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# Tests of discrete symmetries in positronium decays with the J-PET detector

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Positronium is the lightest purely leptonic object decaying into photons. As an atom bound by a central potential, it is a parity eigenstate, and as an atom built out of an electron and an anti-electron, it is an eigenstate of the charge conjugation operator. Therefore, the positronium is a unique laboratory to study discrete symmetries whose precision is limited, in principle, only by the effects due to the weak interactions expected at the level of $10^{-14}$ and photon- photon interactions expected at the level of $10^{-9}$. Violation of T or CP invariance in purely leptonic systems has never been seen thus far. The experimental limits on CP and CPT symmetry violation in the decays of positronium are set at the level of $10^{-3}$ and litmits on charge conjugation violation are set at the level of $10^{-7}$. Thus, there is still a range of six orders of magnitude as regards T and CP, and two order of magnitude as regards the C symmetry, where the phenomena beyond the Standard Model can be sought for by improving the experimental precision in investigations of decays of positronium atoms.

The newly constructed Jagiellonian Positron Emission Tomograph (J-PET) is a first PET tomograph built from plastic scintillators. As a detector optimized for the registration of photons from the electron-positron annihilations, it also enables tests of discrete symmetries in decays of positronium atoms via the determination of the expectation values of the discrete-symmetries-odd operators, which may be constructed from the spin of ortho-positronium atom and the momenta and polarization vectors of photons originating from its annihilation. J-PET is also a unique facility to study the entanglement of photons originating from positronium annihilations.

In the talk we will present the capability of the J-PET detector to improve the current precision of testing CP, T and CPT symmetries in the decays of positronium atoms and report on results from the first data-taking campaigns. With respect to the previous experiments performed with crystal based detectors, J-PET built of plastic scintillators provides superior time resolution, higher granularity, lower pile-ups, and opportunity of determining photon's polarization through the registration of primary and secondary Compton scatterings in the detector. These features makes J-PET capable of improving present experimental limits in tests of discrete symmetries in decays of positronium atom (a purely leptonic system).

## Content of the contribution

Experiment

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