Influence of breakup process in reaction cross section for weakly bound projectiles in $^{6,7}Li + ^{232}Th$ reactions

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Introduction:

In heavy ion reactions the projectile structure plays an important role in the reaction dynamics. For reactions with weakly bound projectiles, the interaction potentials are modified and essentially enhance the total reaction cross-section due to the low threshold energy of the breakup channel. At energies near the Coulomb barrier, the role of projectile structure on reaction mechanism and the influence of the breakup process in the fusion cross sections have been reported earlier for weakly bound projectiles [1-3]. In the present work, we have investigated the effect of the projectile breakup on the reaction cross section for $^{6,7}Li + ^{232}Th$ systems from the measurement of the elastic scattering cross section. The total reaction cross sections have been obtained from the optical model analysis of the elastic scattering cross section data for both the systems at energies around the Coulomb barrier.

Experimental details and results:

The experiment was performed at 14UD pelletron facility, Mumbai using beams of $^{6,7}Li$ to bombard a self supporting ^{232}Th target of thickness 1.6 mg/cm^2. The elastically scattered particles were detected by using four ΔE-E silicon surface barrier detector telescopes mounted inside the general purpose scattering chamber and the measurements were carried out in the angular range of 20-150°. Two monitor detectors were mounted at fixed angles at ± 15° for normalization purposes. The elastic scattering cross section has been measured for various angles for beam energies from 25% below the Coulomb barrier (V_{lab}= 32 MeV) to approximately 40% above the barrier.

The total reaction cross section is obtained from optical model fitting of the elastic scattering data using the ECIS code [4]. The details of the fitting procedure and the related results on elastic scattering have been reported in a separate paper in this conference [5]. The values of the potential parameters for the best fit and the total reaction cross section are given in Table-I for both systems. The total reaction cross sections obtained from the elastic scattering data for $^{6,7}Li + ^{232}Th$ systems have been compared with the couple channel calculation using CCFULL code.

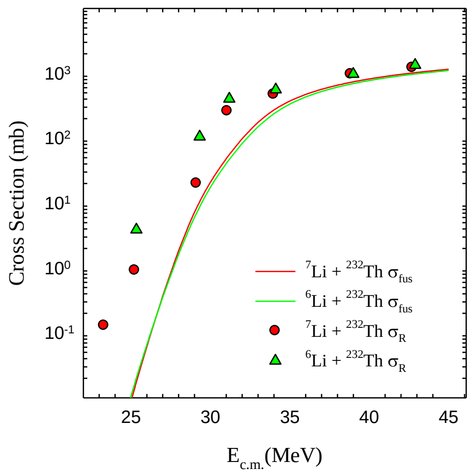

Fig.1: Total reaction cross sections obtained experimentally along with the CCFULL calculations.

From Fig.1, we observe that the total reaction cross section for $^{6}Li + ^{232}Th$ system is large in comparison to $^{7}Li + ^{232}Th$ at all energies and it is predominantly enhanced at sub-barrier energies. This indicates that the breakup cross section is significantly more in ^{6}Li in comparison to ^{7}Li. Similar enhancement in the fission cross section for ^{6}Li + ^{232}Th reaction in comparison to ^{7}Li + ^{232}Th has been reported earlier [6]. Since the total reaction cross sections as well as fission cross section have similar behavior at sub-barrier energies, it can be concluded that the breakup fusion-fission process is the dominant process at these energies.

To eliminate the projectile size effects on the reaction cross section, we have employed the "reduction" method, proposed by Gomes et al. [7]. We have calculated the reduced reaction cross section values at all energies for both the systems. In this method, the quantities $\sigma_R/(A^{1/3}_P + A^{1/3}_T)^2$ vs $E_{c.m.}(A^{1/3}_P + A^{1/3}_T)/Z_P Z_T$ are plotted, where P and T represent the projectile and target respectively and σ_R is the total reaction cross section as shown in Fig.2.

From this figure it can also be seen that total reduced reaction cross section for ^{6}Li is larger than ^{7}Li, below the barrier. This is again an indication of large breakup probability in case of ^{6}Li projectile.

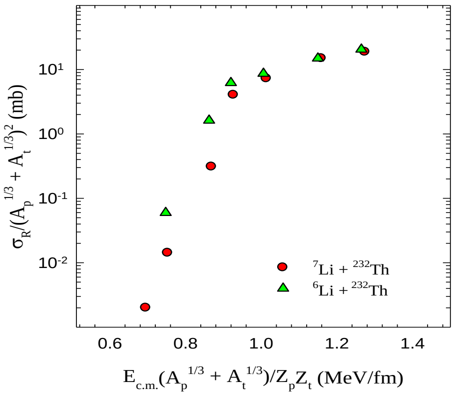

Fig.2: Reduced total reaction cross section vs reduced projectile energy for the ^{6,7}Li + ^{232}Th.

TABLE-I: Optical model parameters obtained by fitting to experiment elastic differential cross section data using the ECIS code in ^{6,7}Li + ^{232}Th reaction. The radius (1.06 fm) and diffuseness (0.71 fm) potential parameters were kept fixed.

^{7}Li + ^{232}Th system				^{6}Li + ^{232}Th system			
Energy(MeV)	V_o(MeV)	W_o(MeV	σ_R(mb)	Energy(MeV)	V_o(MeV)	W_o(MeV	σ_R(mb)
24	70.20	13.70	0.129				
26	85.00	19.70	0.919	26	105.6	90.00	3.884
30	95.22	30.70	20.07	30	263.3	167.7	105.4
32	360.00	58.54	260.8	32	215.9	394.6	404.4
35	157.90	73.62	470.7	35	130.2	183.5	561.2
40	147.42	78.34	967.7	40	97.69	136.0	970.6
44	115.80	67.66	1215	44	128.8	144.7	1336

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