Study of the stable and unstable sd-pf nuclei with AMD

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The theoretical method of antisymmetrized molecular dynamics (AMD)[1,2] is one of the powerful approaches to investigate the stable and unstable nuclei. One of the merits of AMD is that it enables the variation after parity-projection which is essentially important to study the negative-parity states. Another merit of AMD is that it can investigate the cluster structure without assuming the existence of the cluster structures.

The vanishing of the N=20 shell closure is the one of the subject of great interest in light unstable nuclear physics. We discuss the low-lying states of neutron rich Ne isotopes (^{20,26,28,30}Ne) and ^{32}Mg including their negative-parity states by using the AMD. The ground states of ^{32}Mg and ^{30}Ne are largely deformed and the experimental data are reproduced well. As many other theoretical approaches have pointed out, these ground states have neutron $2p2h$ configurations. As the neutron number decreases, this $2pnh$ configuration shifts to the excited level, and in ^{26}Ne it forms the super deformed band about 7MeV above the ground state. This dominance of the intruder $2p2h$ configuration in the ground states of ^{32}Mg and ^{30}Ne implies that one or three neutrons can be promoted into pf shell with small excitation energies. Hence, the negative-parity states of these nuclei are expected to be located at low-energy region [3]. By using the Gogny force, it is found that their lowest negative-parity states which have spin-parity $1^-(K = 1^-)$ have small excitation energies compared to the stable N=20 isotones (the calculated energies are 2.0MeV for ^{32}Mg and 2.3MeV for ^{30}Ne) and that these states have neutron 3p3h configuration. Both nuclei also have 3^- states which have $1p1h$ configuration just above the lowest 1^- states. These low excitation energies of the negative parity states are directly related to the vanishing of the N=20 shell closure. When the neutron number decreases, the excitation energy of negative-parity level becomes higher rapidly and in ^{26}Ne it is about 5.5MeV.

As the second topic, we also discuss the ground and excited states of ^{40}Ca and ^{44}Ti. The cluster structures appearing in the ground states and low-lying states of these nuclei have been discussed theoretically for many years [4], and the parity-doublet bands have been experimentally observed [4]. Furthermore, beautiful rotational spectra associated with the super deformed bands have been observed in ^{40}Ca and ^{38}Ar recently [5]. We discuss the shape co-existence of these nuclei and its possible relation to the cluster structure.

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