Study of quasi-elastic scattering in ^{7}Li+^{116,118}Sn reactions

Arshiya Sood[1],* Arzoo Sharma[1],† Akashrup Banerjee[2],† Pawan Kumar[1], Rudra N. Sahoo[1], Malika Kaushik[1], Pushpendra P. Singh[1], Kavita Rani[3], Abhishek Yadav[4], Gurpreet Kaur[5], Akhil Jhingan[5], N. Saneesh[5], Mohit Kumar[5], Manoj K. Sharma[6], K. S. Golda[5], and P. Sugathan[5]

[1]*Department of Physics, Indian Institute of Technology Ropar, Punjab-140001, India*
[2]*Department of Physics and Astrophysics University of Delhi, Delhi-110007, India*
[3]*Department of Physics, Panjab University, Punjab-160014, India*
[4]*Department of Physics, Jamia Millia Islamia , New Delhi-110025, India*
[5]*Inter-University Accelerator Centre, New Delhi-110067, India and*
[6]*Department of Physics, Shri Varsheny College, Aligarh, Uttar Pradesh-202001, India*

Heavy-ion (HI) induced reactions have inspired a great deal of efforts across the globe as they offer a radical rearrangement of nucleons in a many-body system and have been prodigiously investigated to understand the underlying dynamics. An interesting strand of HI induced reactions is the one involving weakly bound projectiles (^{6,7}Li and ^{9}Be) at energies around the Coulomb barrier as they offer widespread opportunities to explore different aspects of nuclear structure and reactions[1, 2]. Weakly bound nuclei are characterized by their cluster/halo structure and low breakup thresholds, which makes incomplete/breakup fusion a dominant reaction process. The fusion cross-sections are sensitive to the internal structure of interacting nuclei and coupling to other reaction channels like inelastic excitations, breakup, and direct nucleon transfer. The couplings of non-fusion channels substantially modify the effective interaction potential, and leads to the splitting of single, uncoupled fusion barrier into multiple barriers which result in the distribution of barriers. The barrier distribution can be experimentally obtained by two complementary processes - fusion and large angle quasi-elastic (QEL) scattering and are expected to be similar[3–5]. However, for weakly bound projectiles, the distribution obtained from QEL has been found to be broader than that derived from fusion, and a relative shift in peak has also been observed between the two distributions indicating strong influence of breakup or breakup-like processes on fusion at energies near or below the barrier[6–8].

To further investigate this discrepancy, experiments were proposed to derive barrier distributions from fusion and quasi-elastic back-angle scattering cross-sections for ^{6,7}Li+^{116,118}Sn systems. In the first set, quasi-elastic back-angle scattering experiments were performed in General Purpose Scattering Chamber (GPSC) with beams of ^{7}Li in energy range 15-29 MeV (30% below- to above-barrier) bombarded on isotopically pure self-supporting ^{116,118}Sn targets of thickness ≈ 430 μg/cm^2 and 380 μg/cm^2, respectively. Targets were prepared in target laboratory at IUAC using ultra-high vacuum evaporation technique [9]. Beam energies were varied in steps of 2 MeV below the barrier and 3 MeV above it. Beam current was maintained between 2-3 nA throughout the experiment. To detect and identify charged particles produced in the reactions, HYbrid Telescope ARray (HYTAR) detector facility was used[10]. The quasi-elastic backscattering events were measured using telescope array comprising of four telescopes arranged in symmetrical cone geometry, two in- and out- of the plane each, at an angle of 173°, and six telescopes placed at angles +60° to +160° and three telescopes

*Electronic address: arshiya.sood@iitrpr.ac.in
†Present address: GSI Helmholtzzentrum für Schwerionenforschung, Planckstrasse 1, 64291 Darmstadt, Germany

placed at angles -36° to -60° with an angular separation of 20° and 12°, respectively. Two SSBD monitor detectors were placed at ± 10° with respect to the beam direction for normalization and beam monitoring purposes. The experimental set-up is shown in Figure 1(top). For instance, a typical two-dimensional ΔE-

