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X-ray spectroscopy of kaonic atoms with cryogenic detectors

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The HEATES collaboration aims to pioneer the next-generation high-resolution x-ray spectroscopy of hadronic atoms. We use a novel cryogenic x-ray spectrometer: an array of superconducting transition-edge-sensor (TES) microcalorimeters, offering unprecedented full-width-at-half-maximum energy resolution of 2 - 3 eV at 6 keV. 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 [1]. This will open a new door to investigate kaon-nucleus strong interactions.

A kaonic atom is a Coulomb-bound system formed by a kaon, electrons, and a nucleus. Effects of the strong interaction between the kaon and atomic nucleus are experimentally extracted from characteristic x-ray-emission spectra of the most tightly bound energy levels that are the most perturbed by the strong force (e.g., [2-4] are recent measurements). Therefore, many 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 to the nucleus and is one of the greatest problems today in strangeness nuclear physics [6]. Aiming to provide a breakthrough, we will measure the 3d-2p x-rays of kaonic helium-3 and helium-4 (6.2 keV and 6.4 keV, respectively) using arrays of the TES microcalorimeters, and determine the strong-force shifts in those 2p levels with a precision of 0.2 eV to distinguish between the two leading antikaon-nucleus strong-interaction models, J-PARC E62 [7].

We have conducted a pathfinding experiment by measuring pionic-atom x rays with a 240-pixel TES array at the Paul Scherrer Institut (PSI), and successfully demonstrated the feasibility of TES-based exotic-atom x-ray spectroscopy in a hadron-beam environment [8,9]. Recently we performed an experiment at the actual kaon beamline of J-PARC (K1.8BR) as a commissioning run. Kaon stop tuning and TES detector commissioning have been performed [10].

In this presentation we will give an overview of this project and present preliminary results of experiments at PSI and J-PARC.

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