# Study of the Reaction $^{27}$Al(d, d)$^{27}$Al at 5-85 MeV Energies

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## Introduction

We know that, unlike in atoms, due to fundamental limitation of the nuclear theory, the exact nature of nuclear interaction is not fully known to date. Therefore, Study of the nature of nuclear interaction potentials or optical potentials always stands as a focus point in nuclear physics research. Several experimental and theoretical studies have been performed in past decades to understand the nature of the optical potentials. Optical potentials plays important role in the study of direct reactions. Choice of optical potentials always plays important role in the calculation of spectroscopic factors to study the structure of nuclei and is responsible for the uncertainties in spectroscopic factors. Not only from spectroscopic factors points of view, the potential parameters are also found to be responsible for the uncertainties associated with reactions rates calculations. It is well known that optical model potentials are energy and mass dependent, so, in order to understand the nucleus-nucleus or nucleon-nucleus potential, a series of systematic studies are required in a broad range of nuclei at several energy. Elastic scattering data obtained from nuclear experiments are frequently used to derive the phenomenological optical potential parameters. It has been found.

Keeping above importance in mind, we planned to perform a systematic study of elastic scattering data of deuteron + $^{27}$Al reactions at several energy. Two types of optical potential (Wood-Saxon and Sao-paulo) are normally used to derive optical model potential parameters. Here, in this paper we are presenting our systematic study of 27Al(d, d)27Al reaction at 5, 7, 9.8, 11.4, 12.8, 52, 58.7, 80 and 85 MeV using double folding Sao-Paulo potential [1,2]. We have already presented a systematic study of 27Al (d, d)27Al at 11.8, 13, 15, 17 and 28 MeV using the same calculation in Ref.[3]. The present study will be very useful to know the nature of the deuteron- nucleus interaction potential in this mass region.

## Data Analysis

Experimental data of elastic scattering of deuteron beams from 27Al at beam energies 5, 7, 9.8, 11.4, 12.8, 52, 58.7, 80 and 85 MeV have been taken from [4–7]. The angular distributions of elastically scattered deuterons have been shown in Figure.1 and Figure 2 by filled circles.

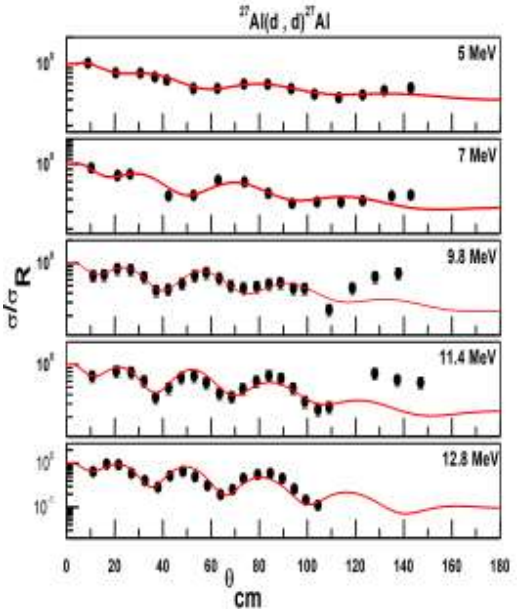


**Figure 1**

We have used S-FRESCO [8] code to calculate the theoretical elastic scattering cross sections for the said reaction using double folding Sao-Paulo potentials. A detailed description about the Sao-Paulo potential and its parameterization can be found in [1, 2]. The angular distributions of the elastic scattering data shown Figure 1 and Figure 2 have been compared with the theoretical predictions obtained from nuclear reaction code S-FRESCO by solid line using $\chi^2$ minimization

condition to extract relevant potential parameters. Energy dependence in elastic scattering angular distributions could be identified from the significant shift in peaks with increasing energy in Figure 1 and Figure 2.

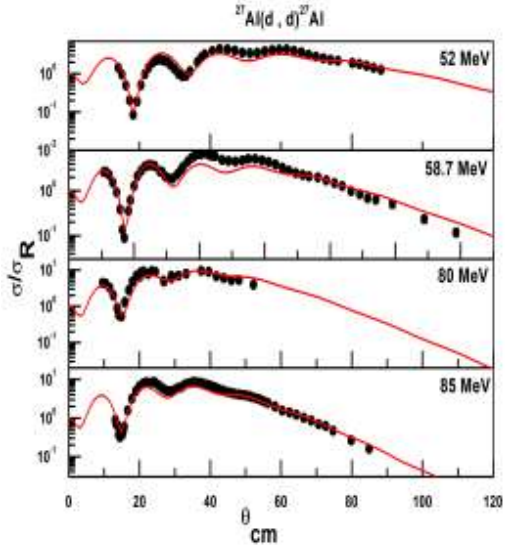


**Figure 2**

## Results and Discussions

From the present analysis, it has been found that the theoretically predicted angular distributions using Sao-Paulo potential has explained the experimental angular distributions nicely at each anergy except some data points at higher angles. We have also reproduced the elastic scattering data of 25 MeV [9] and it has been reproduced very well with using Sao-Paulo potential.

The value of $N_V$ obtained in the present analysis after fitting the elastic angular distributions for 5, 7, 9.8, 11.4, 12.8, 52, 58.7, 80 and 85 MeV energies are 1.5, 0.6642, 0.8335, 0.70714, 0.96867, 1.33075, 1.2552, and 1.3740 while the values $N_I$ are found to be 1.3577, 1.08458, 1.50, 1.50, 1.14961, 1.26233, 0.62220, 0.4875, 0.67253, and 65197. The values of $N_V$ and $N_I$ shows deviations from their standard values (for real part 1 and for imaginary part 0.78). This deviation indicates the effect of nuclear potential with increasing energies above coulomb barrier because Rutherford scattering due to coulomb potential at energies below or around coulomb barrier is not very sensitive to nuclear potential. The values of the reaction cross sections (σ) have also been extracted in this work by the fitting of the elastic angular distributions. The extracted values of σ have been found to follows a nice trained with energy and their extracted values are found to vary between 1093 mb to 1347 mb (this is range only).

In summary, we can conclude that Elastic scattering data at several energies for d + $^{27}$Al system has been fitted nicely using Sao-Paulo potential and relevant fitting parameters have been extracted. The deviations from standard values of the extracted $N_V$ and $N_I$ shows that effect of coulomb potential is continuously decreasing with increasing beam energy. Smooth variation of reaction cross sections with energy has been obtained in this work.

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