Optical model analysis of elastic scattering angular distributions for the $^{6}Li+^{159}Tb$ reaction

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The interaction potential between two nuclei is the key to any nuclear reaction model calculation. The interaction potential is obtained by fitting the experimentally measured elastic scattering angular distribution at a particular bombarding energy.

The elastic scattering angular distribution for the $^{6}Li+^{159}Tb$ reaction in the range $30^{o}\leq\theta_{lab}\leq165^{o}$, for each of the bombarding energies 35, 30, 27, 25 and 23 MeV have been measured using the 14UD BARC-TIFR Pelletron Accelerator at TIFR, Mumbai. We mention here that the ^{159}Tb being a well deformed nucleus, has closely-spaced low-lying excited states (58 keV, 137.5 kev, 241.1 keV *etc.*). This makes the elastic peak in the spectra inseparable from the inelastic peaks. Therefore, for this reaction we could essentially measure quasi-elastic events (*i.e.*, elastic events with an admixture from some of the inelastic events). The experimental details and measurements have already been presented in a previous DAE Symposium [1]. In this work we present the optical model analysis of the data.

To obtain the interaction potential which is key to any nuclear reaction model, we started with the phenomenological optical model potential considering the volume real (V_o, r_o, a), volume imaginary (W_v, r_v, a_v), and surface imaginary (W_s, r_s, a_s) terms, each of Woods-Saxon form along with the Coulomb term. The theoretical analysis of the measured quasi-elastic scattering angular distribution was done with the coupled channels code ECIS94 [2]. The volume imaginary potential with the parameters set at W_v=30.0 MeV, r_s=1.0 *fm*, and a_s=0.40 *fm*, was kept fixed for all the bombarding energies. The radius and diffuseness parameters of the volume real and the surface imaginary potential for the highest energy 35 MeV were varied and fixed at r_o=1.19 *fm*, a=0.63 *fm* and r_s=1.18 *fm*, a_s= 0.6 *fm*. then keeping these geometrical parameters fixed at these values, depths of the volume real (V_o) and the surface imaginary (W_s) potentials were varied for each of the bombarding energies. The best fit parameters of the phenomenological optical model potential thus obtained are shown in Table 1 along with the chi-squared values and reaction cross sections.

Table 1:

E_{lab} (MeV)	V_o (MeV)	W_s (MeV)	χ^2/N	σ_R (mb)
35	28.7	7.71	1.46	1125
30	22.54	4.84	5.9	588
27	28.22	8.0	0.52	414
25	32.77	7.29	1.32	146
23	56.09	1.63	0.83	23.2

The corresponding fits to the quasi-elastic scattering angular distribution is shown in Fig. 1.

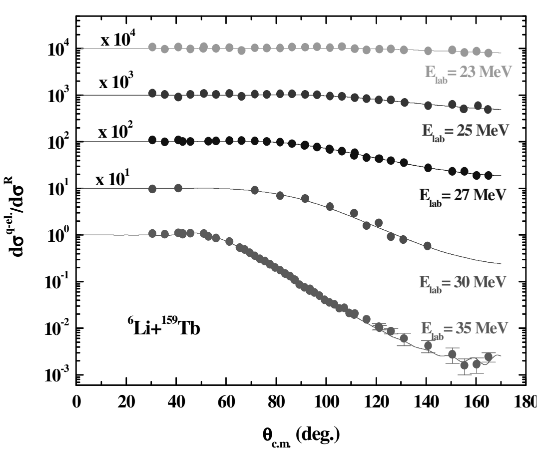

Fig. 1. Measured quasi-elastic scattering angular distribution at five bombarding energies for the $^{6}Li+^{159}Tb$ reaction. The error bars indicate statistical

errors only. The solid lines are the results obtained with the phenomenological optical model potential.

Since in the analysis with the phenomenological potential, we have fitted the calculated elastic scattering cross sections to the measured quasi-elastic scattering cross sections, the parameters obtained are not realistic. For this reason, we attempted the calculations with the Global optical model potential of J. Cook [3] which is taken to be the sum of the volume real (V_o, r_o, a) and the volume imaginary (W_v, r_v, a_v) nuclear potentials of Woods-Saxon form and a Coulomb term.

Using the global optical model potential parametrs for ^{6}Li, Distorted Wave Born Approximation (DWBA) calculations were done by including only the first and second excited states with deformation parameters β_2=0.344 [4] and β_4=0.062 [5] of ^{159}Tb. We started with the angular distribution data for 35 MeV. For the quasi-elastic angular distribution of 35 MeV, *a* was changed keeping other parameters of the global optical model potential fixed. It was found that for *a* = 0.861 *fm*, sum of the cross sections of elastic and first two lowest excited states nearly matches with the measured $d\sigma^{q\text{-}el.}/d\sigma^R$.

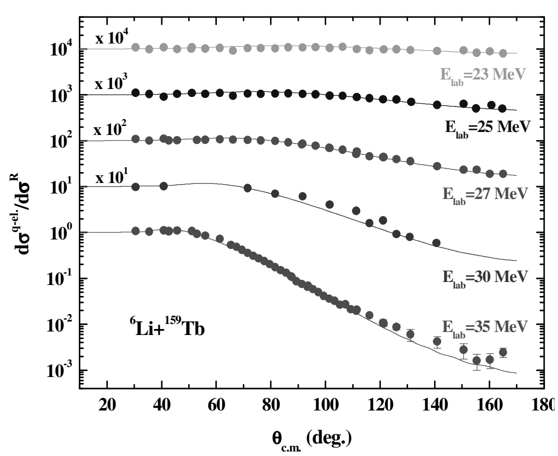

Fig. 2. Measured quasi-elastic scattering angular distribution at five bombarding energies for the ^{6}Li+^{159}Tb reaction. The curves are the sum of elastic, first eccited state and second excited inelastic scattering cross sections obtained with the global optical model potential.

Now with this changed value of *a*=0.861 *fm*, for the angular distributions at other energies (30, 27, 25, and 23 MeV), W_v is changed such that the sum of the cross sections of the elastic and the first two excited states matches with the measured $d\sigma^{q\text{-}el.}/d\sigma^R$ data, as shown in Fig. 2. The values of W_v thus obtained are 24.97, 45.00, 47.0, and 80.0 MeV for the bombarding energies 30, 27, 25 and 23 MeV respectively.

References

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