Study of fusion and direct reaction at near barrier energies in ^{9}Be + ^{197}Au

Malika Kaushik[1],* G. Gupta[2], Swati Thakur[1], H. Krishnamoorthy[3,4], V. Nanal[2], A. Shrivastava[5], Pushpendra P. Singh[1], R. G. Pillay[1], C. S. Palshetkar[2], K. Mahata[5], K. Ramachandran[5], S. Pal[6], S. K. Pandit[5], and V.V. Parakar[5]

[1]*Indian Institute of Technology Ropar, Rupnagar-140001, Punjab INDIA*
[2]*DNAP, Tata Institute of Fundamental Research, Mumbai - 400005, INDIA*
[3]*INO, Tata Institute of Fundamental Research, Mumbai - 400005, INDIA*
[4]*Homi Bhabha national Institute, Anushaktinagar, Mumbai - 400094, INDIA*
[5]*NPD, Bhabha Atomic Research Centre, Mumbai - 400085, INDIA and*
[6]*PLF, Tata Institute of Fundamental Research, Mumbai - 400005, INDIA*

1. Introduction

Nuclear reactions around the Coulomb barrier provide a unique way to probe tunnelling phenomena under diverse conditions ranging from the effect of dissipation in heavy systems to the role of weak binding [1, 2]. Reactions with weakly bound stable and unstable nuclei have been rigorously studied in recent years. The low binding energies of these nuclei, leading to a significant effect of the coupling to continuum on different reaction channels, have been the main driving force in such studies. In addition, radioactive ion beams are found to exhibit unusual features such as halo and skin structures, extended shapes, and large breakup probabilities. Fusion reaction for weakly bound stable (^{6,7}Li) and unstable (^{6,8}He) projectiles on ^{197}Au target have been systematically studied. Here, we extend these measurements to ^{9}Be+^{197}Au system to get a deeper insight into role of weakly bound cluster structure on the reaction dynamics [3].

2. Experimental details and Data analysis

Experiment was performed using ^{9}Be beam of energies 30-47 MeV from the Pelletron Linac facility (PLF), Mumbai. Self supporting target foils of ^{197}Au ($\sim$ 1.3 - 1.7 mg/cm^2) were irradiated with ^{9}Be beam ($\sim$8-15 pnA).

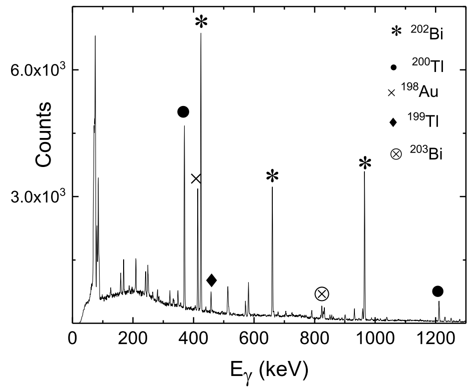

FIG. 1: A typical off-line γ-ray spectrum measured in ^{9}Be + ^{197}Au reaction at E_{Lab} = 44.7 MeV, where lines of interest have been labelled.

Aluminium catcher foils of thickness $\sim$ 1.5 mg/cm^2 were mounted behind the targets to stop recoiling reaction products. The complete fusion and breakup-fusion cross-sections are measured in the energy range of 0.8 to 1.2V_c (V_c = 38.1 MeV). The beam current was recorded at the periodic intervals for taking into account corrections arising due to decay during irradiation. In some cases, cascaded targets with aluminium degrader foils were used for the optimal utilization of the beam time. The reaction products were identified by characteristic gamma rays in the offline counting.

*Electronic address: malika.kaushik@iitrpr.ac.in

TABLE I: Reaction products with half-lives ($T_{1/2}$), characteristic γ-ray energies and absolute intensities (I_γ)

Channel	Residue	$T_{1/2}$	E_γ(keV)	I_γ %
3n	^{203}Bi	11.76 h	820.2	30
4n	^{202}Bi	1.71 h	422.13	83.7
5n	^{201}Bi	103 min	1014.1	11.6
(α,1n)	^{200}Tl	26.1 h	367.94	87
(α,2n)	^{199}Tl	7.42 h	455.46	12.4
1n stripping	^{198}Au	2.69 d	411.8	95.6
1n pickup	^{196}Au	6.16 d	355.73	87

Two efficiency calibrated HPGe detectors (approximate size) were used for offline counting. Detectors were shielded with about 5 cm thick lead rings for reducing the ambient background. At below barrier energies, samples were counted in a close geometry (mounted on the face of a detector). Data was recorded using CAEN 100 MHz digitzer and analysed in LAMPS [5]. A typical gamma spectrum is shown in figure 1. TABLE I lists reaction products together with prominent gamma-rays and half-lives. For unambiguous identification, half-lives of the characteristic gammas were tracked (few mins - 6 days) and were found to be consistent with literature values. The yields of characteristic gamma rays are used to extract the cross-sections following procedure prescribed in ref. [4].

It is well known that for weakly bound nuclei like ^{6,7}Li, ^{9}Be, probability of transfer and breakup reaction are significantly large. A comparison of one neutron transfer reaction i.e., ^{198}Au with different weakly bound projectiles is shown in Fig. 2 as a function of scaled energy (E/V_c).

It can be seen from the figure that at sub-barrier energies, neutron transfer cross-section are very similar for ^{9}Be and ^{6}Li, but overall trend appears to be similar to ^{6}He. The fusion excitation function for ^{9}Be +^{197}Au and comparison with calculations will be presented.

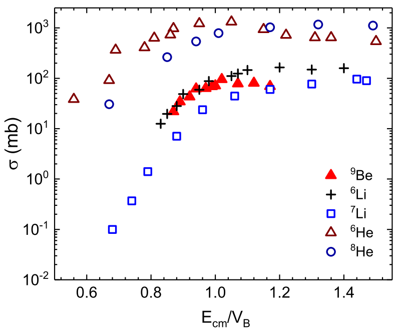

FIG. 2: A systematic comparison of 1n stripping cross sections for ^{197}Au with halo nuclei ^{6,8}He and weakly bound nuclei ^{6,7}Li (figure taken from [4]) along with the present data of ^{9}Be.

3. Acknowledgement

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