Probing inelastic excitation and nucleon-transfer leading to unbound states of the ejectile in ^{9}Be+^{198}Pt reaction

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Introduction

Exploring the properties of weakly bound stable and unstable nuclei via Coulomb excitation and transfer reactions is an important topic of interest for the next generation of high-intensity isotope-separator online (ISOL) radioactive ion beam facilities [1–3]. Recently, we have investigated the inelastic excitation, nucleon-transfer and cluster-transfer leads to ejectile and/or target like nuclei in continuum states involving ^{7}Li [4]. Triton-stripping mechanism is found to be dominant reaction channels in the production of α-yields. Recently, we are investigating on reaction mechanisms involving the Borromean ^{9}Be nucleus. Series of measurements are carried out by bombarding ^{9}Be on various targets ranging from medium (A$\sim$100) to heavy (A$\sim$200) [5, 6]. In this report, we will discuss the breakup and 1n-transfer followed by breakup for ^{9}Be+^{198}Pt system at $E_{\rm lab}$=45 MeV.

Experimental Details

An experiment was conducted using a ^{9}Be beam with an energy of 45 MeV from the BARC-TIFR Pelletron-LINAC facility in Mumbai. The target was a self-supporting ^{198}Pt foil, approximately 1.3 mg/cm^2 thick, with an enrichment of around 95.7%. To measure the energy and scattering angles of the outgoing charged particles, five segmented large-area Si-telescopes (ΔE $\sim$ 20-50 μm; E $\sim$ 1.5 mm), each with an active area of 5x5 cm^2, were employed. The telescopes were mounted at angles of 40°, 70°, 115°, 145°, and -55° within a compact scattering chamber measuring 32 cm in diameter. Fifteen liquid scintillator detectors (EJ-301) were used to measure neutrons.

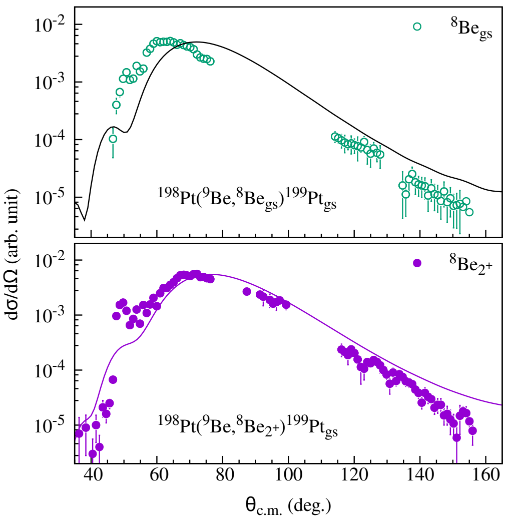

FIG. 1: The measured angular distribution for 1n-stripping channels for ^{9}Be+^{198}Pt reaction at $E_{\rm beam}$ = 45 MeV.

The neutron detectors covered an angular range of 30°–145°, with their centers positioned 72.5 cm from the target [rout18]. A Si-surface barrier detector, $\sim$300 μm thick, was mounted at an angle of 20° in-plane to monitor Rutherford scattering for absolute normalization. Data collection was performed in event-by-event mode. Time calibration was performed using a precision time calibrator. The Si-detectors were calibrated using known α-particle energies from ^{239}Pu-^{241}Am and ^{229}Th sources.

Analysis and result

The energy loss data from the ΔE and E detectors were utilized to identify the α-particles. Neutron discrimination from γ-rays was achieved using both pulse shape discrimination (PSD) and time of flight (TOF) techniques. Neutron energies were determined by measuring their time of flight (TOF) relative to the pulsed beam. Events corresponding to two α-particle

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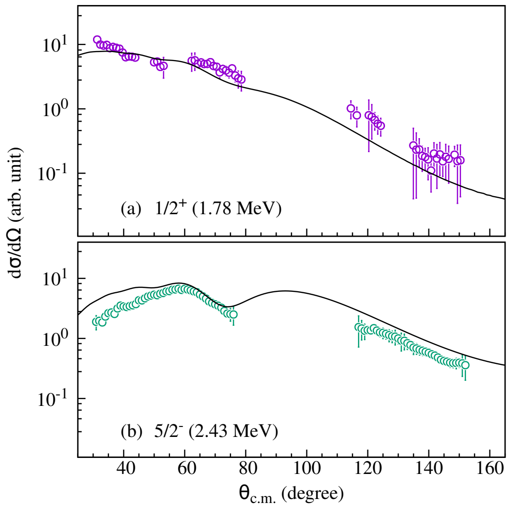

FIG. 2: Measured angular distribution of inelastic excitation of ^{9}Be to (a) $\frac{1}{2}^+$ and (b) $\frac{5}{2}^-$ states compared with the calculations.

in coincidence is used to extract scattering-angle and energy of ^{8}Be prior to breakup. The measured energies (E_α^1, E_α^2) and scattering angles (θ_α^1, ϕ_α^1; θ_α^2, ϕ_α^2) were used to reconstruct both the energy ($E_{^8\mathrm{Be}}$) and angle ($\theta_{^8\mathrm{Be}}$) of the scattered ^{8}Be prior to its breakup. From extracted Q-value of (^{9}Be,^{8}Be) reaction populating the ^{199}Pt in ground state is clearly identified. Angular distribution for 1n-stripping leading to population of ^{199}Pt in ground state, and ^{8}Be in ground state as well as in 2^+ states are extracted and compared in Fig. 1.

Similarly, the measured energies (E_α^1, E_α^2, E_n) and scattering angles (θ_α^1, ϕ_α^1; θ_α^2, ϕ_α^2; θ_n, ϕ_n) were used to reconstruct the energy ($E_{^9\mathrm{Be}}$) and angle ($\theta_{^9\mathrm{Be}}$) of the scattered ^{9}Be prior to breakup. The energy (E^*) of the excited states of ^{9}Be were extracted using the energy conservation E^*=E_α^1+ E_α^2+E_n+E_{BU}^{th}-$E_{^9\mathrm{Be}}$, where, $E_{\mathrm{BU}}^{\mathrm{th}}$=1.57 MeV is the breakup threshold. In the reconstructed ^{9}Be excitation energy spectra, 1.78 $\frac{1}{2}^+$ and 2.43 $\frac{5}{2}^-$ are clearly resolved. Angular distribution of these two states are extracted and shown in Fig. 2.

Two set of calculations using the code FRESCO [7] were performed to understand the measured angular distributions. Continuum discretized coupled channels (CDCC) calculations were carried out for the angular distribution of $\frac{1}{2}^+$ (1.78 MeV) and $\frac{5}{2}^-$ (2.43 MeV) states. Since it is evident from the experimental observation that both the states breaking dominantly via n+^{8}Be($\to \alpha + \alpha$) sequential mode, n+^{8}Be cluster configuration were considered in the calculations. For the optical potential an average of potentials, required to fit ^{9}Be+^{197}Au elastic scattering data at incident energies to 44 and 46 MeV was used for the present reaction ^{9}Be+^{198}Pt at $\mathrm{E_{beam}}$=45 MeV [8]. The calculated angular distribution are compared with the data in Fig. 2. The angular distribution for 1n-stripping was calculated using the DWBA framework. The calculated cross sections are compared with data in Fig. 1. The details of investigation will be presented.

Acknowledgments

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