Molecular structures and monopole transitions in two-center nuclear systems

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In light neutron-excess systems, many kinds of molecular structures are discussed from the viewpoint of the clustering phenomena. In particular, much attention has been concentrated on Be isotopes, and their low-lying states are nicely described by the two-center molecular orbit (MO) structure with the ^{8}Be = α + α core. In the MO structure, the excess neutrons perform the single particle motion in the covalent orbit, such as π^- and σ^+, associated with the covalent bonds of atomic molecules. Moreover, in Be isotopes, many resonant states, decaying into the ^{6,8}He fragments, have been observed in unbound states above the α-decay threshold. In particular, the $J^\pi = 0^+$ resonances are strongly excited by the isoscalar monopole transition induced by the collision with the spin-less targets, such as α or ^{12}C target.

In this report, we will show the systematic studies of the molecular structures and monopole transitions, which are generated from the system of two-center cores plus valence neutrons. We employ the Generalized Two-center Cluster Model (GTCM), which is possible to describe the formation of the covalent and atomic structures in general two-center systems. This model is also feasible to handle the reactions problem as well as the structure problem.

We have applied GTCM to even Be isotopes, ^{10,12,14,16}Be (= α + α + XN). In the analysis of Be isotopes, we have found a systematic change of the excited $J^\pi = 0^+$ level scheme, which is induced by the variation of the neutron number. We have also calculated the strength of the isoscalar and isovector monopole $0^+_{g.s.} \rightarrow 0^+_{ex.}$ transitions, which are important to identify the development of the cluster degrees of freedom. The GTCM calculations clearly shows the enhancement of the monopole transitions. The experimental data on the 0^+ levels and the respective monopole transitions have been especially accumulated in ^{12}Be, and these data are completely consistent to the GTCM calculation.

Furthermore, we have applied GTCM to various system beyond Be isotopes, such as the ^{10}C (=α + α + 2P) and ^{18}O (=α + ^{12}C + 2N) nuclei. A wide variety in the $J^\pi = 0^+$ level scheme and the monopole transitions can be seen in these systematic studies. The systematic studies of the molecular structures and the monopole transitions will be discussed.