Coexistence of cluster structure and mean-field-type structure in medium-weight nuclei

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We have studied the coexistence of cluster structure and mean-field-type structure in medium-weight nuclei using Antisymmetrized Molecular Dynamics (AMD) with a new type of constraint. We found that normal deformed and superdeformed bands of ^{40}Ca have non-small amount of α-^{36}Ar and ^{12}C-^{28}Si cluster structures, respectively. Furthermore, we found α-^{36}Ar higher-nodal band.

Nuclear structure dynamics has many degrees of freedom. As well known, relative motion between clusters is an important degree of freedom at least in light nuclei. It is usually considered that deformation of mean-field (for example, prolate shape, oblate shape and so on) is more important in heavier nuclei. But it is an open problem whether cluster structure is important in medium- and heavy-weight nuclei or not. Recently, many superdeformed states are found experimentally in medium-weight nuclei. The relation between clustering and superdeformation is also important problem.

Our interest in the coexistence of cluster structure and mean-field-type structure is in medium and heavy-weight nucleus, especially in $N \sim Z \gtrsim 20$ nucleus. We consider that cluster structure can be developed well due to proton-neutron correlation and Coulomb interaction in this region. Furthermore, those nucleus are important as path of rp-process.

In ^{40}Ca, it was suggested that $K^\pi = 0_2^+$ band has α-^{36}Ar cluster structure theoretically,[1] and the suggestion was supported by the experiment of ^{36}Ar(^{6}Li, d)^{40}Ca reaction.[2] Furthermore, it was suggested that superdeformed band has ^{12}C-^{28}Si cluster structure.[3]

For studying coexistence of cluster structure and mean-field-type structure, we proposed a new constraint of clustering for AMD, namely d-constraint.[4] By energy variation with d-constraint and quadrupole deformation constraint, we calculated wave functions of α-^{36}Ar cluster structure, ^{12}C-^{28}Si cluster structure and mean-field-type structure. Superposing these wave functions with various types of structures, we performed GCM calculation. We found that α-^{36}Ar cluster structure and ^{12}C-^{28}Si cluster structure were important components of normal deformed and superdeformed bands of ^{40}Ca, respectively. Furthermore, we found α-^{36}Ar higher-nodal band.

We will discuss effective interaction dependence between Gogny D1S and Skyrme (SLy7) force.

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