Probing cluster structures through sub-barrier transfer reactions

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The propensity of nucleons within the atomic nucleus to cluster into strongly bound subunits has been well established in both experimental and theoretical studies [1, 2]. The α-particle, with its particularly high binding energy, is known to be important in the structure of such states. Clustering phenomena have been actively and extensively searched for in light α-conjugate nuclei [3], in which chain states of α-particles have long been predicted close to the α-decay thresholds and in resonances above them [4]— for example $^{8}\mathrm{Be}_{g.s}$ and $^{12}\mathrm{C}_{0_2^+}$ (the Hoyle state). In recent years, evidence has also grown for cluster states in non-α-conjugate nuclei, in which heavier subunits play an important role [5–7]. Recent experimental results have identified cluster configurations in some heavy nuclei [8], suggesting that this phenomenon may be prevalent across the nuclear chart.

Recent theoretical calculations have pointed to the possibility that clustering is important even in the ground state of some nuclei [9]. Interestingly, recent experimental results [10] have found evidence of cluster-structures in the stable doubly-magic ^{40}Ca nucleus in (or close to) its ground state, demonstrating the coexistence of these states with the more standard shell model configurations.

Multinucleon transfer reactions provide a useful tool for studying particle correlations in nuclei, and can be used to probe cluster-structures. Here I will discuss some of the work that has been conducted by the ANU reaction dynamics group to explore clustering phenomena in a range of light to medium mass nuclei, and the influence of these structures on reaction dynamics.

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