Elastic scattering of 240 MeV ^{6}Li ions from ^{40}Ca and ^{58}Ni

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Introduction

Keeping in view the limitations of the NN amplitude [1], used in our recent works [2,3], we have studied the elastic angular distribution [4] and total reaction cross section [5] for α-nucleus collision in the energy range 17-70 MeV/nucleon within the framework of the Coulomb modified Glauber model (CMGM), in which we employed a semiphenomenological parametrization for the NN amplitude that may preserve low-q behavior whereas high-q components are treated phenomenologically. The results of these analyses clearly demonstrate the need for high-q components of the NN amplitude in any realistic study of the nucleus-nucleus collision at relatively lower energies.

In recent years, Chen et al. [6] and Krishichayan et al. [7] have measured the elastic and inelastic angular distributions for 240 MeV ^{6}Li ions from a number of target nuclei and investigated double folding calculations using several NN interactions. The authors [6,7] obtained the B(EL) values in agreement with the e.m. results for low-lying states. Their results have also shown a general agreement with giant resonance distribution obtained with α particles.

Keeping in view the increasing interest in ^{6}Li scattering, we, in this work, consider the analysis of 240 MeV ^{6}Li elastic scattering on ^{40}Ca and ^{58}Ni within the framework of CMGM. Our aim is to see how far the phenomenological treatment of the high-q components of the NN amplitude helps in accounting the data, and what could be said about the behavior of the NN amplitude at a given incident energy/nucleon for different systems involved in the collision process.

Formulation

According to the correlation expansion for the Glauber amplitude [5], the elastic S-matrix element S_{00} for nucleus-nucleus collision is written as:

$$S_{00}(\vec{b}) = (1-\Gamma_{00})^{AB} + \text{ Correlation terms}, \quad (1)$$

$$\Gamma_{00}(\vec{b}) = \frac{1}{ik}\int J_0(qb)F_A(\vec{q})F_B(\vec{q})\,f_{NN}(\vec{q})qdq\,, \quad (2)$$

where k is the incident nucleon momentum, A(B) is the target(projectile) mass number, **b** the impact parameter, $F_B(\mathbf{q})$ and $F_A(\mathbf{q})$ are the intrinsic form factors of the projectile and target nuclei, respectively, and $f_{NN}(\mathbf{q})$ is the NN scattering amplitude. The elastic scattering amplitude for the nucleus-nucleus collision takes the form:

$$F_{el}(\vec{q}) = \frac{iK}{2\pi}\int e^{i\vec{q}.\vec{b}}[1 - S_{00}(\vec{b})]d^2b\,, \quad (3)$$

where K is the c.m. momentum of the system. Equation (3) has, however, been modified to account for the Coulomb effects and the deviation in the straight line trajectory of the Glauber model due to Coulomb field [8]. Moreover, we have considered only the first term in eq. (1), because the correlation terms are found to be insignificant [9] in the energy range considered in this work.

With these considerations, the elastic angular distribution for the nucleus-nucleus collision is given by:

$$\frac{d\sigma}{d\Omega} = \left|F_{el}(\vec{q})\right|^2.$$

Results and discussion

Following the approach outlined above, we have analyzed the elastic scattering of ^{6}Li from ^{40}Ca and ^{58}Ni at 240 MeV. The inputs needed in the calculation are the nuclear form factors for the colliding nuclei and the NN amplitude.

For computational simplicity, the required nuclear form factors are parametrized in the same form as in ref. [2], in which the values of the parameters are obtained by fitting the electron scattering form factors after correcting for the finite size of the proton. The NN amplitude is parametrized as follows:

$$f_{NN}(\vec{q}) = \frac{ik\sigma}{4\pi}(1-i\rho)e^{-\frac{1}{2}(\beta+i\gamma)q^2}[1+T(\vec{q})], \qquad (4)$$

$$T(\vec{q}) = \sum_{n=1,2,3.....} \lambda_n q^{2(n+1)} \;, \qquad (5)$$

where σ is the NN total cross section, ρ is the ratio of the real to the imaginary parts of the forward NN amplitude, β is the slope parameter, γ is the phase variation parameter, and the parameters λ_n take care of the higher momentum transfer components of the NN amplitude. The values of σ and ρ at the desired energy(40.0 MeV) are obtained using the parametrizations given in ref. [5], and the value of β is taken from [4].

In the first part, we take the same values of the parameters of the NN amplitude as obtained in ref. [4]; the calculation involves the variation in the phase(γ) of the NN amplitude only. The results of such calculation are presented by dotted lines in fig. 1. The values of γ are reported in the figure itself. For comparison, we have also plotted the angular distribution without the λ terms in the NN amplitude(dashed lines). From these results, we find that though they demonstrate the need of the high-q components of the NN amplitude, but we notice large disagreement between theory and experiment at relatively large scattering angles.

In order to see if the situation could be improved, we repeat the calculation in which we have considered the free variation of the parameters, λ_n, of the NN amplitude. Here we find that only λ_1 term in eq. (5) is sufficient to provide a satisfactory account of the data up to fairly large scattering angles, shown in fig. 1 by solid lines. Moreover, we find that the parameters(λ_{pp} = 0.820 fm^4, λ_{pn} = 0.125 fm^4) of the NN amplitude are fairly stable for nuclei under consideration; however the phase of the NN amplitude is found to be different for different target nuclei. Finally, it may be mentioned that if we compare the pp and pn angular distributions at 40 MeV(not shown) obtained from the NN amplitudes parameters as reported in ref. [4] and obtained in this work, the results show significant deviations at large q-values It seems that the different overlap regions of the colliding nuclei, which result due to different projectiles at a given incident energy/nucleon, may influence the NN amplitude in the nuclear medium in different ways.

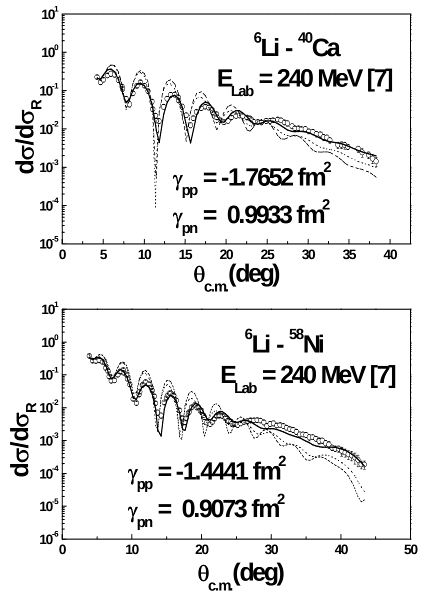

Fig. 1:^{6}Li elastic angular distribution from ^{40}Ca and ^{58}Ni.

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