Optical model potential for ^{6}Li+^{159}Tb

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Introduction

The optical model is the premise of all model based calculations in nuclear physics [1]. Even after so many years of research in nuclear physics, the nuclear potential is still not well understood. One of the ways to obtain the nuclear potential parameter for a given system is to measure the elastic scattering angular distribution at a few energies, and then fit the data using the optical model. The elastic scattering measurements for the purpose of extracting the optical model potential parameters are mainly carried out at above-barrier energies where the elastic scattering deviates substantially from the Rutherford scattering due to the effect of strong nuclear interaction.

Elastic scattering angular distribution measurements of ^{6}Li projectile from ^{159}Tb target at energies E_{lab}=20, 23, 25, 27, 30, 35 MeV (both below and above the Coulomb barrier) had been reported earlier [2]. Owing to the fact that ^{159}Tb is an odd-A, rotational nucleus in the rare earth region, its low lying excited states are very closely spaced[3]. So the elastic scattering data for this system consists of admixture of inelastic scattering events from the low lying excited states of ^{159}Tb. The elastic scattering events may also contain inelastic contribution from first excited state of ^{6}Li, if any. Figure 1 represents a two dimensional ΔE-E spectrum for ^{6}Li+^{159}Tb reaction at θ_{lab}=65° and E_{lab}=35 MeV. Current motivation is to find a set of suitable optical model potential parameters with Wood-Saxon form factor for the system ^{6}Li+^{159}Tb.

Analysis & Calculation

In this work, we have attempted to statistically extract the elastic part from the merged data(elastic+inelastic) by means of fitting it with double Gaussian, the peaks of which represents the elastic part and first inelastic contribution.

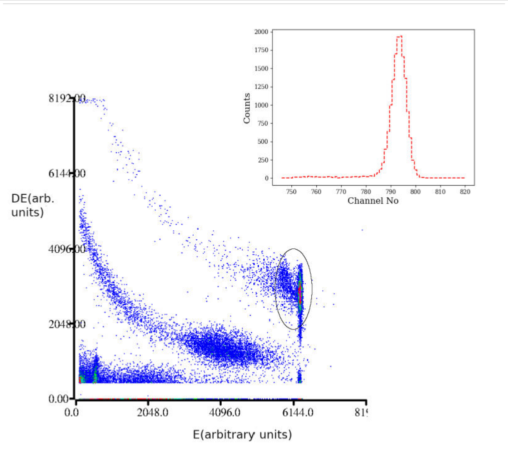

Fig.1 2D *ΔE-E* spectrum at θ_{lab}=65° and E_{lab}=35 MeV. Inset shows 1 dimensional projection of the marked area in Z=3 band

To extract the elastic scattering contribution from the (elastic + inelastic) scattering data, a double Gaussian fitting program has been attempted for E_{lab}=35 MeV data, with some constraints to keep the process physical, such as: (i) the standard deviation of elastic peak will always be less than standard deviation of inelastic peak; (ii) the position of first inelastic peak will occur at an energy difference of ~ 58 keV from the elastic peak, as the first excited state of ^{159}Tb is at 58 keV; (iii) the amplitudes of elastic part was set to be greater than inelastic part at forward angles, though at backward angles that constraint was not imposed. Energy calibration was performed using the elastic scattering data for ^{6}Li+^{197}Au taken during the experiment. It was evident from the fit results that the inelastic scattering contribution becomes important at larger scattering angles. From the extracted elastic data, angular distribution of the ratio of differential elastic scattering cross section and Rutherford scattering cross section was plotted.

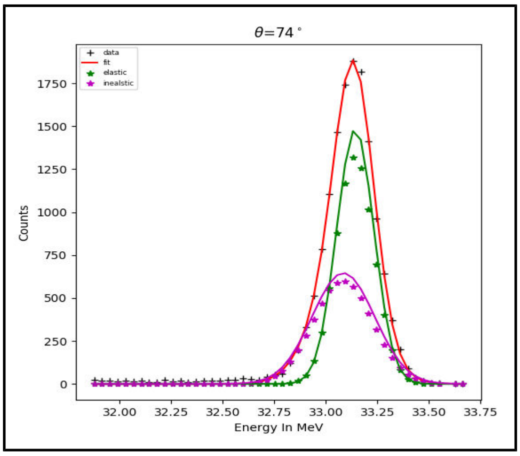

Fig.2 Fit results for 74°;green star:elastic part;magenta star:inelastic part,red line:total fit result

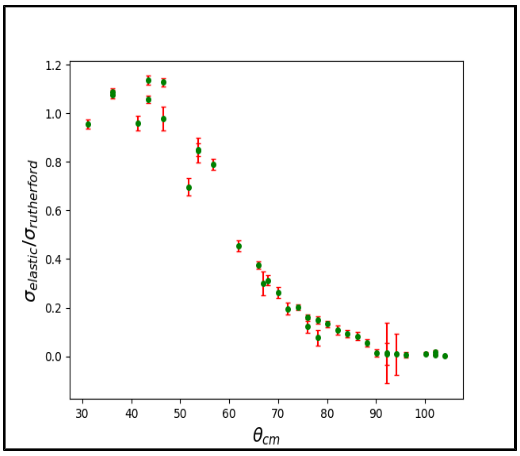

Fig.3 Angular distribution plot of $\sigma_{elastic}/\sigma_{Ruth}$

The elastic scattering cross section thus extracted at 35 MeV,were fitted with an optical model using the code SFRESCO[4] to determine the optical model potential parameters. The fitting was attempted for optical model potential of the form: $U_{opt}=(V_0+iW_0)f(r)$,where V_0 and W_0 are the real and imaginary potential depths; $f(r)$ is the radial form factor which has a Wood Saxon form:

$$f(r)=\frac{1}{1+\exp\left(\frac{r-R_i}{a_i}\right)}$$

where i=real or imaginary parts; R_i and a_i are the radii and diffuseness parameters of the two terms respectively. Only the volume terms in the potential have been considered here.

The χ^2 values for different sets of parameters were observed. Minimum value of the χ^2 resembles the best fit result, keeping that in mind the results were chosen. The results have been shown in Table 1.

Table 1: The different sets of potential parameters obtained by adjusting the diffuseness parameter, keeping the radius parameter fixed.

V_0	W_0	a_R	a_I	r_R	r_I	χ^2
104.53	90.31	0.80	0.80	1.06	1.06	5.25
41.24	41.00	0.95	0.95	1.06	1.06	4.41
72.379	65.5235	0.80	0.80	1.1	1.1	5.20
38.802	38.357	0.90	0.90	1.1	1.1	4.55
39.416	33.5453	0.75	0.75	1.2	1.2	5.44
28.461	26.9612	0.80	0.80	1.2	1.2	4.96

Further analysis is in progress. Detailed results will be presented at the conference

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