Reaction and inclusive-α cross sections with weakly bound ^{9}Be projectile

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Introduction

In recent times, the reaction mechanisms involving weakly bound projectiles (WBP) have received much attention due to the recent availability of radioactive ion beams. In particular, for ^{9}Be projectile, study related to nucleosynthesis of ^{12}C via ^{9}Be(α,n)^{12}C reaction is important. In addition, ^{9}Be has 3-body cluster structure with Borromean nature. The breakup thresholds for ^{9}Be $\rightarrow$ ^{8}Be+n $\rightarrow$ α+α+n and ^{9}Be $\rightarrow$ ^{5}He+α are 1.67 MeV and 2.47 MeV, respectively.

There can be many reaction channels that can contribute to large α-yield *e.g.* incomplete fusion, breakup or transfer breakup etc. [3]. In this respect, there are very few measurements of inclusive α cross sections with ^{9}Be projectile, that forms a major part of the reaction cross-section.[2]

In the present study, we have measured elastic scattering angular distributions to extract the reaction cross-sections and α angular distributions to get inclusive α cross sections with ^{9}Be projectile for various targets. We have performed a systematic study of the present results with the data available in the literature.

Experimental Details

The experiment was performed using ^{9}Be beam at E_{beam}=35.8 MeV from Pelletron-Linac Facility at TIFR, Mumbai, India. Self-supporting targets of ^{209}Bi ($\sim$ 0.5 mg/cm^2), ^{198}Pt ($\sim$ 1.45 mg/cm^2), ^{159}Tb ($\sim$ 1.7 mg/cm^2) and ^{124}Sn ($\sim$ 1.74 mg/cm^2) were used. Three silicon surface barrier (SSB) detectors, three hybrid detectors, seven Si-strip detectors in the ΔE-E telescopic arrangement were mounted inside a 1.5 m diameter scattering chamber. Thickness of ΔE and E detectors were $\backsim$ 25-45 µm and 1-5 mm, respectively for the SSB detectors. The ΔE and E strip detectors were double-sided with 16 strips in front and 16 strips in back sides. Typical thicknesses of ΔE and E detectors were $\backsim$ 20-50 µm and 1-1.5 mm, respectively. The active area and width of each strip of the segmented detectors were 50 x 50 mm^2 and 3.1 mm, respectively. Two Si surface-barrier detectors (thickness $\sim$ 300 µm) were kept at $\pm$20° for absolute normalization and beam monitoring.

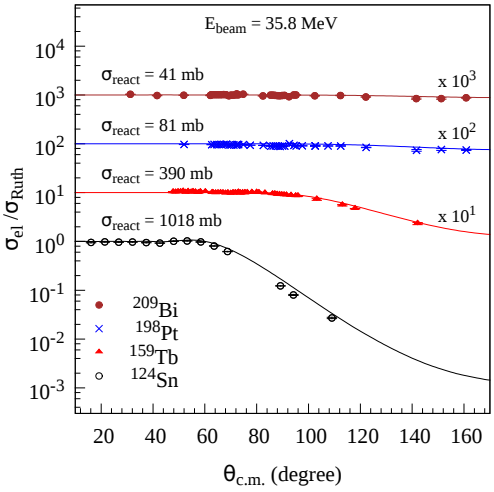

FIG. 1: Elastic scattering angular distributions for different targets with ^{9}Be projectile at E_{beam} = 35.8 MeV. The solid lines are the optical model calculations. The obtained reaction cross sections are also indicated.

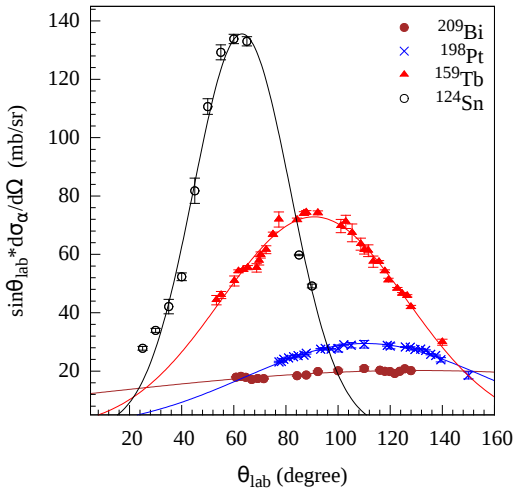

FIG. 2: Inclusive α angular distribution for different targets with ^{9}Be projectile at E$_{beam}$ = 35.8 MeV.

The angular range covered with the detector setup was from 16° to 160°, that covered the grazing angles for all the targets except for ^{209}Bi. The Coulomb barrier for ^{124}Sn, ^{159}Tb, ^{198}Pt and ^{209}Bi are 26.2 MeV, 32.8 MeV, 37.9 MeV, and 40.1 MeV respectively. The data were collected in an event by event mode, with the trigger generated from E detectors. The data was acquired in VME based data acquisition system using LAMPS software [4].

Results and Conclusions

The experimental cross sections, plotted as a ratio of the elastic (σ_{el}) to the Rutherford (σ_{Ruth}) cross section as a function of the scattering angle of the ^{9}Be ejectile, for different targets at E$_{beam}$=35.8 MeV are shown along with the optical model calculations in Fig. 1. Optical model calculations were performed using the code FRESCO [6] for which the Global optical model potential parameters for ^{9}Be were available in literature [5]. The calculated values explains the data very well. The obtained reaction cross sections are also indicated in the Fig. 1. Similarly, angular distributions of inclusive α particles were also plotted for various targets are shown in Fig. 2. The errors on the experimental data points are statistical only. These angular distributions have been fitted with Gaussian distribution and angle integrated inclusive α cross sections were obtained. From Figs. 1 and 2 it can be seen that the reaction cross section is decreasing and the grazing angle for inclusive α angular distribution is shifting towards the backward angles with atomic number of the target, as expected due to change in the Coulomb barrier. For the systematic study the obtained integrated inclusive α cross sections were compared with the literature and were found to follow a universal trend as with the data available in earlier work [1].

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