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Experimental progress towards positronium Bose-Einstein condensation

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Positronium (Ps), the bound state of an electron and a positron, is one of the best candidates for the first Bose-Einstein condensation (BEC) of antimatter system. Ps-BEC can be regarded as an "antimatter laser", which has rich potential for applications to both fundamental and applied physics. For example, the gravitational effect on antimatter can be studied by constructing a Mach-Zehnder interferometer of Ps-BEC. Gamma-ray laser can also be realized using annihilation gamma-rays from Ps-BEC.
The challenge to realize Ps-BEC is to create dense (> 10^{17} cm^{-3}) and cold (< 10 K) Ps atoms in a short lifetime of Ps (142 ns). To achieve these target values, we proposed the following new scheme. Firstly, dense Ps atoms are formed in small (~ 10^{6} nm^{3}) pores in a silica (SiO_2) target by bombarding focused and bunched positron beams. Then, Ps atoms are rapidly cooled to ~300 K by thermalization caused by collisions with pore walls. Finally, Ps are cooled to less than 10 K by laser cooling which uses 243 nm 1S-2P transitions. Monte Carlo simulation shows that this method can realize Ps-BEC in ~300 ns after Ps formation.
We are currently trying laser cooling of Ps at KEK slow positron facility (SPF). In this presentation, I will show the overall development status and future prospects of our experiment, especially about the following topics: positron fusing system using multi-stage brightness enhancement system, Ps generator/condenser/cooler target material, and special home-made 243 nm pulsed laser system for Ps cooling.
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