Cluster-Gas States in Light Nuclei

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In self-conjugate $4n$ nucleus, the $\alpha$ cluster states with highest excitation energies are expected to lie near or above the $n\alpha$ dissociation threshold energy. One of the recent developments of nuclear cluster physics is the proposal and the investigation of the existence of the $n\alpha$ cluster-gas states near the $n\alpha$ dissociation threshold energy. In former days, although the second $0^+$ state of $^{12}\text{C}$ (Hoyle state) was concluded to have $3\alpha$ cluster-gas structure [1], the generality of the $\alpha$-gas state was not pursued in other $4n$ nuclei. Now the $\alpha$-gas character of cluster states is widely investigated mostly in relation with the viewpoint of Bose-Einstein condensation of alpha particles [2]. Cluster-gas states are now also investigated in non-$\alpha$ nuclei and in heavy-mass nuclei [3]. In contrast to the nucleon-gas state whose excitation energy is very high (about 100 MeV for $^{12}\text{C}$), cluster-gas states in light nuclei are expected to show up in low excitation-energy region where spectroscopic studies are possible. Thus cluster-gas states present us with an entirely new and important subject of nuclear structure in general.

In this talk we discuss studies of alpha-condensate-like states in $^{12}\text{C}$ and in $^{16}\text{O}$ which have been made by using THSR wave functions [2] and also by OCM approach. The Hoyle state of $^{12}\text{C}$ is almost confirmed as the $3\alpha$ condensate-like state and the 6th $0^+$ state at 15.1 MeV excitation energy in $^{16}\text{O}$ is suggested strongly as the the $4\alpha$ condensate-like state. We also comment on possible existence of excited cluster states having the structures including $^{12}\text{C}$ cluster in Hoyle state.

References

