Theoretical study of a prototype system of kaonic nuclei “Kpp”

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In strange nuclear physics and hadron physics, kaonic nuclei (nuclear system with anti-kaons ($K^{\text{bar}}$)) have been a hot topic since the formation of dense state are interestingly expected due to the strong $K^{\text{bar}}N$ attraction. To reveal the nature of kaonic nuclei, which could be an exotic system, lots of efforts have been devoted to the study of a prototype system of kaonic nuclei, “Kpp”. Especially, now is the very exciting time because new experimental results are being reported from two groups of J-PARC (E15 and E27). We are theoretically investigating the $Kpp$ with a coupled-channel Complex Scaling Method (ccCSM) which was proposed in our previous work [1]. This method can treat simultaneously coupled-channel problem and resonance problem which are important ingredients in the study of $Kpp$. Recently, we have developed a handy method, so-called ccCSM+Feshbach method. The $Kpp$ is actually a coupled-channel system of $K^{\text{bar}}NN$-$\pi \Sigma N$-$\pi \Lambda N$. However, we can treat it as a single-channel problem of $K^{\text{bar}}NN$ by a tricky use of ccCSM.

As a result of careful calculation with the ccCSM+Feshbach method using an energy-dependent potential based on chiral SU(3) theory [1], we find that the $Kpp$ is not so deeply bound with ~30 MeV binding. The decay width depends on a parameter and ansatz for the treatment of energy dependence; 20–60 MeV. Analyzing the ccCSM wave function, we find that the mean distance of two nucleons in the $Kpp$ is found to be ~2.2 fm which is almost equal to the $NN$ distance in normal nuclear matter. (In the figure, a result obtained with non-relativistic kinematics is shown.)

In the talk, we will report further results obtained with other versions of $K^{\text{bar}}N$ potential and those in the semi-relativistic kinematics. We hope to discuss on comparison of our result and the J-PARC experimental results.

Reference