Effect of coupling on sub-barrier fusion: The case of ^{37}Cl+^{130}Te system

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Fusion at near-to-extremely sub-barrier energies has been extensively studied in last few decades as this is useful to reveal various aspects of quantum mechanics, improve the prevailing knowledge of static and dynamic properties of nuclei, and has the probabilty to explore suitable condition to produce long-lived superheavy nuclei [1, 2]. In classical point of view, fusion can occurs only if the system overcomes the residual barrier, formed due to equilibration of attractive nuclear potential and repulsive Coulomb potential between them. However, some experimental observations suggest that the fusion occurs also at sub-barrier energies. As per the present understanding, sub-barrier fusion occurs due to the quantum mechanical tunnelling, static and dynamic deformations, and positive Q-value neutron transfer channels (PQNT) [3, 4]. In order to understand the effect of aforesaid aspects, the fusion cross-sections of ^{37}Cl + ^{130}Te system is measured from 15 % above to 10 % below the Bass barrier (V_B).

The experiment has been carried out at Inter University Accelerator Centre (IUAC), New Delhi using the Heavy Ion Reaction Analyser (HIRA). The experimental methodology of the present work is same with that of ref. [5]. However, a brief account of the experimental conditions is given here for ready reference. The ^{37}Cl pulsed beams of bombarding energies ($E_{Lab.}$) ranging from 121 to 155 MeV were delivered from 15UD Pelletron accelerator, and bombarded on ^{130}Te target, mounted inside the target chamber of HIRA and maintained 10^{-6} Torr pressure. The pulsed beam was used to get a clear separation

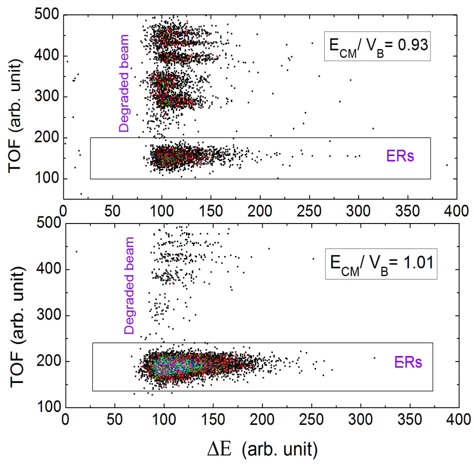

FIG. 1: ΔE - TOF spectra obtained at $E_{c.m.}/V_B$ = 0.93 and 1.01 where the beam-like particles are clearly separted from evaporation residues (ERs).

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between projectile-like particles and evaporation residues (ERs), especially at below barrier energies. For ^{37}Cl + ^{130}Te system, the time interval between two pulses was 2 μs, kept slightly greater than the flight time of recoil residues ($\approx$ 1.5 μs around the barrier,V_B $\approx$ 134 MeV), which distinctly separate ERs and beam-like particles without overlapping the signals. The ERs are identified by making an electronic gate between TOF (subtraction of actual flight time from the time difference between two pulses) and corresponding ΔE (energy loss by the ERs in MWPC). As a representative case, two ΔE-TOF spectra obtained for ^{37}Cl + ^{130}Te system are given in Fig.1.

TABLE I: Spectroscopic parameters of ^{37}Cl and ^{130}Te nuclei included in CCFULL calculations [6].

Nucleus	E_{ex} (MeV)	I^{π}	$E(\lambda)$	β
^{37}Cl	1.73	vib. $(1/2)^+$	2	0.14
	3.09	vib. $(5/2)^+$	2	0.24
^{130}Te	0.83	rot. 2^+	2	0.11
	2.45	rot. 4^+	2	0.11
	1.59	vib. 2^+	2	0.11

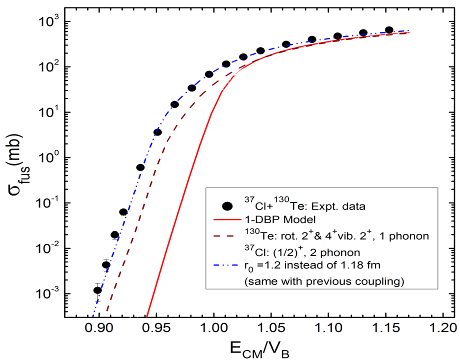

FIG. 2: ΔE - TOF spectra obtained at $E_{c.mm.}/V_B$ = 0.93 and 1.01 where the beam-likes are clearly separted from evaporation residues.

The fusion cross-section at different energies is estimated by using the standard expression [8]. The fusion excitation function has been obtained by plotting the fusion cross-sections as a function of energy, and compared with the predictions of CCFULL [7] with different set of coupling as shown in Fig.2. The AW-potential parameters, *i. e.,* V_0= 74.00 MeV, r_0 = 1.18 fm and a_0 = 0.67 fm of interacting partners are used to reproduce the measured excitation function for ^{37}Cl + ^{130}Te systems. The used spectroscopic parameters in CCFULL are given in Table I.

The measured excitation function is found to be significantly enhanced relative to the one-dimensional barrier penetration model (1-DBPM). To understand this enhancement, further analysis has been performed by implementing different in-elastic excitations of interacting partners as shown in Fig.2. The coupling, *i. e.,* ^{130}Te (target) : rot 2^+, 4^+, vib 2^+ with 1 phonon, and ^{37}Cl (projectile) : $(1/2)^+$ with 2 phonon, well reproduces the observed excitation function after slightly changing the barrier by changing its radius parameter from r_0 = 1.18 to r_0 = 1.2 fm. Further data analysis is underway to understand the behaviour of fusion excitation function at sub-barrier energies. Detailed results and analysis will be presented during the Symposium.

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