Charge symmetry test in decays of positronium atoms using the J-PET detector

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Discrete symmetries (reflection in space (P), reversal in time (T) and charge conjugation (C)) are violated in weak interactions only. Charge conjugation transforms a particle into antiparticle and vice versa by changing its internal quantum numbers. Thus, the Charge symmetry studies can contribute to resolve the ambiguity in excess of matter over antimatter in the Universe. Positronium atom (Ps) which is the meta-stable bound system of particle (e^-) and its antiparticle (e^+) can be an excellent tool for studying the charge symmetry violation [1-3]. In 1967, Mills and Berko measured the C-forbidden decays of the singlet state ($^1S_0$: p-Ps) by estimating the ratio (R) of its decays 3γ / 2γ with best limit so far (R~2.6x10^{-6} at 68% confidence level) [4].

J-PET is the PET device built from 192 plastic scintillators of dimension 500 X 19 X 7 mm^3 which are arranged axially in 3-layers [5-8]. It is used to investigate the C-forbidden decays of the positronium atoms (p-Ps → 3γ) and estimate the branching ratio between 3γ to 2γ [2]. The event wise registration of the annihilation photons emitting from the decay of positronium atoms allow to distinguish either they are originating from the long-lived (o-Ps in range of ns) or short-lived (p-Ps in range of ps) atoms [9-10]. Furthermore, the angular correlation between the emitting photons can also be used as a signature to differentiate between the decays either from singlet (p-Ps) or triplet (o-Ps) states of the Ps atom. Moreover, the plastic scintillators used in J-PET offers the excellent time and high angular resolution and thus the value of R is expected to be measured with better sensitivity [5,6]. First results from the studies in the framework of J-PET detector will be presented and discussed.

References

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