Inclusive breakup α cross sections in the elastic scattering of $^{9}Be+^{89}Y$

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1. Introduction

Breakup of the weakly bound projectiles in the field of the target has important consequences on different reaction channels. In particular, from the optical model analysis carried out for the elastic scattering involving weakly bound stable ^{6,7}Li and ^{9}Be nuclei, the variation of the optical potential parameters as a function of the projectile energy has been found to exhibit a different behavior compared to a similar analysis carried out for systems involving tightly bound projectiles [1]. The weakly bound nuclei exhibit the breakup threshold anomaly (BTA) in which the imaginary potential, even at below barrier energies, has a considerable strength which has been understood to be due to the persistence of the breakup channel at these energies. To investigate this for the elastic scattering of the weakly bound projectile ^{9}Be with a medium mass target, we had studied the elastic scattering for the ^{9}Be+^{89}Y system [2]. For this system the presence of the BTA was observed from the optical model calculations. To further confirm this result the inclusive breakup α cross sections have been estimated from the data and have been compared with the reaction cross sections obtained from the optical model for the system.

2. Experimental Details and Analysis

The experimental details of the elastic scattering for the system have been described in [2]. Fig. 1 shows a typical spectrum acquired at ^{9}Be beam energy of 29 MeV at an angle of 75 degrees in lab. Also shown in the figure is the x-projection of the α band. The α peak position has been found to be at 4/9 of the ^{9}Be beam energy which confirms that the α in the spectrum are coming from the breakup of the projectile. The positions of the minimum and maximum α energies represented by the vertical lines have been found out from kinematics using the following relation:

$$E_{\max,\min} = E_b\left(\frac{m_1}{M}\right)\left[1+\frac{E_x}{E_b}\frac{m_2}{m_1} \pm 2\sqrt{\frac{E_x}{E_b}\frac{m_2}{m_1}}\right]$$

where E_b is the projectile beam energy, m_1 is the mass of α particle, m_2 is the mass of ^{5}He, and M is the total mass of the target-projectile system. E_x is the energy of the excited state of ^{9}Be taken to be 2.43 MeV in the calculations.

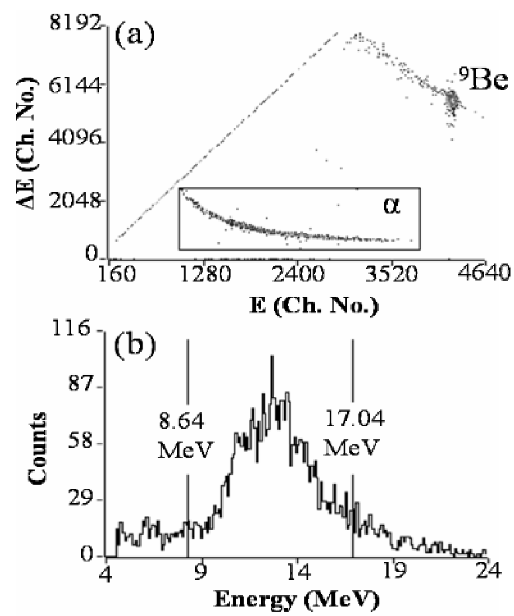

Fig. 1 (a) Typical spectrum obtained in the elastic scattering of ^{9}Be+^{89}Y at beam energy of 29 MeV at angle 75° in lab. (b) X-projection of the α band shown by the rectangle in (a). Also shown in this figure are the minimum and maximum α energies, positions of which are indicated by vertical lines, as found from kinematics.

The alpha yields at all angles have been estimated by using these values of E_{min} and E_{max}. The differential inclusive alpha cross sections were obtained using the formula:

$$\left(\frac{d\sigma}{d\Omega}\right)_{\alpha\ incl} = \left(\frac{Y_\alpha}{Y_{el}}\right)\left(\frac{\sigma_{el}}{\sigma_{Ruth}}\right)\sigma_{Ruth}$$

Fig. 2 shows the experimental angular distribution thus obtained for different energies. The differential cross sections at each energy were fitted by an appropriate function for performing integration in finer steps. The total inclusive breakup α cross sections at these energies were found using:

$$\sigma_{\alpha\ incl} = \int_0^{2\pi} d\phi \int_0^{\pi} \frac{d\sigma_{\alpha\ incl}(\theta)}{d\Omega} \sin(\theta) d\theta$$

where, $d\sigma_{\alpha\ incl}(\theta)/d\Omega$ was taken to be the fitted function as mentioned above.

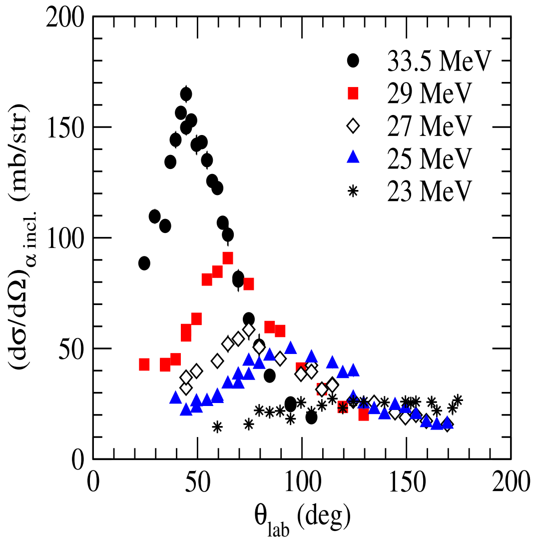

Fig. 2 Experimental differential inclusive breakup α cross sections as a function of θ_{lab} for different energies.

A comparison of these total inclusive breakup α cross sections with the reaction cross sections obtained from the optical model analysis of the elastic data and the fusion cross sections obtained from the fusion measurement [3] for the system is done as shown in Fig. 3.

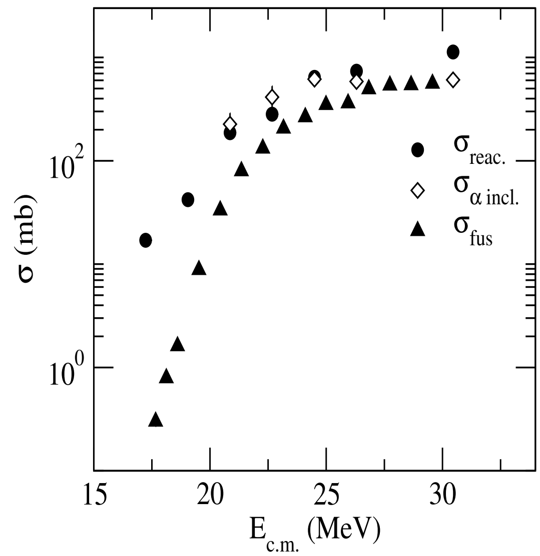

Fig. 3 Reaction cross sections (filled circles), total inclusive breakup α cross sections (unfilled diamonds) and fusion cross sections (filled triangles) as a function of the ^{9}Be projectile centre of mass energy.

3. Results

As can be seen from Fig. 3, the inclusive breakup α cross sections at the measured projectile energies constitute a major fraction of the reaction cross section. Especially at lower energies i.e. 25, 23 MeV the reaction cross section is equal to the breakup cross section within experimental uncertainties. This implies that even at these low energies, reaction channel is still present which is due to the breakup of ^{9}Be in the field of the ^{89}Y target. This gives confirmation that the presence of the imaginary part of the optical potential at below barrier energies is indeed due to the breakup channel thus confirming our observation of BTA for the system.

References

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