

Test of the CPT symmetry in positronium annihilations at sub-permil precision using the J-PET tomography device

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The symmetry under combined charge, parity, and time-reversal transformation (CPT) remains scarcely tested in leptonic systems. We demonstrate that a Positron Emission Tomography device can be put to use in a search for CPT-violating angular correlations in the annihilations of the lightest leptonic bound system, the positronium atom. Using the Jagiellonian PET (J-PET) prototype conceived as a medical imaging device constructed entirely with plastic scintillators, we have collected an unprecedented range of kinematical configurations of exclusively-recorded annihilations of the positronium triplet state (ortho-positronium) into three photons. Employing a novel technique for estimation of positronium spin axis on the basis of a single event, we determined the complete distribution of an angular correlation between spin and annihilation plane of ortho-positronium, non-zero expectation value of which would be a sign of CPT noninvariance. With the first measurement demonstrating this experimental technique, we are able to reach the precision of the CPT test beyond the level of one permil. As the present sensitivity is mostly limited by statistical uncertainty, we discuss the prospects for reaching the precision level of 10^{-5} with the CPT tests in J-PET.

Collaboration

J-PET

Primary author: GAJOS, Aleksander (Jagiellonian University)

Presenter: GAJOS, Aleksander (Jagiellonian University)

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