Inclusive alpha angular distribution in ^{7}Li induced reactions on heavy targets

P. C . Rout[1],* D. R. Chakrabarty[1], V. M. Datar[1], Suresh Kumar[1], E. T Mirgule[1], A. Mitra[1], A. Shrivastava[1], V. Nanal [2], S. P. Behera[1], G. Mishra[1], and R. Kujur[1]
[1]*Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai - 400085, INDIA and*
[2]*Department of Nuclear and Atomic Physics,*
Tata Institute of Fundamental Research, Mumbai - 400005, INDIA

Introduction

The study of the reaction mechanism with weakly bound stable nuclei (^{6,7}Li and ^{9}Be) of well known cluster structure is of current interest. These nuclei have a large breakup probability due to low breakup thresholds. The coupling of the breakup channel to various others reaction channels influence fusion at near-barrier and in the elastic scattering showing threshold anomaly in the optical potential. The contribution to alpha production is from the break up of the ^{7}Li to α+t with a significant contribution from the neutron(s) stripping and proton pickup reactions.

In this paper, we report the data on the production of α particles in ^{7}Li induced reaction on heavy targets from ^{181}Ta - ^{209}Bi at near barrier energies. The angular distributions of breakup α-particles were measured between $\theta \sim 60° - 170°$ at various beam energies. The main objectives were to understand the reaction mechanism with ^{7}Li on heavy targets (A ~200) and the measurement of the breakup α cross section in ^{7}Li+^{205}Tl system at 30 MeV. The latter is relevant to our earlier study on the shell effect on the level density in the ^{208}Pb region [1].

Experimental details

The experiment was carried out at the Mumbai Pelletron Linac Facility (PLF) using the ^{7}Li^{3+} beam on ^{181}Ta, ^{197}Au, ^{198}Pt, ^{205}Tl and ^{209}Bi targets at bombarding energies 25, 27.5, 30, 31 and 35 MeV. The thickness of the ^{197}Au, ^{181}Ta, ^{198}Pt, ^{205}Tl and ^{209}Bi targets were 2.8, 3.85, 1.36, 5.4 and 1.6 mg/cm^2, respectively. The contributions from C and O impurities were assessed using a 100 μg/cm^2 ^{12}C target and a 1 mg/cm^2 Ta_2O_5 on 4 mg/cm^2 Ta backing, respectively. Three ΔE-E telescope (ΔE ~ 15-25 μm and E ~2000 μm thick) consisting of Si surface barrier detectors were placed 10° apart on a movable arm of a 2-m diameter scattering chamber. These telescopes were used to detect the light particles, mainly p, α and Li, produced in the reaction. A 6 mm diameter collimator was placed in front of each telescope. The solid angle subtended by each telescope was 1.29 msr. A monitor detector of 50 μm Si-surface barrier detector was placed at 20° on another arm of the chamber for cross section normalization. A typical two-dimensional ΔE-E spectrum is displayed in Fig. 1 for the telescope set at θ_{lab}=130° in ^{7}Li+ ^{205}Tl system at 30 MeV. Three different groups of reaction products are well separated. An energy spectrum obtained

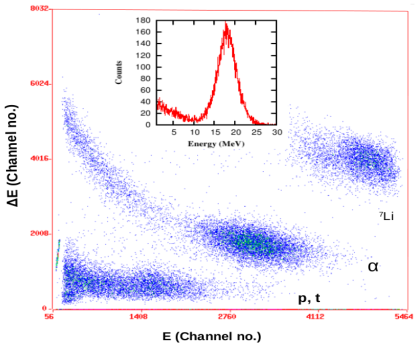

FIG. 1: Two dimensitional ΔE-E spectrum for ^{7}Li+ ^{205}Tl system at E(^{7}Li) = 35 MeV. The inset shows projected energy spectrum for the α groups.

