Development of a high-resolution probing laser suited for cold positronium spectroscopy

R. Uozumi[1,*], Y. Tajima[1], T. Kobayashi[1], K. Shu[1], E. Chae[1,7], K. Yoshioka[1], A. Ishida[2] , T. Namba[2], S. Asai[2], M. Kuwata-Gonokami[2], N. Oshima[3], B.E. O'Rourke[3], K. Michishio[3], K. Ito[3], K. Kumagai[3], R. Suzuki[3], S. Fujino[4], T. Hyodo[5], I. Mochizuki[5], K. Wada[5] and T. Kai[6]

[1] *Department of Applied Physics and Photon Science Center (PSC), Graduate School of Engineering, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656, Japan*
[2]*Department of Physics, Graduate School of Science and ICEPP, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan*
[3]*AIST, 1-1-1 Umezono, Tsukuba, Ibaraki 305-8568, Japan*
[4]*GIC, Kyushu University, 6-1 Kasuga-koen, Kasuga, Fukuoka 816-8568, Japan*
[5]*IMSS, KEK, 1-1 Oho, Tsukuba, Ibaraki 305-0801, Japan*
[6]*JAEA, 2-4 Shirakata, Tokai-mura, Naka-gun, Ibaraki 319-1195, Japan*
[7]*Department of Physics, College of Science, Korea University, Anam-dong 5, Seongbuk-gu, Seoul 02841, South Korea*

[*]email: uozumi@fs.t.u-tokyo.ac.jp

Cooling positronium (Ps) to temperatures below 10 K leads to important research such as precise measurements of energy intervals and realizing Bose-Einstein condensation. Laser cooling and other cooling methods are on intense research to achieve this goal. On this occasion, evaluating the temperature of cold Ps is an important task to be undertaken. Obtaining the Doppler broadening by laser spectroscopy is one of the preferred strategies since it allows high-resolution measurements regarding the laser technology of today.

To conduct efficient and high-resolution laser spectroscopy, the probing laser should have the optimized linewidth and longitudinal mode interval, which would not be achieved by commercially available lasers. Linewidth should be adjusted between the balance of high resolution and quantity of Ps at resonance. Longitudinal mode interval should be comparable to the natural width of Ps (50 MHz) to efficiently excite Ps inside the laser linewidth. We have developed a frequency-tunable 243-nm pulsed laser satisfying the demanded frequency structure mentioned above (Fig. 1). Further developments and spectroscopy experiments using this laser are currently underway.

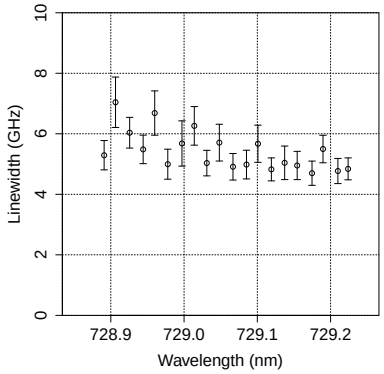

Fig.1. Linewidth of the high-resolution probing laser at wavelength of 729 nm. The wavelength is converted to 243 nm using the third harmonic generation for Ps temperature measurement. An 85-GHz Doppler width, which corresponds to Ps of 10 K, will be probed efficiently using this laser.