Medium effects to $N^*(1535)$ resonance and η mesic nuclei

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Study of in-medium properties of hadrons has attracted continuous attention and is one of the most interesting topics of contemporary nuclear physics. Investigation of bound states of hadrons in nucleus gives us much information which is hard to observe in usual scattering processes. On the other hand, recently it was suggested that some effects of chiral restoration could be seen even in the normal nuclear density, and the in-medium properties of hadrons are interesting also in the aspect of chiral symmetry.

It is reported that the mass of $N(1535)$ (N^*) is reduced as the chiral order parameter decreases in the QCD sum rule [1] and in the chiral doublet model [2]. Considering the fact that the N^* mass in free space lies only 50 MeV above the ηN threshold, the in-medium potential of the η meson will be strongly sensitive to the medium modification of the N^* mass.

In this talk, we discuss in-medium properties of the nucleon resonance N^* through the structure and formation of the η-nucleus bound systems (η mesic nuclei). Special features of the η mesic nucleus to investigate in-medium N^* are as follows; (1) The isoscalar particle η filters out contaminations of the isospin 3/2 excitations in nuclear medium. (2) η-N system dominantly couples to N^* at the threshold region. (3) Due to the s-wave nature of the ηNN^* coupling there is no threshold suppression like the p-wave coupling. This N^*-dominance in η-N system gives advantage in investigations of N^* compared with other nucleon resonances through the π-N system, for instance $N(1440)$ and $N(1520)$.

To calculate the optical potential of η meson in nucleus, we use the N^*-dominance picture and the chiral doublet model to incorporate the medium effect to N^* resonance in chiral symmetric way. The chiral doublet model embodies the reduction of the mass difference of N and N^* associated with the partial restoration of chiral symmetry.

We found that the shape and the depth of the η-nucleus optical potential are strongly affected by the properties of N^* and nucleon in nuclear medium. Especially, enough reduction of the mass difference of N and N^* gives the repulsive core of the η-nucleus potential at the center of nucleus. With attractive part at the surface of nucleus, the optical potential of η becomes 'central-repulsive and surface-attractive', which is concluded as a general feature of the potential. With this new potential, we calculate the bound state properties of η-nucleus system and show an interesting level structure. We also evaluate the (d,^{3}He) spectra for the formation of these bound states to investigate the experimental feasibility. We also make comments on the possible existence of the extremely deep bound states of η due to the energy dependence of the optical potential and of the halo-like η states in β-unstable halo nuclei.

References

[1] D. Jido, N. Kodama and M. Oka, Phys. Rev. **D54**, 4532 (1996).
[2] H. Kim, D. Jido and M. Oka, Nucl. Phys. **A640**, 77 (1998).