Energy dependence of α + ^{27}Al elastic scattering – a reanalysis

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At energies of a few tens of MeV α-particle elastic scattering angular distribution exhibits pronounced structure which usually varies smoothly with target mass and incident energy. The elastic scattering has been generally well described by the optical model potential in which the parameters of the potential have been found to vary smoothly with target mass (A) and bombarding energy (E_{lab}). However, there are cases of low energy α-scattering from light targets which show irregular variations with A and/or E_{lab} which may be due to compound nucleus or nuclear structure effects. This is particularly true for the targets in the s-d shell.

Here we report the α-particle elastic scattering angular distributions from ^{27}Al target at different incident energies. The α-particle elastic scattering from ^{27}Al target was studied earlier at 22.3 - 27.5 [1,2], 40 [3], 41 [4], 65 [5], 80 and 104 [6] MeV however, the energy dependence of the optical model parameters in this wide energy range was not studied yet. Kemper *et al.* [1] showed that while the data at 22.3 and 23.3 MeV favour shallow optical model potentials for description, the 24.9, 25.9 and 27.5 MeV data need very deep potentials.

The elastic scattering angular distribution had been analyzed using the optical model potential. We performed the optical model analysis using the parametric Woods-Saxon (WS) forms for both the real and imaginary potentials. The potential has the following form:

$$U(r) = V(r) + i[W_F(r) + W_D(r)] + V_C(r)$$

$$V(r) = -Vo\,[1+ \exp(r-Ro)/ao]^{-1}$$

$$W_F(r) = -Wv\,[1+ \exp(r - Rv)/av]^{-1}$$

$$W_D(r) = -Ws\,[1+ \exp(r - Rs)/as]^{-1}$$

where V(r) denotes the volume type Woods-Saxon real potential, $W_F(r)$ is a volume type Woods-Saxon imaginary potential to simulate the fusion after penetration of the barrier and $W_D(r)$ is a derivative type Woods-Saxon imaginary potential to account for the absorption due to reactions occurring at the surface and $V_C(r)$ is the Coulomb potential. The search code ECIS94 [7] was used to perform the optical model calculations to obtain the parameters of the best fit potential. The best fits are shown in Fig. 1 by solid lines.

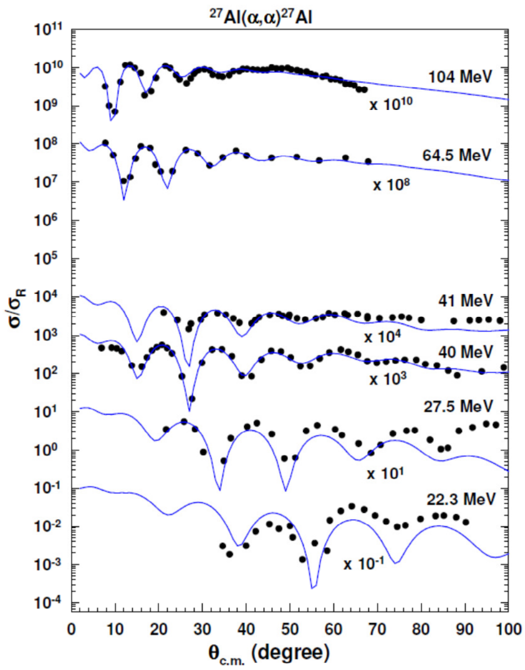

Fig. 1: Elastic scattering angular distributions at different energies along with the optical model potential fitting (solid lines).

In the present calculations we use 'small radius' parameters to obtain the best fit optical model potential parameters. It had been found that the range of radius parameters was 1.150 fm ≤ R ≤ 1.225 fm and the range of diffuseness parameters was 0.63 fm ≤ a ≤ 0.74 fm. The strength of real and imaginary parts of the optical potentials has been plotted in Fig. 2 and Fig. 3, respectively, as a function of bombarding energy. It has been found that up to 65 MeV bombarding energy, both the potential strengths have a linear relation with bombarding energy. The energy-potential strength relations are

$$V_o = (2.377E_{lab} - 323.540) \text{ MeV}$$

for the real part and

$$W_v = -(18.662 + 0.599E_{lab}) \text{ MeV}$$

for the imaginary part.

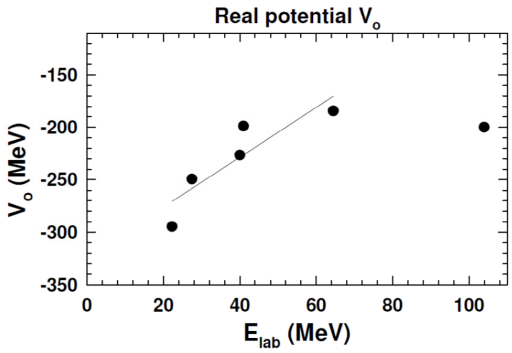

Fig. 2: Real potential parameters as a function of bombarding energy for the $^{27}Al(\alpha,\alpha)^{27}Al$ reaction.

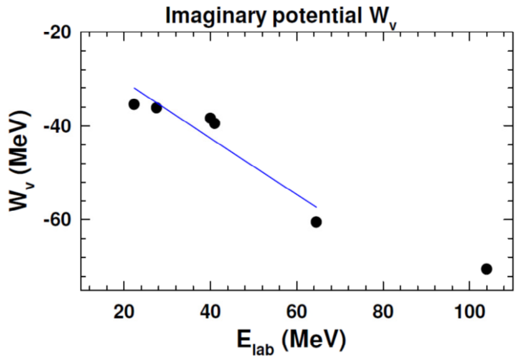

Fig. 3: Imaginary potential parameters as a function of bombarding energy for the $^{27}Al(\alpha,\alpha)^{27}Al$ reaction.

Therefore, from the present study it has been found that at lower bombarding energy the optical model potential parameters maintain a linear relationship with energy; however, the situation is not as easy as we go on with the energy. A detailed study is needed to understand the scenario.

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