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Heavy quark in exotic hadron and nuclear systems[1]

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In recent years, it has turned out that heavy hadrons with charm and bottom flavors have rich structures, which are different from simple quark-antiquark or three-quark systems. The new states of heavy hadrons are called exotic hadrons X, Y and Z. The subjects are now covering not only exotic hadrons but also exotic "nuclei" in which heavy hadrons are bound. The purpose of the presentation is to discuss the general properties of exotic states of hadrons and nuclei with heavy quarks [1]. We begin our discussion by the heavy quark spin (HQS) symmetry in the heavy quark limit, and show that all heavy hadrons are classified by the HQS symmetry, i.e. either HQS singlet or doublet. Next, in order to discuss the long-range physics of exotic hadrons, we introduce the heavy hadron effective theory according to the HQS symmetry in heavy quark sector as well as by chiral symmetry in light quark sector. As examples, we investigate the theoretically possible states of hadronic molecules with an anti-D meson (B meson) and nucleons with baryon number one [2], two [3] and infinity (i.e. nuclear matter) [4]. Calculating the energies, we show that many of them exhibit the HQS doublets. Beyond the leading order in heavy quark limit, we further discuss the 1/M corrections with heavy hadron mass M, and show that finding the HQS-breaking (non-breaking) terms at 1/M is important to investigate the magnetic (electric) gluons in the heavy hadrons in nuclear medium [1,5].

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