and quasi elastic barrier distribution have been studied in great detail for the ^{16}O + ^{208}Pb system [3]. The theoretical calculations are performed using the coupled reaction channels code FRESCO for ^{16,18}O + ^{206}Pb systems. The real part of nuclear potential is the double folding Sao-Paolo potential [6] while an internal potential for the imaginary part is used in the calculations. The absorption of flux through the interior imaginary po-

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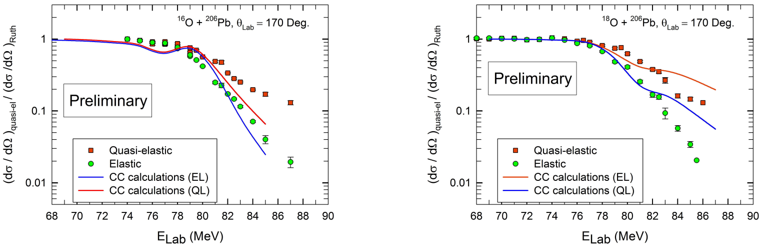

FIG. 1: CC calculations for elastic and quasi elastic excitation functions for ^{16,18}O + ^{206}Pb systems compared with the data.

tential accounts for the fusion. The imaginary parts of the potentials were taken to be of Woods-Saxon form, with parameters W_0 =40 MeV, r_w =1.0 fm and a_w=0.4 fm. The coupling to the collective excitations of the colliding nuclei, namely, the vibrational 3 state at 2.61 MeV, 5 state at 3.20 MeV and 2^+ state at 4.07 MeV in ^{206}Pb nucleus is included in the calculations. For the projectile part the 2^+ state at 1.98 MeV and 3^- state at 5.10 MeV in ^{18}O nucleus and 3^- state at 6.13 MeV for ^{16}O are included in the calculations. The deformation parameters are taken as those available in the literature. Fig. 1 shows the data for the elastic and quasi-elastic excitation functions for ^{16,18}O + ^{206}Pb systems at θ_{lab} =170^o along with the CC calculations including the inelastic couplings as described above. It must be noted, that the calculations don't involve any free parameters and discrepancy with respect to data can be attributed to this fact. The reaction cross sections obtained from the calculations are given in Table. I. The reaction cross sections are found to be higher for ^{18}O + ^{206}Pb system as compared to ^{16}O + ^{206}Pb system at similar energies, underlining the importance of transfer-like channels for the former system.

TABLE I: Reaction cross sections obtained from CC calculations for ^{16,18}O + ^{206}Pb systems at different energies

E_{lab} (MeV)	$\sigma_R(mb)$ (^{16}O + ^{206}Pb)	$\sigma_R(mb)$ (^{18}O + ^{206}Pb)
67	30.6	54.2
69	33.3	61.4
71	36.0	68.8
73	38.6	76.2
75	41.2	83.4
77	45.8	93.2
79	70.7	127.7
81	151.0	214.7
83	257.5	313.8
85	363.4	412.0
87	464.6	513.5

Summary

In summary, we have performed the CC calculations for explaining the measured data for ^{16,18}O + ^{206}Pb systems. The elastic excitation functions and reaction cross sections at different energies are calculated. The inclusions of transfer processes may provide the better description of the quasi elastic distributions.

References

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