Resonant breakup of ^{8}Be in ^{112}Sn(^{7}Li,^{8}Be$\rightarrow \alpha + \alpha$) reaction

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(Dated: August 30, 2017)

Introduction

Measurements involving weakly bound projectiles with $\alpha + x$ cluster structure show significantly larger cross-sections for the inclusive α particle production as compared to production of the complementary fragment 'x'. It has been observed that these projectiles not only breaks into its cluster constituents α and x directly but also exchange a few nucleons with the target before decaying into the two fragments, one of which is α. One of the dominant transfer induced breakup process in the reactions involving ^{6,7}Li and ^{9}Be projectiles is the formation of ^{8}Be by transfer reaction followed by its breakup into two α particles. In a recent measurement for ^{6}Li+^{112}Sn reaction the 1d pickup by ^{6}Li forming ^{8}Be followed by its breakup into $\alpha + \alpha$ via its 0^+ (g.s) and 2^+ resonance states have been observed[1]. The 2α cluster structure of ^{8}Be at its ground state(0^+) as well as other two resonance states at 3.12 MeV (2^+) and 11.35 MeV (4^+) is well reflected by the values of the spectroscopic factors for <^{8}Be| $\alpha + \alpha$> overlaps: S(g.s)=0.84, S(2^+)=0.83 and S(4^+)=0.75[2]. Since the third resonance state (4^+), like other two states, has a good overlap between 2α particles in the cluster, the breakup of ^{8}Be into 2α via this state is also possible at favorable excitation energies. However, there is no experimental evidence reported so far on the observation of ^{8}Be breakup via the 4^+ resonance state. This paper reports the results of experimental investigation on the existence of ^{8}Be breakup via 4^+ resonance state and its cross section along with 0^+ and 2^+ resonance states.

The experiment

Exclusive measurements have been carried out for ^{7}Li+^{112}Sn reaction at beam energy 30 MeV, using the 14-UD Pelletron-LINAC facility in Mumbai. Self-supporting enriched ($\sim$99.5%) ^{112}Sn foil of thickness $\sim$ 540 μg/cm^2 was used as target. Five telescopes (S_1-S_5) of double-sided Si strip detectors were placed on one of the two rotatable arms inside a 1.5 m diameter scattering chamber to detect the projectile like fragments with a total angular range of about $\sim$96°. Two Si-surface barrier detectors (of thicknesses$\sim$1000 μm) kept at $\pm$20° were used to monitor incident flux by measuring the Rutherford scattering. In addition there were five Telescopes (T_1-T_5) of single surface barrier detectors (with ΔE$\sim$50 μm, E$\sim$1000-2000 μm) placed on the second arm of the scattering chamber to measure the elastic scattering cross-sections.

Results

The distribution of relative energy 'E_{rel}' [1] between two coincidence breakup α has been extracted event by event. From the raw data of relative energy distribution Y_i^{raw}, the three peaks are identified corresponding to 0^+, 2^+ and 4^+ resonance states of ^{8}Be, as dominant 2α breakup modes. To confirm the result using efficiency corrected yield Y_i^{eff} (=Y_i^{raw}/ϵ_i), a MONTE-CARLO simulation has been made to obtain relative energy dependent coincidence efficiency (ϵ_i) of the detector array. For each coincident event the values of θ(^{8}Be), ϕ(^{8}Be), Q-Value and E_{rel} were re-

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TABLE I: Expected and observed peak position and width for different breakup states

State	*Expected peak pos.* (MeV)	*Expected width* (MeV)	*Observed peak pos.* (MeV)	*Observed width* (MeV)
0^+	0.092	0.0057	0.09	0.05
2^+	3.12	1.513	3.5	2.2
4^+	11.35	3.5	11.3	3.5

constructed and corresponding efficiency has been obtained. The event by event analysis led to efficiency corrected E_{rel} distribution as shown in Fig.1. The comparison of the peak positions and widths of resonance states with theoretical values in Table I confirms the observation of ^{8}Be breakup via its 4^+ state for the first time along with 0^+ and 2^+ states.

From the efficiency corrected relative energy distribution at each $\theta(^8\text{Be})$ bin, the coincidence yields for 0^+, 2^+ and 4^+ states has been obtained by summing over all $\phi(^8\text{Be})$ coverage of detector array. Differential breakup cross-sections for 0^+, 2^+ and 4^+ state is extracted

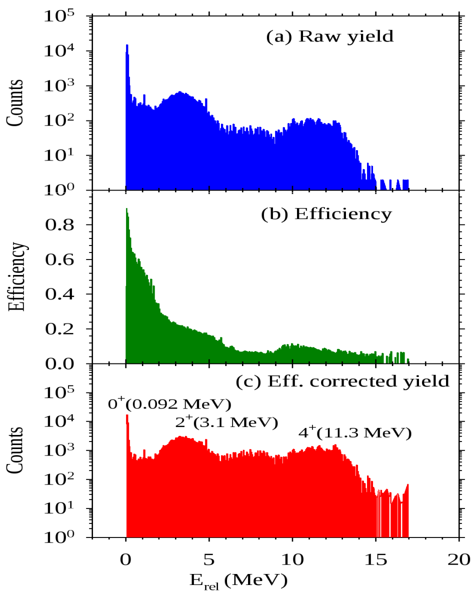

FIG. 1: Relative energy distribution

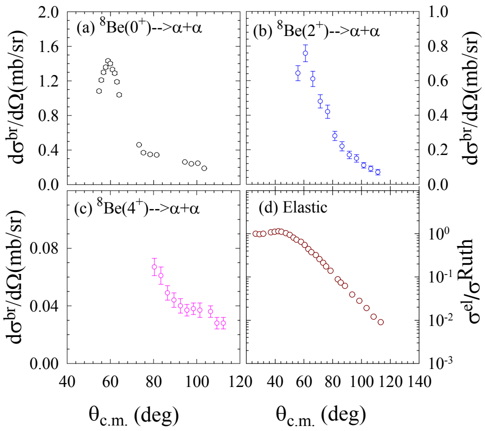

FIG. 2: Differential cross sections for sequential breakup of ^{7}Li→^{8}Be→$\alpha+\alpha$ and elastic scattering measured at E_{beam}=30 MeV

from the given relation

$$\frac{d\sigma^{BU}}{d\Omega} = \frac{\sum_{i=1}^{N} \dfrac{Y_i^{raw} d\zeta_i}{\epsilon_i}}{N_p N_t d\Omega} = \frac{\sum_{i=1}^{N} Y_i^{eff} d\zeta_i}{N_p N_t d\Omega} \quad (1)$$

where, N_p is the total no. of incident projectiles and N_t is the no. of target nuclei/area and $d\Omega$ is the solid angle corresponding to the element $\Delta\theta(^8\text{Be})$, $\Delta\phi(^8\text{Be})$ and ϵ_i is the efficiency for relative energy ζ_i and $\zeta_i + d\zeta_i$. The differential breakup cross-sections for 0^+, 2^+ and 4^+ states of ^{8}Be along with elastic scattering are shown in Fig.2(a), (b) and (c) and (d) respectively.

Detailed study of $1p$ transfer breakup into 2α via 3 resonant states of ^{8}Be including the one at very high excitation (11.3 MeV) presented here provides a good foundation towards understanding the reaction mechanisms of total α production and sequential mode of projectile breakup.

References

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