Study of direct reactions in ^{6,7}Li + ^{197}Au at near barrier energies

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Introduction

Recently, reactions with weakly bound stable nuclei have been extensively studied to investigate the effect of breakup on the fusion mechanisms at energies around the barrier [1]. In fusion with weakly bound stable nuclei, following the breakup of the projectile in the field of target, one of the fragments can be captured by the targets, whereas the other moves away approximately with the beam velocity. This process is referred to as breakup fusion in reactions at near barrier energies [2]. In case of weakly bound nuclei, the coupling to breakup channel is expected to play major role. Also the experimental study with radioactive ion beams indicate that the sub-barrier total reaction cross section is completely dominated by direct reactions, in the form of 1n and 2n stripping [3].

We have carried out simultaneous measurement of direct and compound nuclear processes with ^{6,7}Li on a heavy mass target ^{197}Au at energies around the barrier. The excitation function of fusion and neutron transfer products for ^{6,7}Li + ^{197}Au using offline gamma spectroscopy were reported earlier [4]. In ^{6}Li(^{7}Li) induced reactions, the direct reaction products resulting from d(t) capture, namely, ^{199}Hg(^{200}Hg) undergo neutron evaporation leading to ^{197,198}Hg(^{197,198,199}Hg). Both ^{197}Hg and ^{199}Hg have long lived isomers and cross-sections for these nuclei were measured by offline spectroscopy. For the measurement of ^{198}Hg (stable product) in beam gamma spectroscopy experiment has been carried out. This paper presents the complete measurement of excitation function of direct reactions in ^{6,7}Li+^{197}Au.

Experimental Details & Analysis

The experiment was performed using Indian National Gamma Array (INGA) consisting of 16 Compton suppressed clover detectors [5] at Pelletron Linac facility, Mumbai. Self supporting rolled target foils of ^{197}Au (∼1.6-1.7 mg/cm^2 thick) were bombarded with ^{6,7}Li beam of energies in the range 21 – 45MeV (I∼ 2-3 pnA). The efficiency of the clover array was measured using calibrated sources ^{152}Eu and ^{133}Ba. A monitor detector was mounted at 30^o. Further at each energy background spectra (activity) were taken before and after each measurement. The data was acquired using digital data acquisition system in singles as well as in γ-γ coincidence. The data reduction was done using code MARCOS developed at TIFR [6]. All the residues were identified from single gated spectra with E$_\gamma$-E$_\gamma$ matrix using RADWARE software [7].

Fig. 1 shows the γ ray addback spectrum at 45MeV for ^{7}Li + ^{197}Au showing lines of interest. The cross sections for ^{198}Hg were obtained from 1 fold data by adding the yields of gamma rays feeding the ground state. The yields were corrected for the internal conversion and background, if any. The cross sections for ^{197m,199m}Hg were also measured at

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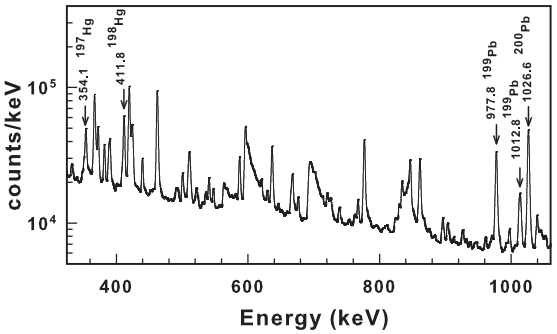

FIG. 1: Gamma ray add back spectrum of the whole array at 45MeV for ^{7}Li+^{197}Au reaction

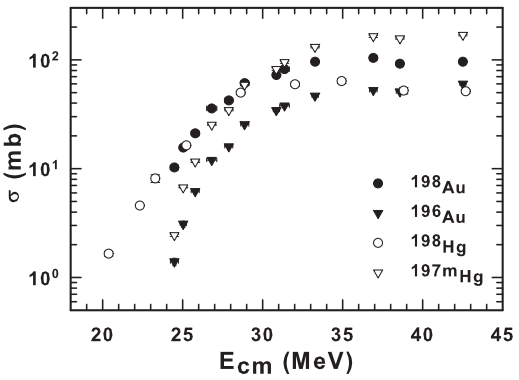

FIG. 2: Measured excitation function for d capture (^{197m,198}Hg) and neutron transfer (^{196,198}Au)in ^{6}Li+^{197}Au reaction.

above barrier energies. The normalisation was done using monitor detector and $\sigma(^{200}$Pb). It should be mentioned that ^{200}Pb is a dominant CF residue in both the reactions and has been measured accurately in earlier offline experiment [4]. The direct particle feeding to the ground state in this mass and energy region is negligible. The (α,xn) products (Tl nuclei) could not be measured in this experiment as cross section are significantly lower.

The measured excitation functions for d/t capture products along with neutron transfer in ^{6,7}Li+^{197}Au reactions are shown in fig. 2

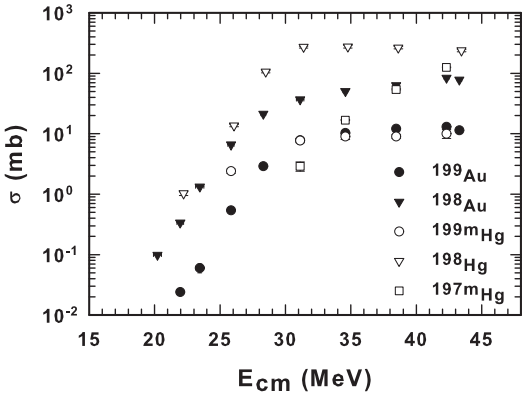

FIG. 3: Measured excitation function for t capture (^{197m,198,199m}Hg) and neutron transfer (^{198,199}Au)in ^{7}Li+^{197}Au reaction.

and fig. 3, respectively. It is clearly seen that the total d/t capture cross section is larger than that for the neutron transfer. Particularly, in the case of ^{6}Li, sub-barrier reaction cross-section is dominated by d capture process.

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