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One-dimensional chirp cooling of positronium

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Positronium (Ps), an electron-positron bound system, is pivotal for testing fundamental physics through Quantum Electrodynamics (QED), the most precise theory in physics. To apply extremely accurate transition frequency measurements to Ps with laser precision spectroscopy and minimize systematic errors, it is important to decelerate the gas of Ps. However, the application of laser cooling to Ps has been challenging due to its 142 ns lifetime and significant Doppler broadening.

In this talk, we detail our recent achievement of one-dimensional laser cooling of Ps [1]. The experiment employed a specially designed laser that emits a sequence of broadband micro-pulses, with their center frequencies sequentially upshifted [2, 3]. With this novel type of laser, we were able to cool a portion of a Ps gas at 600 K to approximately 1 K in 100 ns. We will compare the cooled Ps velocity distribution to Lindblad equation simulations and consider the impact on future precision spectroscopy. Additionally, we will discuss the prospects of extending this technique to three-dimensional cooling, which could open new avenues in the field of precision spectroscopy for atoms containing antimatter.

[1] K. Shu *et al.*, arXiv:2310.08761 (2023).
[2] K. Yamada *et al.*, Phys. Rev. Applied **16**, 014009 (2021).
[3] K. Shu *et al.*, arXiv: 2308.00877 (2023).

Authors: Prof. YOSHIOKA, Kosuke (The University of Tokyo); Dr SHU, Kenji (The University of Tokyo); Dr TAJIMA, Yohei (The University of Tokyo); Mr UOZUMI, Ryosuke (The University of Tokyo); Mr MIYAMOTO, Naoki (The University of Tokyo); Mr SHIRAISHI, Sohma (The University of Tokyo); Mr KOBAYASHI, Takuto (The University of Tokyo); Dr ISHIDA, Akira (The University of Tokyo); Dr YAMADA, Kyohei (The University of Tokyo); Dr GLADEN, Randall W. (The University of Tokyo); Dr NAMBA, Toshio (The University of Tokyo); Prof. ASAI, Shoji (The University of Tokyo); Prof. WADA, Ken (High Energy Accelerator Research Organization (KEK)); Dr MOCHIZUKI, Izumi (High Energy Accelerator Research Organization (KEK)); Dr HYODO, Toshio (High Energy Accelerator Research Organization (KEK)); Dr ITO, Kenji (National Institute of Advanced Industrial Science and Technology (AIST)); Dr MICHISHIO, Koji (National Institute of Advanced Industrial Science and Technology (AIST)); Dr O'ROURKE, Brian E. (National Institute of Advanced Industrial Science and Technology (AIST)); Dr OSHIMA, Nagayasu (National Institute of Advanced Industrial Science and Technology (AIST))

Presenter: Dr SHU, Kenji (The University of Tokyo)

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