Complete and incomplete fusion cross-sections in ^{9}Be+^{124}Sn system and its implications in horizontal spectroscopy

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Introduction

^{6,7}Li, ^{9}Be and ^{10,11}B nuclei, having alpha cluster structure, are increasingly used as projectiles to study nuclear structure and reaction dynamics near the coulomb barrier. Absolute cross section measurements of different reaction channels for the above weakly bound projectiles with targets of medium and heavy nuclei are carried out for studying the effect of different reaction modes on complete and incomplete fusion processes. Depending upon the reaction mode, the population of angular momentum states of the residues can have a different distribution. Recently, Be and B induced reactions were used to populate yrast and non-yrast states of stable and relatively neutron rich nuclei in A$\sim$130 region [1, 2], thereby expanding the information of level structure in horizontal direction. Though the xn channels are dominant in these reactions, the αxn channels contributes substantially to the total cross section. The main motivation of the present work is to report the measured fusion cross-sections of ^{9}Be + ^{124}Sn, compare the relative yield of xn and αxn channels. The spectrum of the emitted alpha was also recorded at two different angles. Such measurement will be useful for the design of ancillary charged particle detectors along with large Clover array for study of nuclear structure of stable and neutron rich nuclei.

Experimental Details

The experiment was performed using the ^{9}Be beam at energies E_{lab} = 26 - 48 MeV in 1 MeV steps, from the 14UD BARC-TIFR Pelletron accelerator, Mumbai. The target used was ^{124}Sn of thickness $\approx$ 2.5 mg/cm^{2}, measured using the Rutherford backscattering method. Two Compton suppressed clover detectors were used, one at 125°, for absolute cross-section estimation of various reaction channels and and other at 90°, for identification of unshifted gamma lines. Along with the this, two charged particle detector telescopes and one monitor detector were placed at 65°, 160° and 30°, respectively. The monitor detector angle is chosen in such a way that even at highest bombarding energy the elastic scattering remains in the Rutherford scattering regime. The integrated beam current deposited at the beam dump after the target has also been recorded using the high precision current integrator. The data have been acquired in the particle-gamma '*OR*' condition. The coincidence between 125° clover detector and particle telescopes (TAC1, TAC2) was also recorded in ADC. We have used the FERA based data acquisition system developed for INGA campaign at BARC-TIFR accelerator facility, for handling these high count rates in the '*OR*' condition. These TAC spectra have been further utilized for putting the gates in the gamma spectra and identification of gamma lines

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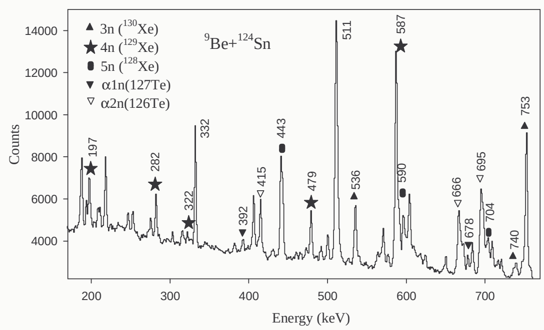

FIG. 1: Addback spectrum of the clover at 125° at E_{lab} = 40 MeV. The gamma lines from the possible evaporation residues are labeled. The gamma lines from the ICF channel (α1n and α2n) are also marked.

of the residues from incomplete fusion process.

Results and Discussion

Fig. 1 shows the typical addback spectrum from the clover at 125° at $E_{lab} = 40$ MeV. The gamma lines from the evapoartion residues (ERs) have been identified and labeled. It also shows the prominent gamma lines expected from the incomplete fusion (ICF) channel residues.

All the corresponding gamma lines cross-sections have been calculated from the relation

$$\sigma_\gamma = \frac{Y_\gamma}{Y_M}\frac{d\Omega_M}{\epsilon_\gamma}\sigma_M$$

where Y_γ is the yield of that gamma line, Y_M is the monitor yield, $d\Omega_M$ is the solid angle of the monitor detector, ϵ_γ is the absolute efficiency of the gamma lines, and σ_M is the Rutherford cross-section at the corresponding beam energy. For even-even ERs (^{128}Xe, ^{130}Xe) the cross-sections were extracted from the extrapolated value of of the γ cross-sections at $J = 0$. For the odd-mass ^{129}Xe (4n channel), there was very little known level structure. Hence the cross-sections for this channel were obtained using the measured intensity of the $\frac{11}{2}^-$ state at 587 keV and using the statistical model code PACE [3]. The ER cross-sections are shown in Fig. 2 along with PACE calculations. The ℓ-distribution corresponding to the 1D-BPM model calculations obtained from the code CCFUS [4] have been fed into PACE as an input. The calculated cross-sections of 3n, 4n and 5n channel are shown in the Fig. 2. The coupled channel calculations are in progress to understand the possible influence of the low separation energy of ^{9}Be nucleus. The measured alpha spectra in the two telescopes clearly indicate the presence of breakup phenomena. Future measurements of coincidence between breakup alpha and gamma are planned, which will give better insights for the above reaction dynamics.

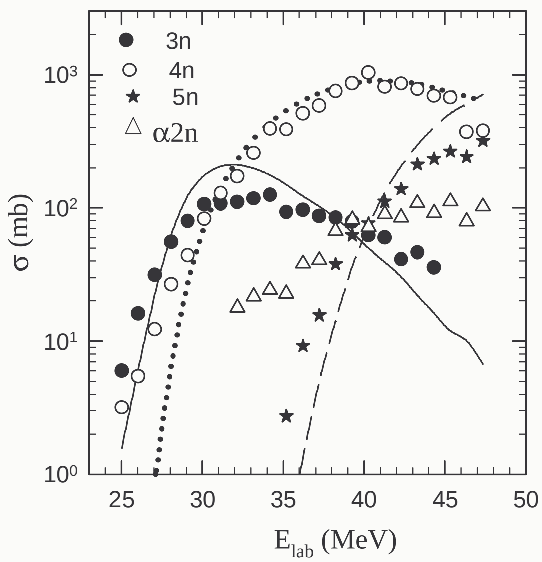

FIG. 2: Measured excitation functions for ^{9}Be+^{124}Sn evaporation channels. The lines are the statistical model predictions. The open triangles denote the cross-sections from incomplete fusion process.

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