Lattice determination of baryon-baryon potentials

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We present some of our recent results on the baryon-baryon potentials from lattice QCD. We begin with a brief review of our method to calculate hadron-hadron potentials from lattice QCD (HAL QCD method). From equal-time Nambu-Bethe-Salpeter (NBS) wave functions generated on the lattice, it is used to determine hadron-hadron potentials based on the first principle calculation of lattice QCD. The method has been applied to many systems such as NN, YN, YY, NNN, etc. It is one of the best advantages of our method that YN and YY potentials can be obtained in the form of coupled channel even if they are calculated in the finite spatial volume. This is supported by the fact that the potentials are compact objects in the spatial region so that they can be obtained regardless of the boundary conditions imposed on the spatial infinity. Note that it can be formally proved that the resulting potentials are faithful to the scattering data. It is possible to apply this method to the p-wave potentials including spin-orbit(LS) potentials of nuclear/hyperon forces and the anti-symmetric LS potentials of hyperon forces. The result is used to discuss the cancellation between the symmetric and the anti-symmetric LS potentials of ΛN potential. Through the hadron potentials, it can be used to study hadronic bound sates, resonances and exotic hadrons. Recent progress of high performance super computers is remarkable, which makes it possible for the lattice QCD to perform more realistic calculations. Indeed, the baryon-baryon potentials are being calculated by using the physical point gauge configurations ($m_\pi \simeq 145$ MeV) on a large spatial volume ($L \simeq 8$ fm). Now would be the best time to determine the realistic hyperon potentials by making collaborations between lattice QCD and experimental/theoretical hyper nuclear physics.

[1] N. Ishii, S. Aoki, T. Hatsuda, Phys. Rev. Lett. **99**, 022001 (2007).
[2] H. Nemura, N. Ishii, S. Aoki, T. Hatsuda, Phys. Lett. **B673**, 136 (2009).
[3] S. Aoki, T. Hatsuda, N. Ishii, Prog. Theor. Phys. **123**, 89 (2010).
[4] T. Inoue et al. (HAL QCD Coll.), Prog. Theor. Phys. **124**, 591 (2010).
[5] T. Inoue et al. (HAL QCD Coll.), Phys. Rev. Lett. **106**, 162002 (2011).
[6] K. Murano et al. (HAL QCD Coll.), Prog. Theor. Phys. **125**, 1225 (2011).
[7] S. Aoki et al. (HAL QCD Coll.), Proc. Jap. Adad. **B87**, 509 (2011).
[8] T. Doi et al. (HAL QCD Coll.), Prog. Theor. Phys. **127**, 723 (2012).
[9] T. Inoue et al. (HAL QCD Coll.), Nucl. Phys. **A881**, 28 (2012).
[10] N. Ishii et al. (HAL QCD Coll.), Phys. Lett. **B712**, 437 (2012).
[11] S. Aoki et al. (HAL QCD Coll.), Prog. Theor. Exp. Phys. **2012**, 01A105(2012).
[12] S.. Aoki et al. (HAL QCD Coll.), Phys. Rev. **D87**, 034512 (2013).
[13] T. Kurth, N. Ishii, T. Doi, S. Aoki, T. Hatsuda, JHEP **12**, 015 (2013).
[14] Y. Ikeda et al. (HAL QCD Coll.), Phys. Lett. **B729**, 85 (2014).
[15] S. Aoki et al. (HAL QCD Coll.), Phys. Rev. **D88**, 014036 (2013).
[16] T. Inoue et al. (HAL QCD Coll.), Phys. Rev. Lett. **111**, 112503 (2013).
[17] K. Murano et al. (HAL QCD Coll.), Phys. Lett. **B735**, 19 (2014).
[18] F. Etminan et al. (HAL QCD Coll.), Nucl. Phys. **A928**, 89 (2014).