Study of Break-up threshold anomaly in ^{6,7}Li + ^{116}Sn system: A dispersion relation analysis

N.N. Deshmukh[1, 2], S. Mukherjee[1], S. Santra[3], B.K. Nayak[3], D.C. Biswas[3], E.T. Mirgule[3], A. Saxena[3], and S. Kailas[3]

1 Department of Physics, Faculty of Science, The M.S. University of Baroda, Vadodara, India
2 Physics Department, Degree (First Shift), Parul Institute of Engineering & Technology, Limda, Waghodia, Vadodara – 391 760, India.
3 Nuclear Physics Division, B.A.R.C. Mumbai-400085. India.

The study of energy dependence of the optical potential (OP) of the elastic scattering of tightly bound nuclei, at near barrier energies is a topic of great interest. This energy dependence is produced by polarization potentials originated from the coupling between the elastic scattering and different reaction mechanisms, such as inelastic excitation, transfer of nucleons or clusters of nucleons, breakup, etc. These mechanisms may produce polarizations of different signs, attractive or repulsive. For systems containing only tightly bound nuclei, couplings to bound excited states or transfer channels produce an attractive polarization potential. This additional attraction of the real potential decreases the Coulomb barrier, consequently enhancing the fusion cross section, when compared with no-coupling calculations. The basic characterization of the energy dependence is the observation of a localized peak in the real part of the potential accompanying a sharp decrease of the imaginary part as the bombarding energy decreases towards the Coulomb barrier. This behavior has been named as "Threshold Anomaly" (TA) [1 – 2]. The behavior of the imaginary part of the potential is related with the closing of reaction channels when the energy approaches or is smaller than the Coulomb barrier.

When at least one of the colliding nuclei is weakly bound, the situation changes because the break-up channel may become important and this channel has excitation function that does not drop sharply at energies below the Coulomb barrier. Recently, the TA has been looked for in elastic scattering of weakly bound stable and radioactive nuclei [3,4]. However, a careful analysis of the data in terms of the dispersion relation reveals that, for the weakly bound systems, the imaginary part of the potential could increase at lower energies and, the real part of the dynamic potential would show a decrease, implying an overall decrease in the real part of the optical potential that fits the elastic scattering. This so called break-up threshold anomaly (BTA) was recently observed in a number of weakly bound systems [5]. The objective of the present work is to study this phenomenon of BTA in terms of dispersion relation analysis. The experimental data has been taken from our recent work [5,6].

The mathematical connection between the energy dependent real and imaginary parts of the optical potential U(E) = V (E) + iW(E) is the dispersion relation which is given elsewhere [7,8]. The fitting procedure of the experimental elastic scattering angular distribution is given in detail in one of our earlier papers [5]. The present analysis suggests the absence of the threshold anomaly (TA) in ^{6}Li + ^{116}Sn system due to the almost energy independence of the real part of the optical potential. The existence of non – zero imaginary potential even below the Coulomb barrier implies the existence of open reaction channel in this energy region. This result is in agreement with those obtained for the scattering of ^{6}Li by heavier and lighter targets, and it show a clear behavior typical of the breakup threshold anomaly (BTA). We explain these behaviors by the fact that the scattering of weakly bound nuclei are affected by the repulsive polarization potential produced by the breakup process, important even at energies below the Coulomb barrier. However, for ^{7}Li + ^{116}Sn scattering the energy dependence behavior of the imaginary potential seems to differ from those in the literature for several other systems involving ^{7}Li as a projectile. In this case there is a strong competition between this repulsive polarization potential and the attractive polarization potential produced by the bound ^{7}Li excited state and transfer reactions. These two components of the real polarization potential may have similar strengths and the net result could give rise to an almost energy independent real part. And the non – zero imaginary part at the sub – barrier energies might have resulted due to the dominant breakup channel similar to ^{6}Li.

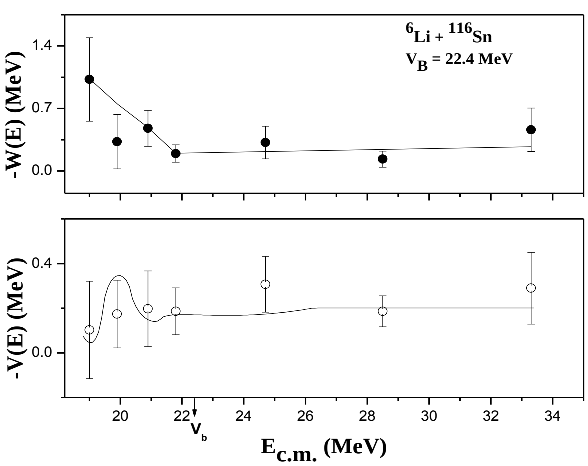

Fig. 1 Values of the imaginary and real parts of the optical potential at the average sensitive radius, equal to 9.40 fm, for the system ^{6}Li + ^{116}Sn. The solid line corresponds to the dispersion relation calculations.

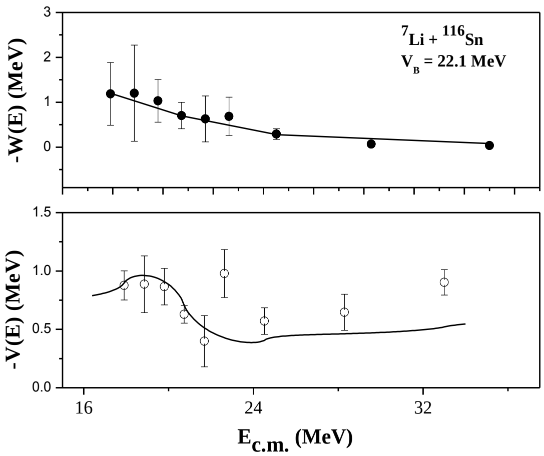

Fig. 2 Values of the imaginary and real parts of the optical potential at the average sensitive radius, equal to 9.685 fm, for the system ^{7}Li + ^{116}Sn. The solid line corresponds to the dispersion relation calculations.

References

1. M.E. Brandan and G.R. Satchler, Phys. Rep. **285,** 143 (1997).
2. G.R. Satchler, Phys. Rep. **199,** 147 (1991).
3. C. Signorini, Eur. Phys. J. A **13**, 129 (2002).
4. N. Keeley et al., Nucl. Phys. A **571**, 326 (1994).
5. N.N. Deshmukh *et al.,* Phys. Rev. C **83,** 024607 (2011).
6. N.N. Deshmukh et al., Eur. Phys. Journ. (2011). In Press.
7. C. Mahaux, H. Ngô, and G. R. Satchler, Nucl. Phys. A **449**, 354 (1986).
8. G. R. Satchler, Nucl. Phys. A **472**, 591 (1987).