Elastic scattering of alpha particles from ^{208}Pb to determine the properties of the alpha cluster states of ^{212}Po

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Introduction

The alpha clustering structure of light nuclei such as ^{12}C, ^{16}O, ^{18}O, ^{28}Si etc. are rather well known. However, the alpha clustering in heavy nuclei was first proposed for ^{212}Po from theoretical calculations relatively recently [1]. The first experimental evidence of this proposition was obtained from a very recent study of ^{208}Pb(^{18}O,^{14}C) alpha transfer measurements [2]. It is also a well known method to investigate spectroscopic properties of states from measurements of elastic scattering phase-shifts and angular distributions. For example, the alpha cluster states in ^{16}O have been studied from ^{12}C(α,α') elastic scattering at low energies [3]. In this work we study the α+^{208}Pb elastic scattering to study the alpha spectroscopic properties of the cluster states of ^{212}Po and also obtain a α+^{208}Pb potential to describe both elastic scattering and the predict the alpha cluster states and their properties in ^{212}Po. This two body cluster core picture is appropriate as both the components are closed shell nuclei. The measurements are performed at higher energy and analyzed in terms of the microscopic folding model for elastic scattering.

Experiment

The experiment was carried out at the K130 VECC Cyclotron facility, Kolkata using the alpha beam at energies 40, 43, 46, 49 and 52 MeV. A 900 μg/cm^2 self supporting target was used whose thickness was determined from alpha particle energy loss from a Thorium alpha source and also from Rutherford scattering of the beam. The 0.9m scattering chamber at the Channel-II beamline was used to make the intended measurements. Three Si ΔE-E telescopes were setup to measure the angular distributions. The average beam current in the experiment was 15-20 nA.

Results and discussions

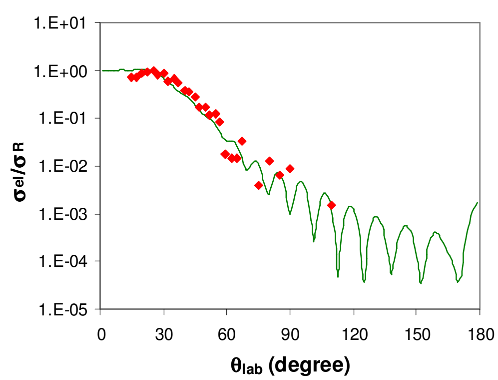

Fig. 1 The comparison of the experimental angular distribution (measured in this work) with the double folding model calculations using the DDM3Y nucleon-nucleon interaction. Shown by green line is the calculation with Reid potential.

In fig.1 we show the measured angular distribution (red points) for the ratio of the elastic to Rutherford cross-section at E_α=40 MeV. The double folding model calculation using a DDM3Y potential is shown by a solid line. The neutron and proton densities for the alpha and Pb nucleus are assumed to be a Fermi function. The M3Y Reid and Paris potentials [4,5] (figure2) are both used to see the prediction of the data. Once α+^{208}Pb potential is obtained by fitting the data with the calculation the properties of the alpha cluster states can be calculated using this potential in the framework of the WKB model. We have also examined the role of the imaginary potential in this calculation. This is because the imaginary potential in our case is a phenomenological potential. In figure 3 we show the dependence of the calculation on the shape and strength of W by keeping the real potential fixed. The shape (and strength) of W is also varied once with a Saxon Wood (SW) shape and the other with a squared Saxon Wood (SW^2) as given below.

$$SW^2(r) = \frac{W_0}{\{1+\exp(r-R_0/a\}^2}$$

The SW^2 potential has been used successfully in the prediction of α-cluster states [5] and in the prediction of ALAS phenomena for light nuclei. However, it is seen that the backward angle data is very sensitive to the value of W. The measurement of extreme backward angle data would therefore be necessary to confirm the value of the imaginary potential. The backward angle data would be also useful to investigate any Anomalous Back Angle Scattering (ALAS) in this nucleus and as observed in the alpha scattering of lighter nuclei.

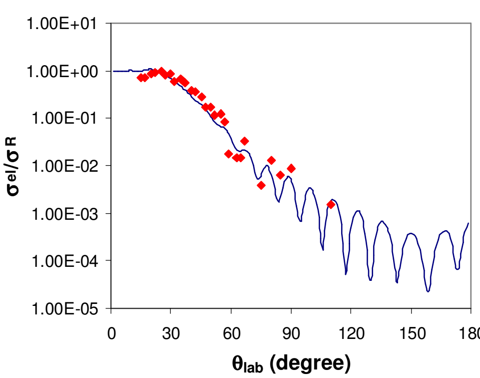

Fig. 2 Same as fig.1 except shown by the blue line calculations with the Paris potential

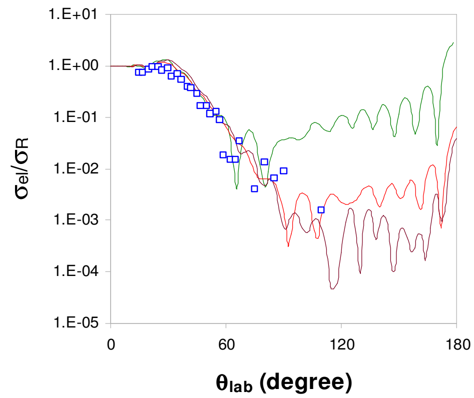

Fig. 3 The sensitivity of the elastic scattering angular distribution to the imaginary part of the optical potential. The brown and green lines show calculations with a SW potential of strength 30 and 10 MeV respectively. The red lines are for a SW^2 potential with strength 30 MeV.

Summary and Conclusions

We have measured the elastic scattering angular distributions for the α+^{209}Pb system at energies where data are not available. A microscopic potential is used for the analysis. The backward angle calculations are very sensitive to the strength and shape of the imaginary part of the nuclear potential. WKB calculations are being pursued to calculate the cluster states. Backward angle measurements are being planned.

References

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