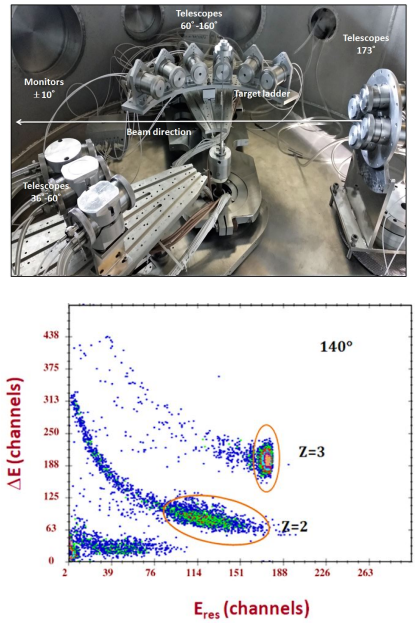

FIG. 1: (top) Experimental set-up for quasi-elastic scattering measurement at IUAC New Delhi, and (bottom) ΔE-E_{res} spectrum at θ_{lab} = +140° for ^{7}Li+^{118}Sn at E_{lab} = 21 MeV.

$E_{residual}$ spectrum obtained from the telescope at +140° for ^{7}Li+^{118}Sn system is presented in Figure 1(bottom). The events corresponding to multiple elastic + inelastic scattering and breakup processes at E_{lab} = 21 MeV are marked as Z=3 and Z=2, respectively. In Figure 2, preliminary analysis of data for four angles i.e., +120°, +140°, +160° and +173° is presented. Figure 2(top) shows the quasi-elastic excitation functions obtained at these angles and Figure xsec(bottom) shows the corresponding derived barrier distributions. The detailed analysis of data and its interpretation in the framework of theoretical model codes is underway. Details of the experiment and results of the investigations will be delineated and discussed during the symposium.

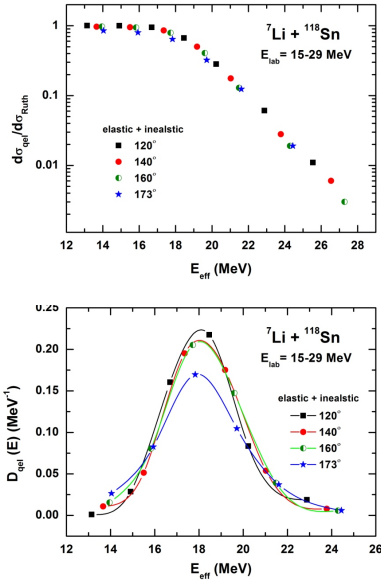

FIG. 2: (top) Quasi-elastic scattering excitation function and (bottom) corresponding barrier distribution obtained at θ_{lab}= +120° to +173° for ^{7}Li+^{116,118}Sn

References

[1] L. F. Canto, et al., Phys. Rep. 424 (2006) 1, and references therein.
[2] V. Zagrebaev, et al., Phys. Rev. C 78 (2008) 034610.
[3] N. Rowley, et al., Phys. Lett. B 254 (1991) 25.
[4] H. Timmers, et al., Nucl. Phys. A 584 (1995) 190.
[5] M. Dasgupta, et al., Annu. Rev. Nucl. Part. Sci. 48 (1998) 5.
[6] M. Zadro, et al., Phys. Rev. C 87 (2013) 054606.
[7] C. S. Palshetkar, et al., Phys. Rev. C 89 (2014) 024607.
[8] M. Moin Shaikh, et al., Phys. Rev. C 91 (2015) 034615.
[9] A. Sood, et al., Vacuum(under review).
[10] A. Jhingan, et al., Nucl. Inst. Meth. Phys. Res. A 903 (2018) 326.