Hyperon-hyperon interactions based on quark-model baryon-baryon interactions

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Compared with nucleon-nucleon ($NN$) and hyperon-nucleon ($YN$) interactions, we have a lot of ambiguity about hyperon-hyperon ($YY$) interactions since there is no scattering data. In order to understand the properties of $LL$ interactions, it is planned to perform the systematic search of $\Lambda\Lambda$ hypernuclei at the J-PARC facility. The purpose of this work is to construct the $YY$ interaction based on the constituent quark model and to study the structure of $\Lambda\Lambda$ hypernuclei such as $^6_{\Lambda\Lambda}\text{He}$ ($= \alpha + 2\Lambda$) and $^{10}_{\Lambda\Lambda}\text{Be}$ ($= 2\alpha + 2\Lambda$) through the three- and four-body calculations using Gaussian expansion method (GEM) [1], respectively. These hypernuclei are very good tests for $\Lambda\Lambda$ interactions since they were already observed.

The quark-model baryon-baryon (QM $BB$) interactions developed by Kyoto-Niigata group have achieved an accurate description of $NN$ and $YN$ experimental data [2]. QM $BB$ interactions are constructed in the framework of resonating-group method (RGM) for two three-quark clusters. One of the main feature of QM $BB$ interactions is the treatment based on the $SU_6$ spin-flavor symmetry. This symmetry governs broad features of $BB$ interactions in each channel. The lattice QCD calculation [3] gives consistent results with those predicted by QM $BB$ interactions. These QM $BB$ interactions, FSS and fss2, have been successfully applied to light ordinary nuclei, hypernuclei ($^3\Lambda\text{H}$, $^3\Lambda\text{H}$ [4], $^9_{\Lambda\Lambda}\text{Be}$ [5] and $^6_{\Lambda\Lambda}\text{He}$ [6]) and the nucleon-deuteron scattering system [7] through Faddeev calculations.

However, the quark structure of the baryon makes QM $BB$ interactions hard to deal with on the applications to more complex systems. From the RGM formalism, QM $BB$ interactions are nonlocal and have the linearly energy dependent term. The energy dependence is eliminated by the off-shell transformation [8]. We have already constructed the energy-dependent nonlocal Gaussian potential [9] based on the QM $NN$ interaction fss2 [10]. We are now constructing the energy-independent version of this Gaussian potential, extending to $YN$ and $YY$ channels and plan to apply it to GEM calculations for the light $\Lambda\Lambda$ hypernuclei.