α - ^{208}Pb elastic scattering at 240 and 386 MeV

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Introduction

In our recent work [1], we have analyzed the α-nucleus elastic scattering in the energy range 25-70 MeV/nucleon within the framework of the Coulomb modified Glauber model. In this work, emphasis has been put on the parametrization of the basic (input) NN amplitude that preserves the low-q behavior at the desired energy, whereas the higher momentum transfer components are treated phenomenologically. Using the realistic form factors for the colliding nuclei, it was found that the proper account of the higher momentum transfer components of the NN amplitude is able to reproduce the data satisfactorily well up to the available range of momentum transfer. Unfortunately, the α-nucleus elastic scattering data, considered in [1], do not cover large scattering angles (θ_{max} ~16°), we expect that the said data may not be a very appropriate choice to assess the importance of higher momentum transfer components of the NN amplitude, which are expected to influence the range of large scattering angles in nucleus-nucleus collision.

Keeping this in view, we, in this work, consider the analysis of α - ^{208}Pb elastic scattering at 240 and 386 MeV, in which the data extend up to relatively large scattering angles. Our aim is to see how far the phenomenological treatment of the higher momentum transfer components of the NN amplitude helps in accounting the data, and what could be said about the behavior of the NN amplitude and the use of Glauber model at relatively large scattering angles.

Formulation

According to the correlation expansion for the Glauber amplitude [2], 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. As pointed out in [1], the study of Abdulmomen and Ahmad [3] has shown that the effect of two-body correlation term may not be important in nucleus-nucleus collision in the energy range considered in this work. This suggests that the consideration of the first term in eq. (1) seems to be a good approximation to the full Glauber S matrix at energies under consideration. With this assumption, 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 [4].

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 α particles from ^{208}Pb at 240 and 386 MeV. The inputs needed in the calculation are the nuclear form factors and the NN amplitude.

For computational simplicity, we parametrize the required nuclear form factors as a sum of Gaussians [1], in which the values of the parameters are taken from refs. [5,6]. The NN amplitude is parametrized as follows:

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

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

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 energies(60 and 96.5 MeV) are obtained using the parametrizations given in ref. [6]. The values of the other parameters, namely β and $\lambda_{n,}$ at 60 MeV are taken from ref. [1]. Thus we first analyze the α - ^{208}Pb elastic angular distribution at 240 MeV, in which we vary only γ which could be possibly different for different target nuclei. The result of such calculation is shown by the solid line in Fig. 1(a), and the corresponding values of γ are mentioned in the figure itself. In the second phase, we perform calculation for α - ^{208}Pb scattering at 386 MeV, in which we vary β, $\lambda_{n,}$ and also γ. The result of such calculation is shown by the solid line in Fig. 1(b), and the corresponding values of β, $\lambda_{n,}$ and γ are reported in table 1. The results are found to be quite satisfactory in both the cases up to the available range of momentum transfer. Moreover, we notice that the values of the NN parameters at 96.5 MeV, reported in table 1, follow the trend of their values obtained in [1]. Thus our results show that the NN amplitude, as obtained in [1], seems to be fairly stable to provide a satisfactory explanation of α -nucleus elastic scattering up to relatively large scattering angles.

Table 1: NN parameters at 96.5 MeV

	NN	
σ[6] (fm^2)	pp pn	2.949 7.626
ρ[6]	pp pn	1.817 1.046
β (fm^2)	pp pn	0.912 1.634
λ_1 (fm^4)	pp pn	0.040+i0.047 0.003+i0.011

Table 1: (continued)

λ_2 (fm^6)	pp pn	0.0028-i0.051 0.0020-i0.023
γ (fm^2)	pp pn	0.7402 0.1274

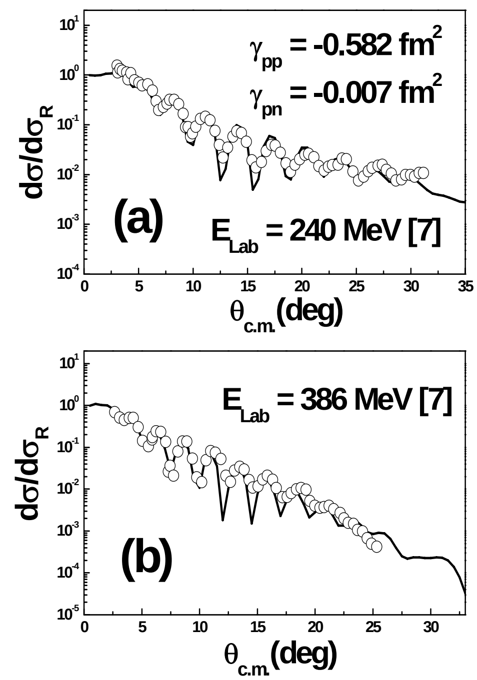

Fig. 1: α -^{208}Pb elastic angular distribution.

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