# Kaonic-atom x-ray spectroscopy with superconducting microcalorimeters

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X-ray spectroscopies of hadronic atoms (e.g., $\pi^-, K^-, \bar{p}, \Sigma^-, \Xi^-$ atoms) provide unique information on the hadron-nucleon/nucleus interaction in the low-energy limits [1]. It is well known that high-resolution wavelength dispersive crystal spectrometers made a great success in the spectroscopies of pionic atom x-rays [2]. However, the spectrometers have been not applied for kaonic atom x-rays mainly due to their small detector acceptances and lower intensity of $K^-$ beam compared with $\pi^-$ beam.

In recent years, there was a remarkable progress in the development of a cryogenic detector system based on an array of superconducting transition-edge-sensor (TES) microcalorimeters [3]. Especially, multiplexed readout technologies to handle hundreds of pixels increased the detector effective area, opening the new possibilities of a variety of scientific applications. The TES spectrometer has achieved the highest energy resolution as an energy dispersive detector, 2–3 eV FWHM at 6 keV, and its portability and wide-dynamic range are suitable for our field of hadron physics.

We plan to use the TES spectrometer developed by NIST, for x-ray spectroscopies of kaonic helium atoms in the J-PARC E17 experiment, instead of conventional semiconductor x-ray detectors originally proposed in [4]. We will deduce $2p$ shifts and $2p$ widths induced by the strong interaction in kaonic helium-3 and helium-4 atoms, by measuring $\sim 6$ keV x-rays from $3d \to 2p$ transitions. Thanks to the drastic improvement in energy resolution, we can perform a simultaneous measurement of the two lines, which would contribute to reduce the systematic error in deriving their energy difference. Our revised precision goal of 0.2 eV for the $2p$ shifts could distinguish the small difference among the interaction models. Furthermore, finite values of the $2p$ widths could be determined for the first time.

In this contribution, we will give an overview of this project and discuss the feasibility of this experiment at J-PARC $K^-$ beam line, based on results of a test experiment at PSI to demonstrate the TES operation under a hadron beam environment.

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