Cluster Structures in Light Nuclei

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In certain classes of nuclear states, nucleons condense into sub-units or clusters. This phenomenon has been shown to be most pronounced close to the associated cluster decay threshold. Perhaps the most famous of these is the Hoyle-state in ^{12}C. This talk will examine a range of cluster states from those composed entirely of alpha-particles to cluster states in neutron-rich nuclei where valence neutrons play a role very similar to electrons in covalent molecules – they are exchanged between the centres/cores.

The structure of ^{12}C has remained something of an enigma, especially the 7.65 MeV, Hoyle-state. It is almost universally accepted to possess a cluster structure, but the very nature of which remains to be fixed. Part of the fascination with the state is its influence on the synthesis of carbon in stars. One step forward to the understanding of the structure would be the discovery of a 2^+ collective excitation. As yet the evidence is sparse. We will present our most recent measurements performed at the iThemba LABs and Notre Dame, in which we have made a search for this excitation and the associated 4^+ state. The results of these results will be discussed in the context of other measurements.

As noted, the Hoyle-state is believed to have a pronounced 3 alpha cluster structure. What happens if valence neutrons are added is an intriguing question. It has been found that in systems composed of two-alpha particles and valence neutrons that the neutrons are exchanged between the alpha-cores in a manner which is similar to the exchange of electrons in covalent atomic molecules. Such structures are found, for example, in the nuclei ^{9}Be and ^{10}Be and due to their similarity with their atomic cousins have been called "nuclear molecules".

We have investigated the resonant scattering of ^{10}Be on ^{4}He in an attempt to populate molecular type resonances in ^{14}C, which are composed of three alpha-particles and two valence neutrons. These measurements were performed at ORNL with a helium gas target populating resonances from the decay threshold to an excitation energy of above 20 MeV. Similarly measurements have been performed on ^{7}Be+^{4}He and ^{9}Be+^{4}He. The latest results from the on-going analysis will be presented.