Alpha-cluster structures in light hypernuclei

Y. Funaki[(a)], T. Yamada[(b)], E. Hiyama[(a)], K. Ikeda [(a)]

[(a)] Nishina Center for Accelerator-Based Science, RIKEN, Wako 351-0198, Japan
[(b)] Laboratory of Physics, Kanto Gakuin University Yokohama 236-8501, Japan

It is well established that the famous Hoyle state, the second 0^+ state in ^{12}C, has the 3α-particle condensate character, as a product state occupying a lowest and identical S-orbit[1-4], with a dilute gas-like structure of weakly interacting 3α particles. We also have proposed that the sixth 0^+ state of ^{16}O, observed around the 4α breakup shreshold, is the candidate of the α condensate state of 4α particles [3]. It is also interesting to investigate how the condensate character changes if a Λ particle is added to the condensates. In this contribution, we discuss the condensate $+\Lambda$ states and other alpha-cluster states in $^{13}_{\Lambda}$C. We introduce a new fully-microscopic cluster model wave function which we call Hyper-THSR wave function. This is based on the THSR (Tohsaki-Horiuchi-Schuck-Röpke) wave function, which has been used in the study of α condensates in light nuclei. We note that the THSR wave function gives extremely nice description of ^{12}C nucleus, and ^{8}Be as well [4]. Concerning the Λ hypernuclei, it should also be mentioned that the Hyper-THSR wave function is flexible and a shrinkage effect of, for example, the Hoyle state, by injecting the Λ particle, as pointed out in several previous papers [5-7], is easy to handle. We show that the Λ particle reduces the spatial size of the Hoyle state from $R_{\rm rms} = 3.8$ fm to $R_{\rm rms} = 2.8$ fm. According to the spatial shrinkage, the condensate fraction is also reduced from 70 % to 50 %. In the excited states of ^{12}C there are still a few mysterious 0^+ resonances which might have exotic cluster structures. The second 2^+ resonance state was also recently observed and is considered to be a family member of the α condensate[8]. We show that the Λ particle plays an interesting role as a probe to investigate the core ^{12}C nucleus, since it does not give any disturbance from the effect of the antisymmetrization to the core nucleus. The structures of the mysterious excited states are clarified by the Λ particle. For example, the 0^+_4 state is shown to have a clear 3α-linear-chain structure and the 0^+_3 state a $^{8}\mathrm{Be} + \alpha$ structure, together with the corresponding rotational band structures for 2^+ and 4^+ states.

[1] A. Tohsaki *et al.*, Phys. Rev. Let. **87**, 192501 (2001).

[2] Y. Funaki *et al.*, Phys. Rev. C **67**, 051306(R) (2003).

[3] Y. Funaki *et al.*, Phys. Rev. Lett. **101**, 081502 (2008).

[4] Y. Funaki *et al.*, Phys. Rev. C **80**, 064326 (2009).

[5] T. Yamada *et al.*, Prog. Theor. Phys. Suppl. **81**, 104 (1985).

[6] E. Hiyama *et al.*, Phys. Rev. Lett. **85**, 270 (2000).

[7] E. Hiyama and T. Yamada, Prog. Part. Nucl. Phys. **63**, 339 (2009).

[8] M. Itoh *et al.*, Phys. Rev. C **84**, 054308 (2011).

E-mail: funaki@riken.jp