Experimental signatures of simultaneous existence of $\alpha - d$ and $^{3}He - t$ clusters in $^{6}$Li


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Clustering in light nuclei is an interesting structure phenomenon. It is obvious to think of $^{6}$Li as a cluster of $\alpha - d$ because it is energetically most favored. There have been theoretical suggestions of the simultaneous existence of $\alpha - d$ and $^{3}He - t$ clusters as their wavefunctions are not orthogonal [1]. Here, we report our recent findings on the existence of both these cluster structures in $^{6}$Li. The experiment was performed with $^{6}$Li beams from the 14UD tandem accelerator at the Australian National University incident on thin $^{58}$Ni and $^{64}$Zn targets. Charged fragments were measured at sub-barrier energies in coincidence using the BALIN array [2]. Breakup can be characterized by $E_{rel}$ (the relative energy between the breakup fragments) and $Q$ (the reconstructed $Q$-value). Fig. 1 (Left) shows the reconstructed $Q$-$E_{rel}$ spectrum for $^{6}$Li bombarding $^{58}$Ni. The main mode of breakup is neutron stripping from the projectile followed by breakup of $^{5}$Li into $\alpha + p$ populating several excited states of $^{59}$Ni. The other significant breakup channel is direct breakup of $^{6}$Li into $\alpha + d$, giving the peak at 0.7 MeV in $E_{rel}$ corresponding to the first excited state of $^{6}$Li. We observed for the first time a break-up mode in which triton is transferred to the target nucleus and the excited $^{3}$He breaks up into a proton and a deuteron. Only by assuming a triton is transferred can the coincident $p$ and $d$ be reconstructed into sharp peaks in the $Q$ spectrum, corresponding to excited states in the (target+triton) nucleus, as shown in Fig. 1 (Right) for the reaction with $^{64}$Zn.

FIG. 1: Left: Two-dimensional $E_{rel}$-$Q$ spectrum of breakup pairs for $^{6}$Li + $^{58}$Ni. The blue color is for $\alpha + p$, the green color is for $\alpha + d$ and the red color is for $p + p$ breakup channel.; Right: One-dimensional $Q$ spectrum showing peak for $^{3}He - t$ breakup mode for $^{6}$Li + $^{64}$Zn.