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Spectroscopy of η'-mesic nuclei with 12C(p,dp) reaction at GSI/FAIR

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The possible existence of η' meson nucleus bound states (η'-mesic nuclei) has been attracting interests both theoretically and experimentally, since in-medium properties of the η' meson are closely related to the axial $U(1)$ anomaly and the chiral symmetry in QCD. The especially large mass of the η' meson (∼958 MeV/c^2) compared with the other light pseudoscalar mesons is theoretically explained by an interplay between the axial $U(1)$ anomaly and spontaneous breaking of chiral symmetry in the QCD vacuum. In the nuclear medium, where chiral symmetry is partially restored, the η' meson mass is expected to be reduced. Such a mass reduction would lead to an attractive η'-nucleus potential, suggesting the existence of bound η'-mesic nuclei. In two experiments to search for η'-mesic nuclei, previously performed by using the (p,d) reaction and the (γ, p) reaction, no significant signal of the η'-mesic nuclei was observed due to the limited experimental sensitivities.

We have recently performed a new spectroscopic experiment of the ^{12}C(p,dp) reaction in order to search for η'-mesic nuclei with an increased experimental sensitivity. We have integrated the WASA central detector into the fragment separator (FRS) at GSI. A 2.5 GeV proton beam impinged on a carbon target to produce η'-mesic states via the ^{12}C(p,d)^{11}C$\otimes\eta'$ reaction. The missing mass of the reaction is obtained by measuring the deuteron momenta with FRS used as a forward high-resolution spectrometer. Simultaneously, possible decay particles from the η'-mesic nuclei, especially high-momentum protons (∼1 GeV/c) emitted in the decay via the two-nucleon absorption process, are identified with the WASA detector system surrounding the reaction target in order to improve the signal-to-background ratio of the missing-mass spectrum. First data taking was successfully accomplished in February 2022. In this contribution, preliminary results of this experiment and future prospects will be discussed.

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