Strong binding and shrinkage of single and double $\bar{K}$ nuclear systems (K^-pp, K^-ppn, K^-K^-p and K^-K^-pp) predicted by Faddeev-Yakubovsky calculations

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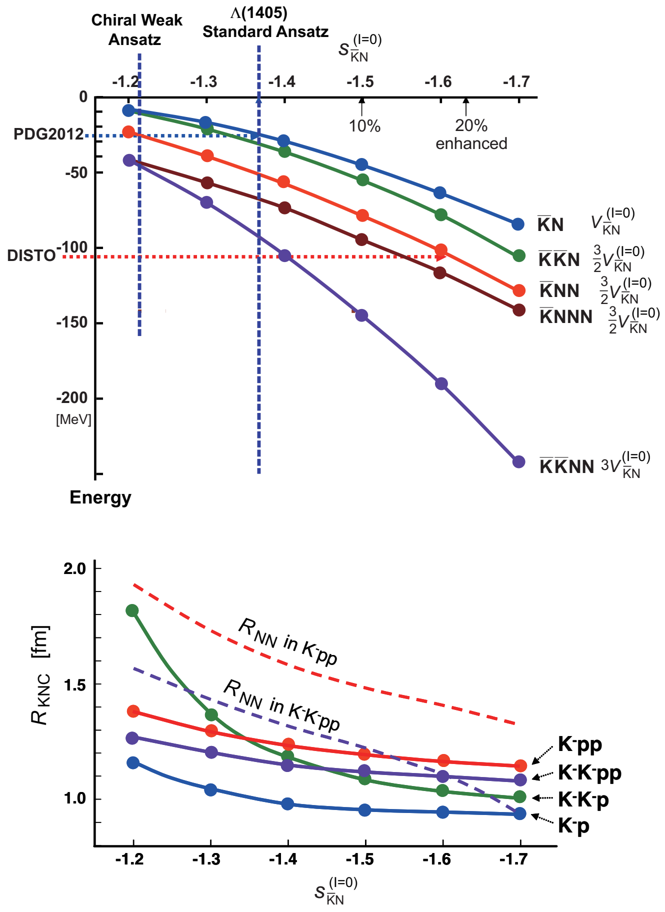

Fig. 1. Global view of the calculated bound-state energies (upper) and sizes (lower), $R_{\rm KNC}$ and R_{NN} of $\bar{K}$ nuclear clusters as functions of the $\bar{K}N$ interaction strength, $s_{\bar{K}N}^{(I=0)}$, which is normalized so as to be -1 at the binding threshold. The zones of the standard "Λ(1405) ansatz" ($s = -1.37$) and the "Chiral" ansatz ($s = -1.22$) are shown by vertical broken lines. The experimental value of the mass of K^-pp as observed by DISTO[7] is shown by a horizontal broken line, where a relativistic correction for the binding energy around 10 MeV is not taken into account.

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, obtained for various values of the $\bar{K}N$ interaction, were found to increase rapidly with the $\bar{K}N$ interaction strength. Their behaviors are shown in a reference diagram, Fig. 1, where possible changes by varying the $\bar{K}N$ interaction in the dense nuclear medium are given. Using the Λ(1405) ansatz with a PDG mass of 1405 MeV/c^2 for K^-p, the following ground-state binding energies together with the wave functions were obtained: 51.5 MeV (K^-pp), 69 MeV (K^-ppn), 30.4 MeV (K^-K^-p) and 93 MeV (K^-K^-pp), which are in good agreement with previous results of variational calculation based on the Akaishi-Yamazaki coupled-channel potential[2–5)]. 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 inner NN repulsion. Relativistic corrections on the calculated non-relativistic results indicate substantial lowering of the bound-state masses, especially of K^-K^-pp, toward the kaon condensation regime. The fact that the recently observed binding energy of K^-pp[7)] is much larger (by a factor of 2) than the originally predicted one may infer an enhancement of the $\bar{K}N$ interaction in dense nuclei by about 25%, possibly due to chiral symmetry restoration. In this respect some qualitative accounts are given based on "clearing QCD vacuum" model of Brown, Kubodera and Rho.[8)]

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