A novel high-brightness and energy-tunable positronium beam and future applications

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The first, high-brightness and energy-tunable positronium (Ps) beamline produced using the photodetachment of positronium negative ions (Ps^-) has been recently constructed at Tokyo University of Science [1]. Slow positrons are generated by a ^{22}Na source (740 MBq) in conjunction with a solid Ne moderator. The positrons are accumulated in a buffer-gas trap to form a ns-pulsed (50 Hz) positron beam that is synchronized with the pulsed laser beam for the Ps^- photodetachment. The positron beam extracted from the trap is electrostatically accelerated and focused onto a W (100) film of 100-nm thickness using a magnetic lens. Ps^- ions are efficiently emitted in a transmission geometry from the downstream surface of the W thin film that is coated with a sub-monoatomic Na layer. The Ps^- ions are electrostatically accelerated to the desired kinetic energy and photodetached by a Nd:YAG IR laser beam (0.2 J cm^{-2}, 1064 nm). This way an energy-variable Ps beam in the kinetic range 0.2-3.3 keV is obtained. The Ps atoms are detected by a position sensitive detector located 419 mm downstream of the photodetachment point in a differentially-pumped chamber.

The successful performance of the beamline has already been thoroughly characterized [1]. Several kinds of experiments are currently being carried out and planned using this beamline. These include the detection of the hyperfine transition between ortho- and para-Ps when passing through a multi-layered transmission magnetic grating [2], measurements of Ps scattering from crystal surfaces in a grazing-angle geometry [3] and the observation of the interference of Ps wave functions transmitted through a single layer of graphene.

Absolute cross sections measurements of the inner-shell ionization of the atomic *K*- and *L*-shells of thin film targets, such as Cu and Ag, by Ps impact are also planned. The knowledge of those cross sections will allow us to clarify the role of the fundamental interactions in the scattering process involving a composite antimatter-matter system, as cross sections by electron and positron impact are quite different [4]. Those measurements are also important for a better understanding of the dynamics of the inner-shell ionization process for the development of accurate scattering theories.

The details on the plan and progress of these experiments will be presented at the conference.

References

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