Breakup of ^{9}Be by ^{112}Sn and ^{209}Bi target nuclei

R. Gandhi[1],* D. Chattopadhyay[1,2], B. K. Nayak[1,2], S. Santra[1,2], P. C. Rout[1,2], A. Pal[1,2], A. Kundu[1,2], K. Ramachandran[1], R. Tripathi[2,3], V. Jha[1,2], T.N. Nag[3], G. Mohanto[1], B.J. Roy[1,2], T. Santhosh[1,2], A. Gandhi[4], P. N. Patil[5], J. Pandey[6], and S. Kailas[1,2]

[1]*Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai - 400085, India*
[2]*Homi Bhabha National Institute,Anushaktinagar,Mumbai - 400094, India*
[3]*RadioChemistry Division, Bhabha Atomic Research Centre, Mumbai - 400085, India*
[4]*Department of Physics, Banaras Hindu University, Varanasi - 221005, India*
[5]*Department of Physics, Karnatak University, Dharwad - 580033, India and*
[6]*Department of Physics, G. B. Pant University of Agriculture & Technology, Pantnagar - 236145, India*

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Introduction

^{9}Be is a weakly bound stable nucleus. It breaks into $\alpha + \alpha + n$ with a breakup threshold energy of only $E_{\rm th}$=1.57 MeV. So, the reactions involving ^{9}Be as a projectile (similar to other weakly bound projectiles like ^{6,7}Li with $E_{\rm th}$=1.48 and 2.45 MeV) are expected to exhibit several unusual features compared to the strongly bound projectiles [1, 2]. One of the cluster constituents of the above nuclei or the intermediate unstable ejectiles (e.g., ^{5}Li, ^{5}He, ^{8}Be, etc.) formed after a transfer reaction being an α particle, the inclusive alpha particle production is observed to be very large. The present work reports on the results of the measurements of exclusive two α particle production in reactions involving ^{9}Be with two different target nuclei, ^{112}Sn and ^{209}Bi. These coincident α pairs can be produced by two dominant processes: (i) direct breakup of ^{9}Be into $\alpha+\alpha+n$ or (ii) $1n$ stripping-transfer followed by breakup, i.e., (^{9}Be,^{8}Be$\rightarrow \alpha + \alpha$) reaction [3]. The motivation of this work is to identify the processes by which the α pairs are produced in the present systems at above barrier energies.

Experimental details

Exclusive measurements have been carried out for ^{9}Be+^{112}Sn,^{209}Bi at energies around the Coulomb barrier ($E/V_b \sim 1.24$ and 1.12), using the 14-UD Pelletron-Linac facility in Mumbai. A large array with five sets of Si strip telescopes was used to detect the breakup fragments in coincidence and placed side by side to cover a total angular range of about $\sim 93^{\circ}$. Two Si-surface barrier detectors (of thickness $\sim 1000\mu$m) kept at $\pm 20^{\circ}$ were used to monitor the incident flux by measuring the Rutherford scattering. In addition, there were five single telescopes of silicon surface barrier detectors placed on the scattering chamber to measure the elastic scattering angular distribution covering additional angular range.

Data analysis and Results

The analysis of the events corresponding to the direct breakup of ^{9}Be into $\alpha + \alpha + n$ is difficult as no information on outgoing n is recorded. So, the data were analyzed assuming all events are due to the second process, i.e., (^{9}Be,^{8}Be$\rightarrow \alpha + \alpha$) and then see if the results are consistent. Using the energies and laboratory detection positions of two outgoing α fragments of each coincident event, the values of 'θ,ϕ' of outgoing ^{8}Be (for $\alpha + \alpha$ breakup), 'Q Value' and α-α relative energy '$E_{\rm rel}$' were reconstructed [4]. The Q value versus relative energy distribution '$E_{\rm rel}$' of two α coincidence events thus obtained for two systems are shown in Fig. 1 and Fig. 2 respectively. From these distributions, it is observed that the events with highest Q values (horizontal bands) for ^{9}Be+^{112}Sn and ^{9}Be+^{209}Bi

*Electronic address: rgandhi@barc.gov.in

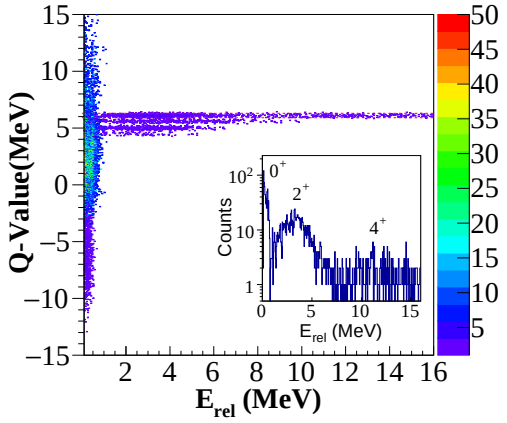

FIG. 1: Two-dimensional plot of 'E_{rel} versus Q value' showing the distribution of events with projectile-like and target-like excitations for ^{9}Be+^{112}Sn reaction at $E_{\rm beam}$=36 MeV. Projection of uppermost band within red dashed box on E_{rel} axis is shown as an inset.

are respectively $\sim$ 6.08 and 2.94 MeV which actually correspond to the ground state Q values of (^{9}Be,^{8}Be) reactions in respective systems. Different horizontal bands with lower Q values correspond to events accompanied by residual target excitations. Within the same horizontal band, e.g., the band with highest Q value, two clear group of events are observed at $E_{\rm rel}$ $\sim$ 0.1 MeV and $\sim$ 3.1 MeV corresponding to 0^+ and 2^+ resonance states of ^{8}Be, followed by a broad distribution around 4^+ (11.3 MeV) resonance (see insets of Fig. 1 and 2). At lower Q values, these bands are not visible as the excitation energies may not be sufficient to excite ^{8}Be leading to higher relative energies and the breakup proceeds only via the g.s. of ^{8}Be. When residual target is in ground state (events with highest Q value), there is a sharp peak corresponding to breakup of ^{8}Be via its 0^+ state. However, at lower Q values the peaks corresponding to the events around 0.1 MeV of relative energy are quite broad which may be due to the mixup of the events of direct breakup of ^{9}Be$\rightarrow \alpha+\alpha+n$ as in [3]. Therefore, from the present measurements, it may be concluded that the outgoing two-α particles are produced by both the processes.

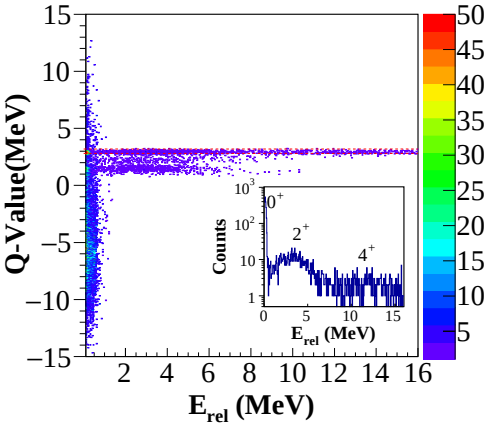

FIG. 2: Same as Fig. 1 but for ^{9}Be+^{209}Bi reaction at $E_{\rm beam}$=47 MeV.

References

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