

Spectroscopy of η' -mesic nuclei in $^{12}\text{C}(p, dp)$ reaction with the WASA-FRS setup

Friday, 26 June 2026 16:05 (20 minutes)

The masses of mesons belonging to the nonet of pseudoscalar mesons are closely related to fundamental symmetry breaking in QCD. The η' meson, in particular, has an anomalously large mass due to the axial U(1) anomaly arising from nonperturbative gluon dynamics in the QCD vacuum. In the nuclear medium, where chiral symmetry is partially restored, a mass reduction of the η' meson is predicted in a range of 1–150 MeV/ c^2 depending on the theoretical model, leading to an attractive potential between the η' meson and a nucleus. Consequently, the formation of η' -mesic nuclei, bound states of the η' meson with a nucleus, is expected if the mass reduction is sufficiently large.

To search for η' -mesic nuclei, we measured the excitation spectrum of the $^{12}\text{C}(p, d)$ reaction near the η' meson production threshold at the FRS in GSI. We employed a 2.5 GeV proton beam incident on a 4 g/cm² ^{12}C target. The momenta of the ejectile deuterons were measured using the FRS and ~ 1 GeV/ c protons emitted backward from the decay of η' -mesic nuclei via the two-nucleon absorption process ($\eta'NN \rightarrow NN$) were simultaneously tagged using the WASA detector.

We obtained the excitation spectrum of the $^{12}\text{C}(p, d)$ reaction near the threshold with an experimental resolution of 1.6 MeV, in coincidence with the 1 GeV/ c protons detected in the WASA detector. The observed spectrum exhibited two structures below the threshold, suggesting the possible formation of η' -mesic nuclei. We fitted the spectrum with a sum of a theoretically calculated spectra and a 3rd-order polynomial by scanning the real and imaginary parts of the η' - ^{11}C optical potential, V_0 and W_0 respectively. A null-hypothesis testing was performed to evaluate the statistical significance, resulting in local and global significances of 3.5σ and 2.1σ , respectively. The analysis result indicated $V_0 = -61 \pm 1 \pm 5$ MeV and $|W_0| \leq 10$ MeV (68% C.L.).

In this presentation, we discuss the details of the experiment, the data analysis, and the result of the experiment.

Collaboration

η -PRiME Collaboration and Super-FRS Experiment Collaboration

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Session Classification: Parallel session B3

Track Classification: Hadron-hadron interactions