Studies on Elastic Scattering of ^{6}Li + ^{40}Ca Using BDM3Y-Paris and Wood-Saxon Potential

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Introduction

Study of elastic scattering is an important part to understand peripheral heavy ion (HI) interaction. Any nuclear interaction involves nuclear potential along with Coulomb potential and the choice of the nuclear potential reveals a wide variety of phenomenon subjected to the fitting percentage with the experimental data. Highly celebrated optical model (OM) formalism allows us to play with different kind of potentials such as Wood-Saxon (WS), Folding, Proximity etc. In Wood-Saxon formalism at least six parameters are varied in order to analyze elastic scattering data and previous experimental results have showed that WS formalism is very good phenomenological model to study nuclear collision. However, great success of WS formalism is shadowed when interaction is observed with very high energetic beam. Though, any HI interaction can be dissected by considering the aspects such as beam energy, charge, mass etc., however more satisfactory understanding is more probabilistic using nucleon-nucleon (NN) interaction potential. To construct nucleus-nucleus potential, integration is carried out over a NN potential over the whole mass distribution of colliding partners. This approach is known as folding and this method has been widely used to generate real part of the OM potential [1-3]. In this work, we have analyzed elastic cross section of the reaction ^{6}Li+^{40}Ca at energies 20 MeV, 26 MeV, 28 MeV, 30 MeV, 32 MeV and 34 MeV. Data are taken from the website archive of www.nrv.jin.ru [4-8]. Analysis is carried out employing two approaches. In the first approach, real part of the potential is generated using a double folding potential and the imaginary potential is generated using WS potential, whereas in the second approach both real and imaginary nuclear potential is taken to be WS. We obtain unique set of OM parameters from both approaches by comparing the theoretical data with experimental data.

Theoretical background

Nuclear interaction between a pair of nuclei is described by the potential consisting of Coulomb (V_C), nuclear (V_N) and centrifugal potentials which affect the interaction process leading to various elastic and non-elastic processes. The interacting potential is given as

$$V = V_C(r) + V_N(r) + \frac{h^2 l(l+1)}{4\pi^2 \mu r^2}$$

where l is the angular momentum quantum number and μ is the reduced mass of the system and r is the inter-nuclear distance. We have used the code the available at the website www.nrv.jinr.ru for analysis of elastic scattering cross sections. We used the M3Y-Paris double folding potential which has the following form [2]

$$v_{NN}(r) = \left(11062 \frac{e^{-4r}}{4r} - 2538 \frac{e^{-2.5r}}{2.5r} + F_{ex}(E)\delta(r) \right)$$

and the Wood-Saxon potential has the following formalism [3]

$$V_N(r) = \frac{-V_0}{1+\exp(\frac{r-R_{0R}}{a_R})} + i\frac{-W_0}{1+\exp(\frac{r-R_{0I}}{a_I})}$$

Result and Conclusion

A comparison between experimental data and present calculations is made and best fit parameters are listed. The energy dependence of Wood Saxon potential parameters is examined. A typical comparison is shown in Fig. 1.

In Table 1, extracted OM parameters using M3Y-Paris potential are tabulated by comparing the theoretical data with the experimental data. Correlation between normalization parameter (N_R) with incident energy (E_{lab}) is concluded in the form of an equation:

$$N_R = -0.014E_{Lab} + 1.74$$

Table 1: Extracted OM parameters using BDM3Y-Paris potential.

Energy (MeV)	N_R	W_0 (MeV)	r_{0I} (fm)	a_{0I} (fm)
20	1.45	30	1.1	0.65
26	1.36	39	1.1	0.65
28	1.35	40	1.1	0.65
30	1.30	43	1.1	0.65
32	1.28	48.1	1.1	0.65
34	1.25	50	1.1	0.65

It is observed that elastic scattering data of ^{6}Li is sensitive to the potential near the strong absorption radius ($1.3(A_P^{1/3}+A_T^{1/3})$ fm). Overlap of densities takes place because of which large angle anomalies are observed. In the first approach using BDM3Y-Paris, normalization factor decreases roughly with increase of beam energy from 20 MeV to 34 MeV. As well, imaginary depth increases from 30 MeV to 50 MeV with the increase beam energy from 20 MeV to 34 MeV. In the second approach, real depth decreases with increase of beam energy whereas imaginary depth increases gradually. Data around 30 MeV have shown anomalous angular behavior which may reveal more about the potentials at smaller distances.

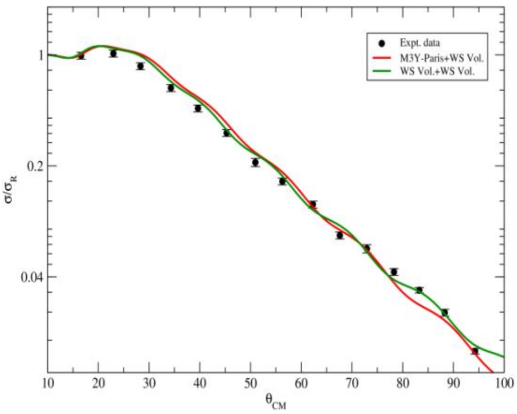

Fig. 1 The elastic scattering angular distribution of 6Li+40Ca reaction at 20 MeV using BDM3Y-Paris and WS potentials are compared with the experimental data. In the plot, black dots are experimental data points.

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