First search for invisible decays of ortho-positronium confined in a vacuum cavity

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The experimental setup and results of the first search for invisible decays of ortho-positronium (o-Ps) confined in a vacuum cavity are reported. No evidence of invisible decays at a level $\mathrm{Br}\,(\text{o-Ps} \to \text{invisible}) < 5.9 \times 10^{-4}$ (90 % C. L.) was found. This decay channel is predicted in Hidden Sector models such as the Mirror Matter (MM), which could be a candidate for Dark Matter. Analyzed within the MM context, this result provides an upper limit on the kinetic mixing strength between ordinary and mirror photons of $\varepsilon < 3.1 \times 10^{-7}$ (90 % C. L.). This limit was obtained for the first time in vacuum free of systematic effects due to collisions with matter.

The experimental setup will also allow us to measure the o-Ps decay rate. Currently, the experimental uncertainty of the o-Ps decay rate is at 140 ppm precision; this exceeds the theoretical accuracy (1 ppm level) by two orders of magnitude. We propose a method that relies on the o-Ps confinement cavity and the granularity of the surrounding calorimeter to subtract the time dependent pick-off annihilation rate of the fast backscattered positronium from the o-Ps decay rate prior to fitting the distribution. Therefore, this measurement will be free from the systematic errors present in the previous experiments and thus could reach the ultimate accuracy of a few ppm level to confirm or confront directly the higher order QED corrections.