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Exclusive Measurement of the $^{12}\mathrm{C}(K^-, p)$ Reaction for Probing the $\bar{K}$-Nucleus Interaction at J-PARC

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The antikaon-nucleus ($\bar{K}$-nucleus) interaction is fundamental to understanding the low-energy QCD and the behavior of strangeness in dense nuclear matter. While kaonic atom X-ray spectroscopy has provided valuable information about the interaction at the nuclear surface, the strength of the potential in the nuclear interior has remained a subject of long-standing debate, characterized by the "shallow vs. deep" potential ambiguity. In particular, the imaginary part of the potential (W_0), which describes the absorption dynamics, has been poorly constrained ever. In this talk, we report the first experimental constraint on the imaginary part of the $\bar{K}$-nucleus optical potential through the exclusive measurement of the K^- emission process. The experiment (J-PARC E42) was performed at the K1.8 beamline. We simultaneously measured the inclusive $^{12}\mathrm{C}(K^-, p)$ and exclusive $^{12}\mathrm{C}(K^-, pK^-_{esc})$ reactions at 1.8 GeV/c, where K^-_{esc} is denoted as a quasi-free Kaon emitted without absorption in the core nucleus. Utilizing the large-acceptance Hyperon Spectrometer, we successfully detected the recoil K^- in coincidence with the forward proton. By performing a simultaneous likelihood fit to the inclusive and exclusive spectra, we extracted the potential depths at the nuclear center: $V_0 = -72^{+3}_{-5}(\mathrm{stat.})^{+0}_{-8}$ (syst.) MeV and $W_0 = -100^{+7}_{-1}(\mathrm{stat.})^{+0}_{-16}$ (syst.) MeV. The obtained W_0 is significantly stronger than predictions from standard chiral unitary models based on one-nucleon absorption, providing a quantitative indication of the dominance of multi-nucleon absorption processes ($K^-NN \to YN$) in the nuclear interior. We will discuss the details of the analysis, the extracted potential parameters, and their implications for the onset of kaon condensation in neutron star interiors.

Collaboration

J-PARC E42

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