Dipole polarizability of ^{9}Be

S. K. Pandit[1],* K. Mahata[1], S. Santra[1], A. Chatterjee[1],
K. Ramachandran[1], C. Palshetkar[1], V. Jha[1], V. V. Parkar[2],
P. Patale[1], B. J. Roy[1], H. Kumawat[1], and S. Kailas[1]
[1]*Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai - 400085, INDIA and*
[2]*Deptartment of Nuclear and Atomic Physics,*
Tata Institute of Fundamental Research, Mumbai - 400005, INDIA

Introduction

It is well known that weakly bound nuclei like ^{6,7}Li, ^{9}Be have cluster like structure [1, 2]. In the presence of a strong Coulomb field, due to the cluster structure the charge centre and mass centres of the nucleus does not coincide. This gives rise to a induced dipole moment. This induced dipole moment leads to a polarization potential [3], which in the adiabatic limit is given by

$$V_{pol} = -\frac{1}{2}\alpha_0 \frac{Z_T^2 e^2}{r^4} \qquad (1)$$

where α_0 is the dipole polarizability, $Z_T e$ is the charge of the target nucleus, and r is the separation between the centre of masses of projectile and target. The elastic scattering is influenced by this dipole potential at well below the Coulomb barrier. So measuring the deviation of elastic scattering cross-section from Rutherford cross-section we can extract the dipole polarizability.

The polarizability of the projectile is related to the dipole distribution B(E1) [3]. For stable projectiles, the dipole strength is usually located at fairly high excitation energies and hence coupling of the ground state to dipole states is not significant. However in view of the low break-up threshold for the weakly bound projectiles, substantial dipole strength could be energetically possible at the lower excitation energies. The dipole polarizability of ^{7}Li has been measured [3]. Theoretical calculation [4] predicted that the dipole polarizability of ^{9}Be can be fairly large (0.3 fm^3), which is an order of higher magnitude than that for ^{7}Li. In order to extract dipole polarizability of ^{9}Be we have measured the elastic scattering cross-section of ^{9}Be+^{208}Pb system in the energy range 24-36 MeV with high precision (statistical uncertainty $< 0.5\%$).

Experimental Details

The experiment was carried out using 14UD BARC-TIFR Pelletron facility. We have measured elastic scattering yield for ^{9}Be+^{208}Pb system at $\pm 40^o$ (forward) and $\pm 160^o$ (backward) angles. For this measurement we used four Silicon surface barrier ΔE (17-35μm)-E (300 -1000μm) telescopes. Two pairs of identical telescopes were placed symmetrically to the left and right of the incident beam at $\pm 40^o$ and $\pm 160^o$ as shown in FIG. 1. The target was enriched ^{208}Pb (>98%) of thickness 200 μg/cm^2 supported by ^{12}C layer of thickness 35 μg/cm^2.

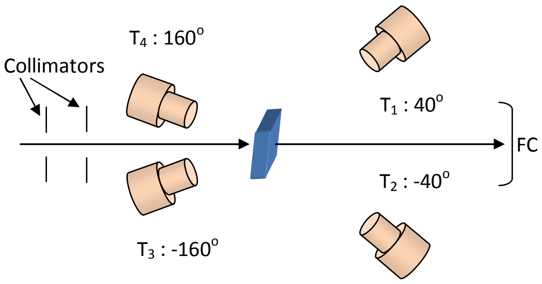

FIG. 1: Schematic of experimental set-up

Data analysis

To calculate the deviation of elastic data from Rutherford scattering at backward angle as a function of energy we define the ratio

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*Electronic address: `sanat@barc.gov.in`

R(E) [5] as

$$R(E) = \frac{\sqrt{Y_3(E) * Y_4(E)}}{\sqrt{Y_1(E) * Y_2(E)}} / \frac{\sqrt{Y_3(E_0) * Y_4(E_0)}}{\sqrt{Y_1(E_0) * Y_2(E_0)}}$$

where Y_1(E), Y_2(E), Y_3(E), Y_4(E) are measured yields by the respective telescope with beam energy E. E_0=24 MeV which is the lowest beam energy and much below the Coulomb barrier (∼ 38.9 MeV). So E_0 is considered here as reference energy. The effect due to beam wandering is minimized by taking the geometrical mean of the yields of the two forward (T_1,T_2) and two backward (T_3,T_4) detectors respectively. The uncertainties due to the target thickness and beam current are eliminated by taking the ratio of the geometric mean of the backward to forward yields. The solid angle uncertainties are eliminated by normalizing these ratios to that of the lowest energy (see the equation above). The total error (fitting and statistical error) on the data points for R(E) was less than 1%.

We have done continuum discretized coupled channel (CDCC) calculations using the FRESCO code. The results are shown in FIG. 2. The dashed line is the calculated ratio of elastic scattering cross section to Rutherford scattering, taking into account Coulomb scattering only. We know that ^{9}Be nuclei has a cluster structure with ^{5}He as core and ^{4}He as valence [1, 4, 6]. Therefore we have to use the folding potential as interacting potential between ^{9}Be and ^{208}Pb, where the interactions between ^{4}He and ^{208}Pb, ^{5}He and ^{208}Pb, ^{5}He and ^{4}He have to be considered simultaneously. To get the exact folding potential we have fitted the higher energy (46-75 MeV) elastic scattering data measured by R. J. Woolliscroft et al. [6]. The energy-dependence of the folding potential studied at higher enegy, and extrapolated potential at lower energy was used in our calculation. The dot-dashed line represents the calculated R(E) using the folding potential and elastic channel coupled with ^{9}Be ($5/2^-$, 2.43 MeV) inelastic state. Then we take into account the continuum break up state of ^{9}Be. The continuous line represents the CDCC calculation including both ^{9}Be ($5/2^-$, 2.43 MeV) inelastic state and continuum break-up state. The present preliminary calculations indicate a fairly large value ($\alpha_0 \sim 0.6 fm^3$) for the dipole polarizability of ^{9}Be.

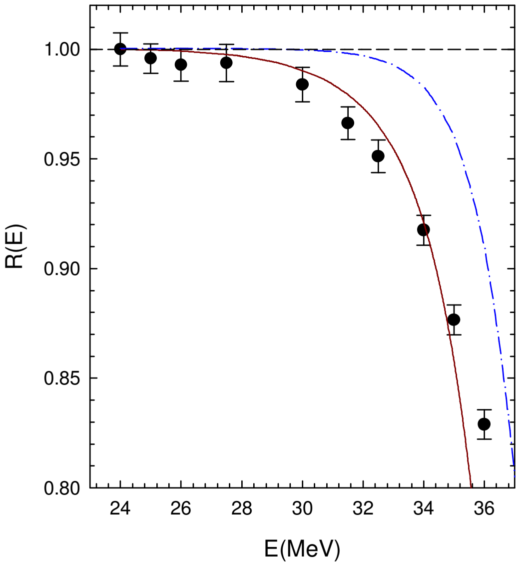

FIG. 2: The measured ratio, R(E) as defined in the text. The dashed line represents the calculation taking into account Rutherfor scattering only. The dot-dashed line represents the CDCC calculation coupled with ^{9}Be ($5/2^-$, 2.43 MeV) inelastic state. The continuous line represents the CDCC calculation including both ^{9}Be ($5/2^-$, 2.43 MeV) inelastic state and continuum break-up state.

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