

# Antiprotonic and kaonic Helium Atoms

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At past PSAS conferences, we presented the progress in the precision laser spectroscopy of antiprotonic helium atoms [?]. By using a radio-frequency quadrupole antiproton decelerator (inverse linac), a frequency comb, pulse-amplified single-mode lasers, and a counter-propagating two-photon method, we have now determined the antiproton-to-electron mass ratio with a relative precision of  $\sim 10^{-9}$  [?]. But as long as we use pulsed lasers, we cannot reach higher precision due to the systematic errors caused by chirp and ac-Stark effects. Efforts are therefore underway to realize the antiprotonic-helium spectroscopy using cw lasers.

Other exotic helium atoms we are working on are the kaonic helium-4 and kaonic helium-3 atoms, with which we would like to determine the kaon-nucleus strong interaction potential; whether the potential is shallow or deep has been a focus of intense theoretical debate for the past 10 years, and this can be settled by the measurement of so-called “strong-interaction shift” of the  $2p$  state. Experimentally, we determine the kaonic-helium  $3d \rightarrow 2p$  x rays at  $\sim 6.4$  keV. This in fact requires a rather sophisticated setup involving many silicon-drift detectors and drift chambers. With such a setup, we recently succeeded to determine the  $3d \rightarrow 2p$  x-ray energy of kaonic helium 4 with 2-eV precision, much higher than similar measurements conducted in the past [?]. This will be combined with a similar experiment on kaonic helium 3, which will soon to be carried out at the soon-to-be-completed J-PARC accelerator.

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  - [3] S. Okada *et al.*, *Physics Letters B* **653** (2007) 387.