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X-ray spectroscopy of muonic atoms isolated in vacuum using transition edge sensors

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High-resolution X-ray spectroscopy of highly-charged muonic atoms/ions isolated in vacuum is an ideal probe to explore quantum electrodynamics (QED) effects. One of the major topic in fundamental atomic physics is to conduct these experiments in high-Z atom in which the bound particles experience extremely strong electric fields.
A negatively-charged muon can bind to a nucleus via the Coulomb field. This "muonic atom"is essentially hydrogen-like in its electronic structure. Since a muon is 200 times more massive than an electron, a muonic atom has a Bohr radius 200 times smaller than that of atomic hydrogen. This allows to test QED in strong field in a very different regime, since at such short distances the dominant QED contribution is the vacuum polarization, while it is the self-energy in highly-charged ions. After a negatively-charged muon is captured by the nucleus in a highly excited state, the muon peels off most (or all) of the electrons bound to the nucleus as Auger electrons, and thereby generating highly-charged muonic atoms in vacuum.
While a low-density target is required to avoid rapid refilling of electrons into the highly charged muonic atom from the surrounding atoms, it is experimentally difficult to efficiently stop muons in a low-density target. This is due to their large momentum distribution via traveling pion decay, resulting in insufficient x-ray yields with the conventional high-resolution x-ray spectroscopy technology based on diffraction from Bragg crystals, unless one uses a device like the PSI cyclotron trap.
We aim to realize the high-resolution muonic atom X-ray spectroscopy with low-density gas target with a combination of the world highest intensity pulsed negative muon beam at J-PARC MLF MUSE (Tokai, Japan) and an X-ray spectrometer based on a 240 pixel array of superconducting transition-edge-sensor (TES) microcalorimeters.
In April 2019 we will perform a feasibility test at J-PARC and report the outcome of these new result.

Less than 5 years of experience since completion of Ph.D

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