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The history and future of hadronic-molecule/cluster with strangeness

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Mesons are known to behave as virtual particles in nuclei, repeatedly being created and annihilated rapidly so as to form a nuclear potential. In contrast, R. H. Dalitz suggested in the 1960s that the Λ(1405) can be a peculiar $\bar{K}N$ system, i.e., a nucleon and a $\bar{K}$ meson molecule-like hadronic cluster.

However, there was no clear experimental evidence to strongly support this hypothesis at that time. In 1997, atomic kaonic hydrogen data suggested a strong attraction between kaon and proton, sufficient to form a two-body nuclear bound state. This data triggered a variety of intensive search experiments to confirm the discovery of the kaonic nuclear bound states ($A \geq 2$). This is because the existence of a kaonic nuclear state is a natural interpretation of the Λ(1405), to be a molecule-like $\bar{K}N$ hadronic cluster.

Recently, very clear peak formation below "K−pp"binding threshold (mass ummation of a K− and two protons) was observed in the Λp invariant mass spectrum of the K− + 3He → (Λp) + n′ reaction. The most simple interpretation is that the nucleon knockout reaction K−N → $\bar{K}$n′ initiates $\bar{K}N$ N state (charge +1, isospin 1/2 and decay to Λp) formation. In other ords, the peak is the signal of the simplest kaonic nuclear bound state, "K−pp", a $\bar{K}$ meson behaves as a quasi-on-mass-shell particle and forms its own quantum state together with two nucleons. Very interestingly, a simple form(structure)-factor analysis of the experimental data on the "K−pp"signal suggested that this state may be extremely compact compared to the normal inter-nucleon distance in nuclei. This might lead us to explore physics beyond the normal nuclear saturation density in a quantum equilibrium, via the detailed systematic study on light kaonic nuclei utilizing new ~ 4π spectrometer system under construction. This spectrometer system could be utilized to search for other hadronic-molecule with strangeness such as "φn"two-body bound state, recently predicted by lattice QCD.

In this talk, we'll describe the $\bar{K}N$ interaction study via the x-ray spectroscopy, exploring experiments to identify kaonic nuclear bound states, and the future prospects of the experimental study on molecule-like hadronic cluster with strangeness ($\bar{K}$ and φ), in relation to quark-confinement and in conjecture with the quark-hadron cross over scenario

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