Cluster formation and breaking, and cluster excitation in light nuclei

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In the recent progress of experimental and theoretical studies of unstable nuclei, it was revealed that cluster aspect is one of the essential features in light unstable nuclei as well as stable nuclei. For instance, a variety of cluster states have been suggested in neutron-rich Be, where the 2α core and surrounding excess neutrons play important roles (for example, Refs. [1,2] and references therein). In addition to such two-center cluster structures suggested in Be and Ne isotopes, three-center cluster structures have been attracting a great interest. A 3α cluster gas state suggested in the excited ^{12}C is one of the recent hot topics and often discussed in relation with alpha condensation in dilute nuclear matter [3,4,5]. In excited states of neutron-rich C, further rich cluster phenomena are expected due to the 3α core formation and valence neutrons.

These facts indicate that various kinds of cluster structure emerge depending on the excitation energy and also depending on the number and the kind of core clusters as well as the number of excess neutrons. In low-lying states, clusters are tightly bound in general and the cluster feature is characterized by spatial many-body correlation or cluster formation at the surface. On the other hand, in highly excited states, one may often see remarkable cluster structures where clusters weakly couple to each other. Another cluster aspect peculiar to neutron-rich nuclei is the molecular orbital structure where clusters are bonded by excess neutrons in molecular orbitals.

In this work, we focus on the cluster aspects of light nuclei such as Be and C isotopes and discuss the cluster formation/breaking and the cluster excitation in nuclear many-body systems. Based on the calculations of antisymmetrized molecular dynamics (AMD) [2,6], which is a microscopic model for study of nuclear structure and does not rely on any assumption of clusters, we will show how the cluster formation and the cluster excitation occur in dynamics of many-nucleon systems as a function of the proton and neutron numbers and the excitation energy (or density).

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