The peculiarly larger mass of the $\eta'$ meson than the other light pseudoscalar mesons is explained by explicit breaking of the $U_A(1)$ chiral symmetry owing to quantum gluon dynamics. It is also known that the $\eta'$ 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 $(\bar{3}, \bar{3}) \oplus (\bar{3}, 3)$ of the $SU(3)_L \otimes SU(3)_R$ group in the chiral limit, when the chiral symmetry is restored, the flavor singlet and octet spectra should degenerate, no matter how the $U_A(1)$ anomaly depends on the density [1]. This means that the $\eta$ and $\eta'$ 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 $\eta$ and $\eta'$ comes from the quark condensate linearly, it is expected that an order of 150 MeV attraction for the $\eta'$ meson coming from partial restoration of chiral symmetry in nuclear medium. Because the attraction is caused by the suppression of the $U_A(1)$ anomaly effect in the nuclear medium, the influence acts selectively on the $\eta'$ meson and, thus, it does not induce inelastic transitions of the $\eta'$ meson into lighter mesons in nuclear medium. Consequently, the $\eta'$ 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 $\eta'$ mass reduction leads to the possibility of so narrow bound states of the $\eta'$ meson in nuclei to be observed in hadronic reactions with light nuclear targets [3,4].


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