$1p$ stripping followed by resonance breakup in ^{112}Sn(^{6}Li,^{5}He$^{*} \rightarrow \alpha + n$) reaction

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Introduction

The weakly bound stable projectile nuclei of light masses mostly exhibit $\alpha + x$ cluster in their ground state. The breakup of these nuclei into its cluster constituents producing alpha particles is thus not surprising. However, the yield of α particles is observed to be much larger compared to its complementary breakup fragment 'x'. It is now well established that, in addition to the breakup of the projectile directly into α and x particles, there exist, several different transfer breakup modes that contribute to the inclusive α particle production. In our recent study on inclusive alpha cross sections in ^{6}Li+^{112}Sn system [1], it has been concluded that one of the important transfer breakup modes contributing to α yield is the $1p$ stripping reaction followed by the breakup of ^{5}He into $\alpha + n$, i.e., ^{112}Sn(^{6}Li,^{5}He$\rightarrow \alpha + n$).

Though there are several measurements [1] to find the contribution to inclusive alpha from other breakup modes like α+d, α+p and α+α, no measurement exists for $\alpha + n$ channel to confirm the contribution of α from ^{5}He. The measurement of the last channel involves the experimental setup consisting of both charged particle detectors and neutron detectors. In the present study, we have measured the $\alpha + n$ channel and attempted to understand the breakup mechanism of this particular channel from the relative energy distribution of α and n.

Experimental details

Measurements were carried out for ^{6}Li+^{112}Sn system at E_{beam}= 28 MeV, using the BARC-TIFR Pelletron facility. Four sets of strip telescopes, covering a total angular opening of $\approx 106°$, were used to detect the charged particles. In coincidence, the neutrons were detected by 15 liquid scintillator detectors, placed outside the scattering chamber. The neutron energies were obtained from the time-of-flight (TOF) measured w.r.t. the RF pulses. The separation of neutrons and gamma particles were made using the pulse shape discrimination (PSD) as well as TOF technique, see Fig 1(a). Fig. 1(b) shows a typical 2D spectrum of ΔE-E of the charged particles detected in one of the Strip telescopes.

Results and Discussions

Using the energies and laboratory detection positions of breakup fragments α and n corresponding to each coincident event, the values of 'θ,ϕ' of outgoing ^{5}He (for $\alpha + n$ breakup), 'Q-Value' and α-n relative energy 'E_{rel}' were reconstructed and corresponding efficiency of the detector array was obtained by a Monte-

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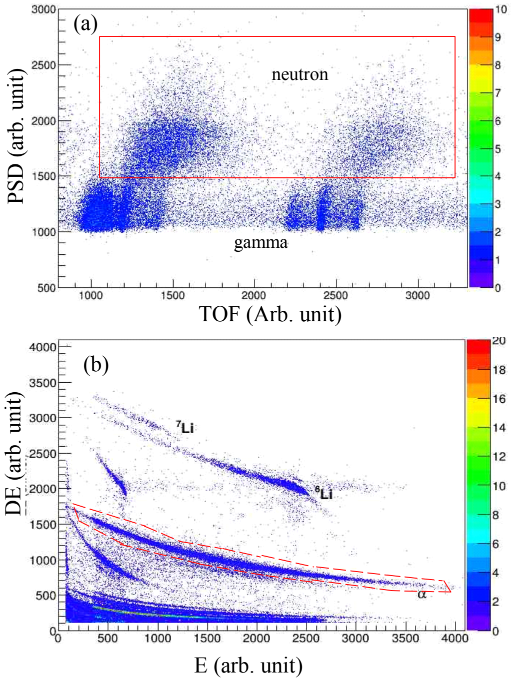

FIG. 1: Typical 2D plots of (a) PSD vs TOF measured by a neutron detector and (b) ΔE vs E measured by a strip detector telescope. Events inside the red curves are used for neutron and α coincidence analysis.

Carlo simulation. The efficiency corrected distribution of ‘E_{rel}’ obtained for $\alpha+n$ breakup are shown in Fig. 2. It is interesting to observe that the relative energy distribution shows two peak-like structures at energies around 0.77 and 2.13 MeV corresponding to the resonance states $3/2^-$ and $1/2^-$ of ^{5}He respectively [2, 3]. The peak energies and respective widths of these resonances obtained from the present work are found to be reasonably close to the literature data as shown in Table I. So, it may be concluded that breakup of ^{5}He mainly proceeds via the resonance states. Using the efficiency corrected relative energy distribution of Fig. 2 one can estimate the absolute cross section for $n+\alpha$ breakup channel which will help us determine the contribution of this channel to the total production of α particles in the reaction ^{112}Sn(^{6}Li,α).

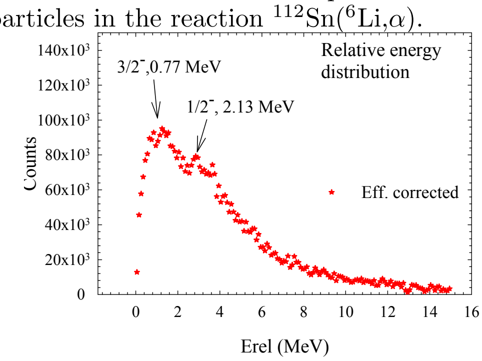

FIG. 2: Efficiency corrected α-n relative energy distribution.

TABLE I: Observed energies and widths of the resonances in ^{5}He compared to the literature data.

$E(3/2^-)$ (MeV)	$\Gamma(3/2^-)$ (MeV)	$E(1/2^-)$ (MeV)	$\Gamma(1/2^-)$ (MeV)	Ref.
0.77	0.69	2.13	7.26	[2, 3]
1.05	1.95	2.80	6.30	Present work

Conclusions

Exclusive measurements of charged particles using strip detector array in coincidence with neutrons using liquid scintillator detector array was performed for ^{112}Sn(^{6}Li,^{5}He$\rightarrow \alpha+n$) reaction. Significant number of correlated events of α and n were observed. The breakup of ^{5}He was found to be proceeding mainly via its two resonance states ($3/2^-$ and $1/2^-$).

References

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