Status of K^-pp search experiments

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Kaonic nuclei are a new type of hadron many-body system with strangeness degrees of freedom, if existed. It is a bound system of meson and baryons instead of baryon many-body systems such as hypernuclei. Among them, so-called "K^-pp" system which is composed of a K^- and two protons is in strong focus as the simplest case. There is a possibility that the system has a large binding energy of > 60 MeV which could reach a high nuclear density close to twice the normal nuclear matter density. Thus, the experimental confirmation of the existence of kaonic nuclei or "K^-pp" is an urgent task in this field.

A lot of experimental searches are recently carried out or on-going in various facilities in the world. In SPring-8/LEPS, a search for the "K^-pp" was carried out in the $\gamma + d \to K^+\pi^- + X$ reaction at $E_\gamma = 1.5-2.4\ GeV$. Because of a large background from $K^+\Lambda(1520)$ and $K^+\pi^-\pi\Lambda\Sigma$ processes, they were only able to put the upper limits of the production cross section of the order of 10-20% of typical hyperon production cross sections, when the decay width is assumed to be Γ=100 MeV.

HADES collaboration has reported their partial wave analysis result on the reaction of $p(3.5\ \text{GeV}) + p \to pK^+\Lambda$ to search for the "K^-pp". They also put the upper limit for the "K^-pp" production cross section of about 4 μb, while the $\Lambda(1405)$ production cross section at this energy is about 10μb.

At J-PARC, there are two experiments, E15 and E27, on the "K^-pp" search. The E15 collaboration just reported a semi-inclusive spectrum of the $^3\text{He}(K^-, n)$ reaction at 1 GeV/c with a preliminary data. They estimated the upper limit of the "K^-pp" production cross section to be 100–270 μb/sr in the case of Γ=100 MeV, which is about 5% of the quasi-elastic $\bar{K}N$ cross section. In E27 experiment, the "K^-pp" search was carried out in the $d(\pi^+, K^+)$ reaction at 1.69 GeV/c. In order to enhance the signal to background ratio, high-momentum proton ($\geq$250 MeV/c) coincidence in the large scattering angles was requested. Such proton coincidence probability showed a large bump structure centered at around 2.27 GeV/c^2 for the "K^-pp" mass, in addition to the rather sharp structure of $\Sigma N \to \Lambda N$ cusp and conversion process near 2.13 GeV/c^2. With two-proton coincidence condition, the decay modes of the "K^-pp" into Λp, $\Sigma^0 p$, and $\pi Y p$ were separated in the missing energy. From the mass distribution obtained for the $\Sigma^0 p$ decay mode, the mass and width of the "K^-pp" were obtained to be $2275^{+17}_{-18}(stat)^{+21}_{-30}(syst)$ MeV/c^2 and $162^{+87}_{-45}(stat)^{+66}_{-78}(syst)$ MeV, respectively. It corresponds to the binding energy of $95^{+18}_{-17}(stat)^{+30}_{-21}(syst)$ MeV.

In this talk, the above experimental data and their implications will be discussed.