*Electronic address: prout@barc.gov.in

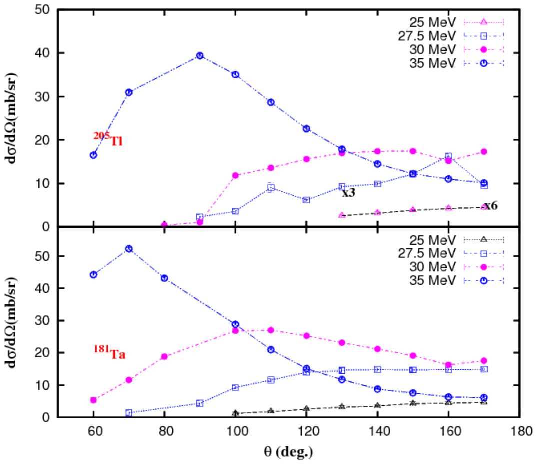

FIG. 2: Alpha angular distribution in ^{7}Li on ^{181}Ta, and ^{205}Tl targets at various bombarding energies (lines are only to guide the eye).

with suitable gates on alpha groups is shown in the inset of Fig. 1.

Results and Discussion

The α differential cross section $d\sigma/d\Omega$ was calculated from the normalized alpha yield and the Rutherford differential cross section at 20°. The angular distribution of α groups for two representative targets at 25-35 MeV are shown in Fig 2. The distribution peaks at forward angles for above barrier energies and becomes flat at backward angles at below barrier energies for all targets. The total α cross sections were obtained from the measured angular distributions. In order to eliminate the geometrical effects, the reduced cross section was calculated by scaling the total cross section by r_{pt}^2, where $r_{pt} = A_p^{1/3} + A_t^{1/3}$ and the reduced energy was obtained by dividing the center of mass energy by $Z_p.Z_t/r_{pt}$ [2]. Here Z_p , Z_t are the charges and A_p, A_t are the mass numbers of the projectile and target, respectively. The reduced cross sections are plotted against the reduced energies for all targets and are shown in Fig. 3. The α-excitation functions can be seen to show a universal behaviour at near barrier energies. Triton capture cross section measured by offline γ-ray counting techniques in ^{7}Li + ^{198}Pt system [3] and counting residue α activity in ^{7}Li + ^{209}Bi system [4] reasonably fits the same universal trend.

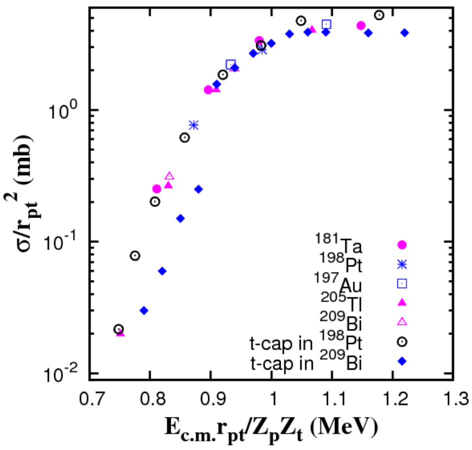

FIG. 3: Reduced cross section for systems consisting ^{7}Li with various targets.

In summary, the angular distributions of alpha production in ^{7}Li induced reaction on heavy targets were measured and the calculated reduced total cross sections have a universal behaviour at near barrier energies. The total α cross section in ^{7}Li + ^{205}Tl at 30 MeV is found to be ∼40 mb. The theoretical investigation using statistical model of compound nuclear theory and continuum discretized coupled channel calculation is expected to give an estimation to the total alpha production from various reaction channels and will be compared with the present data.

Acknowledgments

We thank the PLF staff for smooth operation of the machine and Ms. Deepa and Mr. Mahadkar for the preparation of targets.

References

[1] P C Rout *et al.*, Proc. of DAE Symp. on Nuclear Physics, Vol.**56**, 482 (2011).
[2] P R S Gomes *et al.*, Phys. Rev. C **71**, 017601 (2005).
[3] A. Shrivastava *et al.*, EPJ Web of Conferences, **17**, 03001 (2011).
[4] M Dasgupta et al., Phys. Rev. C **70**, 024606 (2004).