Chapter 7

Summary, Conclusions and Future Outlooks

7.1 Summary and conclusions

In the present thesis, we have studied the breakup effects on reaction dynamics of some specific channels for $^{6}Li+^{51}V$, $^{7}Li+^{92}Mo$, $^{7}Li+^{100}V$, and $^{6}Li+^{100}Mo$ systems, particularly below and around the Coulomb barrier energies. The details are summarized as below:

7.1.1 Elastic scattering for $^{6}Li+^{51}V$ and systematic study of breakup threshold anomaly

The study of reaction with weakly bound projectile (WBP) ^{6}Li has been performed with light-middle mass target ^{51}V to understand breakup of projectile around Coulomb barrier energies. The measurement was done at 14 UD Pelletron facility, TIFR, Mumbai using a $^{6}Li^{3+}$ ion beam bombarded on ^{51}V target for energies 14, 20, 23, 26 MeV. The data has been analyzed in the phenomenological model, optical model, and CDCC calculation frameworks. The present system exhibits breakup threshold anomaly as a near barrier rise can be observed in imaginary part and a corresponding dip in real part. Breakup coupling effect in 3 body CDCC model calculation was precisely producing elastic scattering data. Well, the polarization potential extracted from these calculations are in some difference compared to Double Folding (DF) potential analysis. The possible reason may be the approximation method used in CDCC analysis. Dynamic polarization potential is repulsive for real part and attractive for imaginary part. In order to investigate the mass dependence of BTA, DF potential framework using HFB model densities was used and was resulting into the same conclusion. The same framework was used in light to heavy mass range and a systematics of reaction cross section for 6Li projectile was drawn ton conclude a universal behavior. Systematic analysis of reaction cross section for strongly bound projectile, weakly bound projectile and radioactive ion beam with ^{51}V depicts an increasing trend of reduced reaction cross- sections from SBP to RIB affected by lower binding energy, cluster as well as halo structure.

7.1.2 Inclusive Alpha production for ^{6}Li+^{51}V system

For a large angular range, the inclusive α- production cross sections have been experimentally measured for the weakly bound projectile ^{6}Li +^{51}V system around the Coulomb barrier of the system. The production of large α-particle was noted which is a signature of WBP. The compound nucleus contribution and direct α contributions are differentiated by statistical model calculations and thus only direct part is considered for further consideration. Different calculations were performed to disentangle the contribution from different channels viz. non-capture breakup calculations using CDCC calculations, n, p, and d transfers using CRC calculations, and ICF (incomplete fusion) α assessments using fusion cross sections. It could be noted that the summing up of the cross sections of all these channels are reproducing well the energy and angular distribution as well as the integral cross section. The higher Q value of the deuteron transfer reaction is responsible for the negligible contribution of transfer to discrete states and the considerable contribution to continuum states. In the case of p and n transfers, the transfer to continuum contributes to enhancement in cross section along with discrete states. Thus the total calculated direct α cross sections are in very well agreement with the measured experimental cross section data. The ICF α cross sections were extracted from the fusion cross section. Direct α particle cross section depicts a universal trend and a difference is always there among different targets possibly due to structure effects during transfer channels furnishing to α production. A relative study for α production to that of deuteron production is done for numerous targets close to the Coulomb barrier and α production cross section is found to be much higher compared to the deuteron production cross section. This may be due to the difference in the Coulomb barrier in deuteron production and more reaction channels for α production. The ratio saturates above the barrier energies probably due to the saturation of the number of open channels.

7.1.3 Exploring Breakup Coupling Effect in ^{7}Li+^{92,100}Mo Elastic Scattering around Coulomb Barrier Energies

In the view to study another WBP ^{7}Li, we have done the experiment for measurements of elastic scattering angular distribution for the systems ^{7}Li+^{92,100}Mo in the energy range of 0.85 to twice the Coulomb barrier i.e. around the barrier. The optical model analysis of the experimental data was carried out using two different potentials, Woods-Saxon potential and São-Paulo potential. The potential parameters are extracted at radius of sensitivity and energy dependence of the parameters are calculated at that. The energy dependent parameters show breakup threshold anomaly around the Coulomb barrier. The result from the study of normalization parameters obtained from the São-Paulo potential model analysis are also the same as above. The Continuum Discretized Coupled Channels (CDCC) calculations show breakup couplings effects of projectile. It was observed from the calculations that CDCC calculations with breakup coupling to the channels give a better description of experimental data compared to calculations without breakup coupling although he difference between the two calculations was marginal. The total reaction cross section compared to the fusion cross section show marginal dominance for ^{7}Li+^{92}Mo system, considerable dominance for ^{7}Li+^{100}Mo in the sub-barrier energy region. This could suggest that the endured differences were because of dynamic effects of channel coupling, essentially with remarkable contribution from breakup channel. The dominance of reaction cross section over fusion can be observed for ^{6}Li+^{100}Mo system which is even larger than ^{7}Li. A systematic study on total reaction cross section for numerous mass region targets with ^{7}Li signifies mass and shape dependence of cross section.

7.1.4 Study of Breakup Effect of Weakly Bound Projectile around Coulomb Barrier Energies for $^{6}Li+^{100}Mo$ System

The measurements for elastic scattering angular distribution for $^{6}Li+^{100}Mo$ systems have been carried out around the Coulomb barrier energies. The optical model analysis of the data was carried out using Woods-Saxon potential. The potential parameters are calculated at sensitivity radii and energy dependence of these potential parameters are calculated at that. The parameters show a rise in imaginary potential before closing of the reaction channels. This is the indication of breakup threshold anomaly around the Coulomb barrier for the middle mass region system $^{6}Li+^{100}Mo$.

7.2 Future Outlook

In recent years, exploring heavy ion reactions is of great interest due to the discovery advanced accelerators, unstable weakly bound nuclei, and radioactive ion beams (RIBs). The availability of RIBs and unstable WBPs are in less intensity and therefore the precise study of their structure and reaction dynamics is a challenge. Therefore the study of stable WBPs (viz. $^{6,7}Li$, ^{9}Be) prepare a platform of basic understanding of these advanced nuclei. Thus the next step could be structure and reaction studies of unstable Weakly Bound Projectiles and RIBs. In the near future it will be interesting to investigate the other systems from different mass regions to enrich the understanding of reaction dynamics. The more and more experimental data contributes to enhance the preciseness and thus predictability in the development of theoretical models also. Thus the experimental part of the research in seek of vast data availability is a wise investment.

In continuation of the work done in thesis, the other reaction channels should be studied experimentally to have a confident understanding of reaction dynamics and coupled channel models should be near enough to reproduce the experimental observations.