Strong binding and shrinkage of double $\bar{K}$ nuclear system K^-K^-pp predicted by Faddeev-Yakubovsky calculations

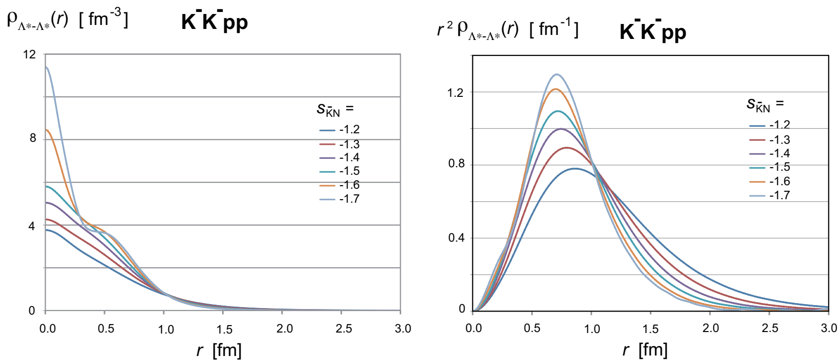
S. Maeda [1], Y. Akaishi[2], T. Yamazaki[2,3]

[1]Obihiro University of Agriculture and Veterinary Medicine, Obihiro, Hokkaido, Japan

[2]RIKEN, Nishina Center, Wako, Saitama 351-0198, Japan

[3]Department of Physics, University of Tokyo, Bunkyo-ku, Tokyo 113-0033, Japan

Comprehensive non-relativistic Faddeev and Faddeev-Yakubovsky calculations were made for K^-pp, K^-ppn, K^-K^-p and K^-K^-pp kaonic nuclear clusters, where the quasi bound states were treated as bound states by employing real separable potential models for the K^--K^- and the K^--nucleon interactions as well as for the nucleon-nucleon interaction [1]. The binding energies and spatial shrinkages of these states were obtained for various values of the $\bar{K}N$ interaction parameters ($s_{\bar{K}N}(I=0)$), and were found to increase rapidly with the $\bar{K}N$ attraction strength. Using the $\Lambda(1405)$ ($\equiv \Lambda^*$) ansatz with a PDG mass of 1405 MeV/c^2 for K^-p ($s_{\bar{K}N}(I=0) = -1.37$), the ground-state binding energies of 51.5 MeV (K^-pp), 69 MeV (K^-ppn), 30.4 MeV (K^-K^-p) and 93 MeV (K^-K^-pp) were obtained, showing good agreements with previous coupled-channel calculations [2]. The K^-K^-pp state has a significantly increased density where the two nucleons are located very close to each other, in spite of the short-range NN repulsion, leading to a growth of significantly high nuclear density region in the center of this double $\bar{K}$-nucleus. The fact that the recently observed binding energy of K^-pp [3, 4] is much larger (by a factor of 2) than the originally predicted ones is interpreted based on "clearing QCD vacuum" model of Brown, Kubodera and Rho [5], as due to the significant shrinkage of the $\bar{K}$-nuclei. Fig. 1 shows the distance distribution between two Λ^* clusters $\rho_{\Lambda^*\Lambda^*}(r)$ calculated from the obtained K^-K^-pp wave function, for various values of $s_{\bar{K}N}(I=0) = -1.2$ to -1.7.



References

[1] S. Maeda, Y. Akaishi and T. Yamazaki, Proc. Jpn. Acad. Ser. B **89**, 418-437 (2013).

[2] T. Yamazaki and Y. Akaishi, Phys. Lett. B **535**, 70-76 (2002).

[3] T. Yamazaki *et al.*, Phys. Rev. Lett. **104**, 132502 (2010).

[4] Y. Ichikawa *et al.*,, Prog. Theor. Exp. Phys. 021D01 (2015).

[5] G.E. Brown, K. Kubodera and M. Rho, Phys. Lett. B **192**, 273-278 (1987).