Contribution ID: **48** Type: **not specified**

Compositeness of near-threshold states with Coulomb plus short range interaction

Wednesday, April 2, 2025 3:50 PM (20 minutes)

In hadron physics, the near-threshold exotic hadrons have been actively studied, motivated by the recent experimental reports. One of the possible internal structures of exotic hadrons is the hadronic molecular state, which is the composite state of two hadrons. The fraction of the hadronic molecular component in the wavefuction is called the compositeness [1]. Through an analysis of the internal structure using the compositeness, the universal nature of near-threshold states has been studied. It is shown that when hadrons scatter through the short-range interaction, the shallow bound states near the threshold are usually dominated by the hadronic molecular component, which is consistent with the expectation from the low-energy universality [2]. In contrast, near-threshold resonances which exist above the threshold are found to have the completely different structure from shallow bound states [3].

In addition to the short range interaction, the Coulomb force acts between the charged hadrons. In contrast to the case with the short-range interaction, the general internal structure of near-threshold states of the Coulomb plus short-range interaction have not been understood yet. In hadron physics, Coulomb force is usually neglected because the short-range interaction is much stronger. However, in addition to the short-range interaction, also the long-range Coulomb force is expected to play an important role in the near-threshold energy region. In fact, with the presence of the Coulomb force, the low-energy scatterings exhibit different properties compared to the case with the short range interaction [4].

In this work, we focus on the near-threshold states with the Coulomb plus short range interaction. The universal nature of the systems with the Coulomb plus short-range interaction can be described with the zero-range model whose length scales are given by the Coulomb scattering length a_s and the Bohr radius a_B [5]. Here we adopt the low-energy scattering theory with the Coulomb effective range r_e in Ref. [6] to describe the scatterings in the larger momentum region. We investigate the scattering length dependence of the eigenenergy both for the Coulomb attractive and repulsive cases. We demonstrate that the bound state directly turns into the resonance with the variation of the scattering length for Coulomb repulsive case [5]. We then calculate the compositeness, and find that the near-threshold nature is determined by the competition of the short-range interaction and the Coulomb interaction. If the Bohr radius a_B is larger than the magnitude of the Coulomb effective range |r_e|, it is expected that the low-energy universality associated with the short-range interaction emerges before the Coulomb interaction becomes dominant, as the binding energy is decreased. In this case, the compositeness increases near the threshold as the remnant of the short-range universality. On the other hand, when a_B < |r_e|, we show that the compositeness does not increase even near the threshold, because the system does not exhibit the universal nature due to the Coulomb interaction. As an application of this framework, we discuss the internal structure of hadrons, nuclei, and atoms.

[1] T. Kinugawa and T. Hyodo, [arXiv:2411.12285 [hep-ph]].
[2] T. Kinugawa and T. Hyodo, Phys. Rev. C 109, no.4, 045205 (2024).
[3] T. Kinugawa and T. Hyodo, [arXiv:2403.12635 [hep-ph]].
[4] H. A. Bethe, Phys. Rev. 76, 38-50 (1949).
[5] S. Mochizuki and Y. Nishida, Phys. Rev. C 110, no.6, 064001 (2024).
[6] W. Domcke, J. Phys. B: Atom. Mol. Phys. 16, 359 (1983).

Presenter: KINUGAWA, Tomona (Tokyo Metropolitan University)

Session Classification: Parallel Session (B)