Search for three centre cluster structures in $^{10,11,12}\text{B}$

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Recently there has been considerable interest in the structure of light neutron rich nuclei at, or near, the neutron drip-line. In order to understand the properties of these exotic nuclei it is crucial that the structure of the near stability isotopes, and the evolution of this structure towards the limits of stability, is fully understood. One example is that of the boron isotopic chain. Ground state cluster structures of $^4\text{He} + ^{11}\text{Li}$, $^6\text{He} + ^{11}\text{Li}$ and $^8\text{He} + ^{11}\text{Li}$ have been predicted for $^{15}\text{B}$, $^{17}\text{B}$ and $^{19}\text{B}$ respectively following Antisymmetrised Molecular Dynamics calculations of the ground state properties of $^{11,13,15,17,19}\text{B}$ by Kanada-En’yo and Horiuchi [1]. In order to test these predictions it is clear that the cluster structure of the near stability boron isotopes must be studied in detail to provide a foundation for measurements closer to the drip-line.

In this paper we will report on a study of the $\alpha + ^6\text{Li}$, $\alpha + ^6\text{Li}^*$, $d + ^8\text{Be}$ and $p + ^9\text{Be}$ decay of $^{10}\text{B}$, the $\alpha + ^7\text{Li}$, $t + ^8\text{Be}$ and $d + ^9\text{Be}$ decay of $^{11}\text{B}$ and the $\alpha + ^8\text{Li}$ and $t + ^9\text{Be}$ decay of $^{12}\text{B}$ using the $^{12}\text{C}(^7\text{Li},^{10}\text{B})^9\text{Be}$, $^{16}\text{O}(^7\text{Li},^{10}\text{B})^{13}\text{C}$, $^7\text{Li}(^7\text{Li},^{11}\text{B}^*)t$ and $^7\text{Li}(^7\text{Li},^{12}\text{B}^*)d$ reactions and a 58 MeV $^7\text{Li}$ beam provided by the 14 UD tandem Van de Graaff accelerator of the Australian National University. The excitation energy of the $^{10,11,12}\text{B}^*$ was determined following the coincident detection of the $\alpha + \text{Li}$ and $\text{H} + \text{Be}$ decay fragments in an array of four (50 mm $\times$ 50 mm) detector telescopes. The first element in each telescope was a 70 $\mu$m thick silicon $\Delta E$ detector, segmented into four independent (25 mm $\times$ 25 mm) quadrants. The second element was a 500 $\mu$m thick silicon strip detector. This was segmented into 16 independent (50 mm $\times$ 3 mm) resistive strips, each providing position information along the strip length with a resolution of $\sim$ 0.3 mm. The third element in each telescope was a 10 mm thick CsI scintillator. Used in combination the three detectors comprising each telescope provided energy and position information as well as particle identification for all isotopes from $^1\text{H}$ to $^9\text{Be}$.

A study of the observed yields to the decay channels listed above for a number of excited states has provided the first measurement of the relative decay strengths of the $\alpha + \text{Li}$ and $\text{H} + \text{Be}$ decay of $^{10,11,12}\text{B}$ [2]. In all three isotopes studied the dominant decay channel is $\alpha$-decay. This suggests that the $\alpha$-particle plays an important role in the structure of $^{10,11,12}\text{B}$ and may be seen as strong evidence for two centre $\alpha + \text{Li}$ clustering in these nuclei. In the case of $^{10}\text{B}$, for example, the dominance of $\alpha + ^9\text{Li}$ decay over that of $d + ^8\text{Be}$ suggests that three-centered cluster states are not important in the excitation energy region studied, given the association of $^8\text{Be}$ with an $\alpha + \alpha$ cluster structure (such that the $d + ^8\text{Be}$ channel can be seen as a representation of an $\alpha + \alpha + d$ three-centered structure).

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References
