Exotic dibaryons with a heavy antiquark

Yasuhiro Yamaguchi[1], Shigehiro Yasui[2] and Atushi Hosaka[1]
[1] *Research Center for Nuclear Physics (RCNP), Osaka University, Ibaraki, Osaka 567-0047, Japan*
[2] *KEK Theory Center, Institute of Particle and Nuclear Studies, High Energy Accelerator Research Organization, 1-1, Oho, Ibaraki, 305-0801, Japan*

The recent experimental discoveries of quarkonium-like states in the heavy quark region have been motivated us to explore exotic hadrons. Especially, many of these states observed near the threshold are suggested that they are loosely bound states of two hadrons, called as hadronic molecules or hadronic composites. The hadronic molecules inspire us to investigate not only meson-meson molecules which would explain structures of quarkonium-like states, but also a meson-baryon molecules. We have been also studied molecular states formed by $\bar{D}N$ and BN states for two-body systems in Refs. [1, 2]. In the molecules, one pion exchange potential (OPEP) plays a crucial role to yield bound and resonant states.

Here, we discuss possibility existence of mesonic nuclei with a heavy antiquark, $\bar{D}NN$ and BNN for three-body systems. Because there is no quark-antiquark annihilation, these states are genuine exotic dibaryons, which don't couple to other hadronic channels, such as $\pi\Lambda_c N$ and $\pi\Sigma_c N$. These exotic dibaryons have never been investigated in the literature so far, while there have been several studies for many-body $\bar{D}(B)$ mesonic nuclear systems [3, 4]. They provide useful information on interactions between heavy meson and nucleon, a impurity effect, e.g. glue-like effect, which is not observed in normal nuclei, and so forth.

The OPEP plays an important role to compose a bound state as discussed in Refs [1, 2]. Especially, a tensor force of the OPEP, coming from the couplings of the s-wave state of PN and d-wave state of P^*N by changing the relative orbital angular momentum by 2 ($\Delta L = 2$), generates a strong attraction. Here, we denote heavy pseudoscalar meson $P = \bar{D}, B$ and heavy vector meson $P^* = \bar{D}^*, B^*$. The OPEP is enhanced by the mass degeneracy of P and P^*.

We perform variational calculations for PNN employing the OPEP as PN potential, and the Argonne v_8' potential [5] as a realistic NN potential. By diagonalizing Hamiltonian with the gaussian basis [6], we obtain a bound energy. In addition, we apply the complex scaling method [7] to deal with a resonance.

As a result, we find a bound state in the $(I, J^P) = (1/2, 0^-)$ and a resonance in the $(I, J^P) = (1/2, 1^-)$. The energy levels for $\bar{D}NN$ and BNN states are displayed in Fig. 1. It is turned out that the tensor force of OPEP in the PN interaction produces a strong attraction. This is particularly so for the heavy quark sector, where P and P^* mesons degenerate. Hence, the binding energy of BNN is larger than that of $\bar{D}NN$.

For the resonance in the $(I, J^P) = (1/2, 1^-)$, we find an interesting structure. When the $\bar{D}NN$ channels are switched off and only $\bar{D}^*NN$ channels are considered, we obtain a bound state of $\bar{D}^*NN$ state. The bonding energy are -13.6 MeV for the $\bar{D}^*NN$, measured from $\bar{D}^*NN$ threshold and -35.8 MeV for the B^*NN, measured from B^*NN threshold. Therefore, these resonances are the Feshbach resonances.

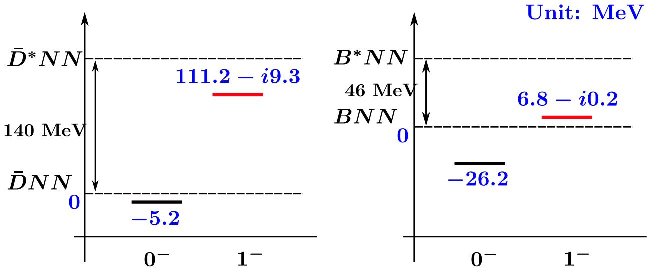

Figure 1: Energy levels of $\bar{D}NN$ and BNN for $I = 1/2$ with $J^P = 0^-$ and 1^-. The energies are either pure real for bound states or complex for resonances, measured from $\bar{D}NN$ or BNN thresholds. The complex energies for resonances are written as $E_{re} - i\Gamma/2$, where E_{re} is resonance energy and $\Gamma/2$ is the half width.

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