η' meson under partial restoration of chiral symmetry in nuclear medium

Daisuke Jido[(a)], Hideko Nagahiro[(b)], Satoru Hirenzaki[(b)],

[(a)] Yukawa Institute for Theoretical Physics, Kyoto University, Kyoto 606-8502, Japan
[(b)] Department of Physics, Nara Women's University, Nara 630-8506, Japan

In this talk, we shed light upon the η' meson mass in nuclear matter in the context of partial restoration of chiral symmetry, pointing out that the $\mathrm{U}_A(1)$ anomaly effects causes the η'-η mass difference necessarily through the chiral symmetry breaking. As a consequence, it is expected that the η' mass is reduced by order of 100 MeV in nuclear matter where partial restoration of chiral restoration takes place, and that this strong attraction does not accompany large absorption of η' into the nuclear medium [1].

The peculiarly larger mass of the η' meson than the other light pseudoscalar mesons is explained by explicit breaking of the $\mathrm{U}_A(1)$ chiral symmetry owing to quantum gluon dynamics. It is also known that the η' spectrum strongly depends on the breaking pattern of chiral symmetry [2]. Because the flavor singlet and octet pseudoscalar mesons belong to the same chiral multiplet $(\mathbf{3}, \bar{\mathbf{3}}) \oplus (\bar{\mathbf{3}}, \mathbf{3})$ of the $\mathrm{SU}(3)_L \otimes \mathrm{SU}(3)_R$ group in the chiral limit, when the chiral symmetry is restored, the flavor singlet and octet spectra should degenerate, no matter how the $\mathrm{U}_A(1)$ anomaly depends on the density [1]. This means that the η and η' mass splitting can take place only with (dynamical and/or explicit) chiral symmetry breaking.

Recent experimental observations of pionic atoms, especially deeply bound states in Sn isotopes, and low-energy pion-nucleus scattering have figured out whether the partial restoration does take place in nuclei with order of 30% reduction of the quark condensate. Assuming that the mass difference of η and η' comes from the quark condensate linearly, it is expected that an order of 150 MeV attraction for the η' meson coming from partial restoration of chiral symmetry in nuclear medium. Because the attraction is caused by the suppression of the $\mathrm{U}_A(1)$ anomaly effect in the nuclear medium, the influence acts selectively on the η' meson and, thus, it does not induce inelastic transitions of the η' meson into lighter mesons in nuclear medium. Consequently, the η' absorption in nuclear matter can be small, which is consistent with the recent experimental finding of the transparency ratio. Therefore, we conclude that the present mechanism of the η' mass reduction leads to the possibility of so narrow bound states of the η' meson in nuclei to be observed in hadronic reactions with light nuclear targets [3,4].

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E-mail: jido@yukawa.kyoto-u.ac.jp