Charm hadrons in nuclear systems

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Charm hadrons in nuclear systems are important topics in flavored nuclei. A new insight can be drawn from the heavy mass of charm quark. The heavy quark symmetry, which is a new symmetry in the heavy quark, plays an important role for understanding the properties of nuclear systems with a heavy quark, such as the hadron-nucleon interaction, the medium effects, and so on. In this presentation, we discuss new aspects from the recent works about the heavy quark nuclear systems.

(1) *Probing gluon fields in nuclear systems* [1]. The heavy quark effective theory, which is an effective theory of QCD for a heavy quark, is an important theoretical tool to analyze the heavy quark dynamics. The HQET Lagrangian is given by a series of $1/m_Q$ with a heavy quark mass m_Q. In the leading term the heavy quark symmetry, namely the spin symmetry for a heavy quark, is the basic symmetry, and in the next-to-leading term, the heavy quark symmetry is violated. This series expansion is realized in the mass of the heavy quark systems. We apply this scheme to the nuclear matter with a heavy quark, and analyze the mass terms as a series of $1/m_Q$. Interestingly, those terms are related to the expectation values of the gluon fields in medium, and hence they can be used to discuss the strength of the gluon fields in nuclear matter. In order to numerically evaluate them, we introduce the effective fields for heavy hadrons and utilize the heavy hadron effective theory which reflects the heavy quark symmetry in the heavy quark effective theory at the quark level. As an concrete example, we consider the $\bar{D}$, $\bar{D}^*$ (B, B^*) mesons in nuclear matter, and present how the gluon fields change in nuclear matter.

(2) *Nuclear Kondo effect* [2]. In condensed matter systems, it is known that the impurity with finite spin (atom) causes the instability of the Fermi surface of the electron gas, and leads to the strong enhancement of the scattering amplitudes of the impurity and the electrons. This is called the *Kondo effect*. This phenomena is given when the following three conditions are satisfied; the non-Abelian interaction (eg. spin-spin interaction) and the loop effects from the virtual creation of particle-hole pairs near the Fermi surface. Those conditions are fulfilled in nuclear matter with having a $q\bar{Q}$ meson as an impurity. In this case, the non-Abelian interaction is provided from the isospin-isospin interaction. With a setup of the simple model, we obtain the Kondo scale characterizing the energy scale for the Kondo effect, and present that the Kondo effect can occur in the nuclear matter having a $q\bar{Q}$ meson.

[1] S. Yasui and K. Sudoh, Phys. Rev. C89, 015201 (2014).

[2] S. Yasui and K. Sudoh, Phys. Rev. C88, 015201 (2013).