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Positronium negative ion photodetachment experiment at the KEK-PF slow positron facility

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Introduction

It is well known that an electron can bind to a positron to form positronium (Ps). Another electron can also bind to Ps to form a positronium negative ion (Ps$^-$), provided the two electrons are in a single spin state. Although there are a lot of theoretical investigations concerning the ions, no experimental investigations have been performed except for a few measurements of the decay rate since the first observation of the ions in 1981 [1] because the production has been very difficult.

Recently, we observed the efficient emission of Ps$^-$ from alkali metal coated tungsten surfaces [2]. The efficiency was two orders of magnitude higher than the previous method [3, 4].

In the present work, we have started photodetachment experiment for the Ps$^-$ produced using alkali metal coated surface.

Experimental Setup

An apparatus was developed at the KEK-PF slow positron facility. Figure 1 shows a schematic diagram of the chamber for the Ps$^-$ photodetachment experiment.

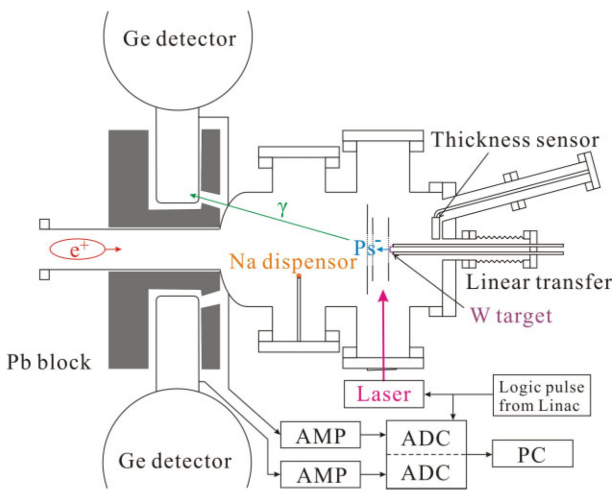

Figure 1. The setup for the Ps$^-$ photodetachment experiments.

The pulsed positron beam was collimated by an aluminum plate with a hole of 5 mm in diameter before entering the target chamber and guided by an axial magnetic field to the chamber with a transport energy of 4.2 keV. The pulses were repeated at a frequency of 50 Hz with a pulse width of 12 ns. The pressure of the chamber was about 4×10^{-8}Ps.

The target was a polycrystalline W film and annealed in situ at 1800K for 30 min. After being cooled down to room temperature, the target was exposed to evaporating Na atoms.

The Ps$^-$ ions emitted from the target were accelerated and annihilated in the zero-electric-field region. The blue-shifted γ-rays emitted from 2γ annihilation were detected using two Ge detectors. The detectors were encased in lead shielding with a 25mm slit to allow the passage of the annihilation γ-rays, so as to reduce the excess count by the pile-up of the γ-rays emitted simultaneously.

Results

The blue shifted γ-rays attributed to the annihilation of the Ps$^-$ ions emitted from the target were observed clearly [4].

The apparatus, together with an intense pulsed laser synchronized to the positron pulses, will allow the observation of the Ps$^-$ photodetachment. We aim at the success of the Ps$^-$ photodetachment in 2010.

The technique will be used to generate a beam of Ps with tunable energy. That is, Ps$^-$ will be accelerated electrostatically to the required energy and then undergo photodetachment to produce an energy-controllable beam of Ps.

References

[1] A. P. Mills, Jr., Phys. Rev. Lett. 46 (1981) 717.
[2] Y. Nagashima et al., New J. Phys. 10 (2008) 123029.
[3] K. Michishio et al, J. Phys. Conf. Series 199 (2010) 012003.
[4] T. Tachibana et al., Nucl. Instr. and Meth. in Phys. Res. A, in press.

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