

Preface

The availability of radioactive ion beams (RIBs) have enhanced the importance of reaction studies with stable weakly bound nuclei (${}^6,{}^7\text{Li}$, ${}^9\text{Be}$). This is due to the similarity in structural properties of stable and unstable weakly bound nuclei, that can serve a testing ground for unstable weakly bound nuclei. During the nuclear interaction, in the field of target nuclei the weakly bound nuclei having a lower breakup threshold can be directly broken into two fragments (core + valence) or it can be broken after nucleon transfer. This breakup channel affects the other associated reaction channels such as transfer, fusion, elastic and quasi-elastic scattering. The present thesis mainly focuses the study of breakup coupling effects on elastic and fusion channels that involve stable but weakly bound nuclei, namely ${}^6,{}^7\text{Li}$. With this objective, three different experiments have been performed for ${}^7\text{Li}+{}^{27}\text{Al}$, ${}^7\text{Li}+{}^{159}\text{Tb}$ and ${}^6,{}^7\text{Li}+{}^{209}\text{Bi}$ reactions at around the Coulomb barrier energies.

In depth, elastic scattering angular distributions for ${}^7\text{Li}+{}^{27}\text{Al}$, ${}^{159}\text{Tb}$ systems have been carried out. Optical model analysis employing Woods-Saxon form of potentials has been performed to extract the optical model (OM) potential parameters. On the basis of the energy dependence analysis using OM potentials for ${}^7\text{Li}+{}^{27}\text{Al}$ system, no strong conclusion regarding the presence of the ‘TA’ or ‘BTA’ could be made. This observation is consistent with the earlier results in the literature. However, for ${}^7\text{Li}+{}^{159}\text{Tb}$ system, the behavior of real and imaginary parts of the optical potential may indicate the presence of ‘TA’. The possible reason may be the strong contributions from inelastic states of ${}^{159}\text{Tb}$ target that vanishes the effects of breakup coupling. In ${}^7\text{Li}+{}^{27}\text{Al}$ reaction, the CDCC and transfer calculations have been carried out to see the breakup and $1n$ -transfer coupling effects on elastic scattering angular distributions. The $1n$ -transfer was found to be more dominant as compared to breakup channel particularly at above barrier energies. Similarly, in the reaction of ${}^7\text{Li}+{}^{159}\text{Tb}$ system, the effect of breakup coupling is very small. For ${}^7\text{Li}+{}^{27}\text{Al}$ system, the fusion cross sections at energies near the Coulomb barrier have also been obtained from the measured alpha evaporation spectra at backward angles. Thus, simultaneous study of elastic and fusion channels have been performed for the reaction of ${}^7\text{Li}$ with ${}^{27}\text{Al}$. The calculated fusion cross sections from the CDCC+transfer calculations using FRESKO, were compared with the present fusion cross sections. The obtained fusion cross sections by the BPM calculation was found in better agreement with the experimental data. From the systematic study of reduced total reaction cross sections for ${}^7\text{Li}$ -projectile

and variety of target nuclei ($A=16$ to 232), it has been observed that the total reaction cross sections may show target mass dependences at below the barrier energies.

Other method that can help in understanding of breakup coupling is the extraction of fusion barrier distribution from quasi-elastic scattering. Measuring barrier distribution from quasi-elastic scattering at backward angle data, is much easier with smaller experimental uncertainties as compared to fusion excitation function. Unlike the tightly bound nuclei, in case of weakly bound nuclei, there is a difference between barrier distributions that are obtained from quasi-elastic and fusion excitation functions. This has led to the interest to obtain the fusion barrier distribution from quasi-elastic scattering for ${}^6,7\text{Li}+{}^{209}\text{Bi}$ systems and to compare with the one obtained from fusion cross sections. For both the ${}^6,7\text{Li}+{}^{209}\text{Bi}$ systems, it has been observed that the fusion barrier distributions obtained from quasi-elastic and fusion excitation function measurements are consistent only when BU and/or transfer channels are included to the quasi-elastic events. The observed shifts in the barrier peak positions with and without inclusion of BU and/or transfer channels, is more for ${}^6\text{Li}$ as compared to ${}^7\text{Li}$ projectile. This supports the feature of lower breakup threshold energy of ${}^6\text{Li}$ than ${}^7\text{Li}$. For ${}^6\text{Li}+{}^{209}\text{Bi}$ system CRC calculations are also done to understand the $1n$ -transfer effects on fusion barrier distributions, which shows negligible effect of this channel. Moreover, simultaneous calculation for breakup and transfer with the reduced binding energy of core and valence particle have been carried out. The relative contribution of breakup and $1n$ -stripping channels have been reproduced at below barrier energies for the reaction of ${}^6\text{Li}$ with ${}^{208}\text{Pb}$ and ${}^{209}\text{Bi}$.