Formation of $\eta'(958)$ bound states in nuclei

S. Hirenzaki, D. Jido$^a$, H. Nagahiro

Department of Physics, Nara Women’s University, Nara 630-8506, Japan
$^a$Department of Physics, Tokyo Metropolitan University, Tokyo, 192-0397, Japan

zaki@cc.nara-wu.ac.jp

The $\eta'(958)$ meson is an interesting and important particle because of its exceptionally large mass and connection to the $U_A(1)$ problem, where the gluon dynamics is believed to play important role to give peculiarly larger mass to the $\eta'$ meson than those of the other pseudoscalar mesons, $\pi$, $K$, and $\eta$. However, we have not yet understood the $\eta'$ mass generation mechanism quantitatively.

Recently, important developments have been reported in theoretical [1-3] and experimental [4] point of view for the study of the $\eta'$ mass and the $\eta'$-nucleus systems. Theoretically, it has been pointed out [1] that the anomaly effect can contribute to the $\eta'$ mass only with the presence of the chiral symmetry breaking, which naturally leads to a conclusion of a relatively large mass reduction ($\sim 100$ MeV) of the $\eta'$ mass at normal nuclear density due to the partial restoration of chiral symmetry. The mass reduction at finite density is considered to be equivalent to the attractive meson-nucleus interaction in the equation of motion, which may support the existence of the bound states, $\eta'$ mesic nuclei. The recent study based on the theoretical optical potential has concluded the possible existence of the bound states [2] assuming the sign of the real part of the $\eta'N$ scattering length which is not known. Thus, the study of the $\eta'$ properties at finite density by observing the $\eta'$ mesic nuclei is extremely interesting for the studies of the $\eta'$ mass generation mechanism and the $U_A(1)$ problem. The formation reaction of the $\eta'$ mesic nuclei was first studied in [5] and is considered to be possible in the actual experiments at GSI [3,4] recently.

In this report, we show the theoretical formation spectra of the $\eta'$-nucleus systems in the hadron reactions such as $(p,d)$ [3,4] based on the latest theoretical considerations of the $\eta'$ properties in nucleus [1,2]. The results shown here are important to give predictions for the future experiment [4], and to make clear relations between the $\eta'$ mesic nucleus formation spectra and the modifications of the $\eta'$ properties at finite density, which will give us new information on the $\eta'$ mass generation mechanism.