

Studies of ortho-positronium decays into three photons with the J-PET detector

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The Jagiellonian Positron Emission Tomograph (J-PET) setup, besides being the first PET scanner built with plastic scintillators [1,2] is currently used to conduct a broad range of experiments involving ortho-positronium (o-Ps) decays into three photons [3,4].

We will present results of studies of o-Ps $\rightarrow 3\gamma$ decays performed in J-PET with a view to searching for angular correlations between the photons' momenta and positronium spin direction which would violate the combined CPT symmetry, scarcely tested in leptonic systems. To date, the most precise CPT test using ortho-positronium decays reached the precision of 3×10^{-3} [5] whereas effects limiting the sensitivity are only expected at the level of 10^{-9} [6].

In the discussed J-PET measurement, ortho-positronium atoms are created by positrons from a ^{22}Na source thermalizing in an extensive-size cylindrical target of porous XAD4 material and decay positions are reconstructed using a trilateration-based technique [7]. Decay photons are recorded by 192 strips of plastic scintillators with high timing resolution. Such a setup (presented in Figure 1) allows for registration of an unprecedented spectrum of geometrical configurations of o-Ps $\rightarrow 3\gamma$ decays including also correlations with positronium spin.

Angular and energetic relative distributions of the decay photons will be presented along with the current stage of studies of a CPT-odd angular correlation operator $\hat{S} \cdot (\hat{k}_1 \times \hat{k}_2)$ where \hat{S} denotes positronium spin direction and \vec{k}_i are momentum vectors of the annihilation photons ordered so that $|\vec{k}_1| > |\vec{k}_2| > |\vec{k}_3|$. With an angular resolution and o-Ps polarization control improved with respect to previous measurements, J-PET aims at achieving the sensitivity of such CPT test at a precision level of at least 10^{-4} .

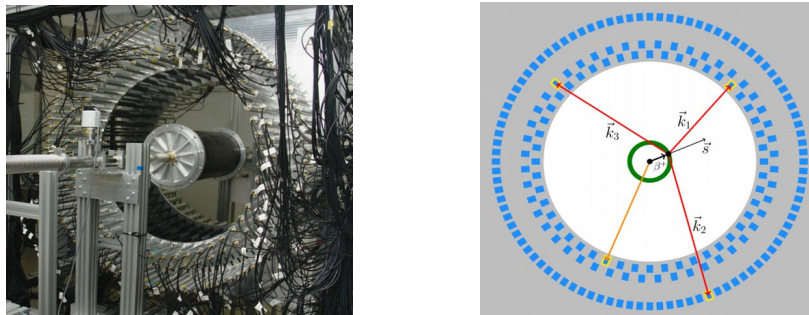


Figure 1 A cylindrical target ($r=12$ cm) for o-Ps formation inside the J-PET detector (left) is used to estimate the ortho-positronium spin in every event using positron polarization (right).

References

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