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High-resolution hadronic-atom x-ray spectroscopy with cryogenic detectors

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High-resolution x-ray spectroscopy of hadronic atoms will be performed with a cryogenic x-ray detector system based on an array of superconducting transition-edge-sensor (TES) microcalorimeters [1]. The spectrometer offers unprecedented full-width-at-half-maximum energy resolutions of 2 - 3 eV at 6 keV, which is about two orders of magnitude better than that of conventional semiconductor detectors. The 240 pixel spectrometer array will have a large collecting area of about 20 mm^2 thanks to recent technological advances in multiplexed readout of TES multi-pixel arrays. This will open a new door to investigate hadron-nucleus strong interactions and will also improve the precision of charged-hadron mass values.

A hadronic atom is a Coulomb-bound system formed by a negatively charged hadron (e.g., pi^-, K^-, pbar, Sigma^-, Xi^-), electrons, and a nucleus. Effects of the strong interaction between the hadron and atomic nucleus are experimentally extracted from characteristic x-ray-emission spectroscopy of the most tightly bound energy levels that are the most perturbed by the strong force (e.g., [2-4] are recent measurements).

Many kaonic-atom experiments have collected data on a variety of targets [5]; however, the energy resolution of the conventional semiconductor spectrometers employed in these experiments is insufficient to see the small spectral effects due to the strong interaction. As a result, the depth of the K^- - nucleus potential at zero energy remains unknown. This is closely related to the investigation of bound states of the kaon in the nucleus that is one of the hottest topics in strangeness nuclear physics now. Aiming at a breakthrough in this field, we are planning to perform ultra-high-resolution x-ray spectroscopy of kaonic atoms at J-PARC hadron beamline using arrays of TES microcalorimeters developed by NIST, which will be the first application of TESs to a hadronic atom experiment. Additionally, hadronic-atom x-ray spectroscopy has been used as a tool for measuring the charged hadron mass; we intend to improve the precision of the charged kaon mass measurement with TES spectrometers.

In this talk we will give an overview of this project and discuss the recent progress.

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[5] C.J. Batty, E. Friedman, A. Gal, Phys. Rep. 287 (1997) 385-445.

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