A measurement of $K^0, \overline{K^0} \rightarrow 3\pi^0$ and an improved test of CPT

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The CPLEAR experiment at CERN is aimed to study CP-, T- and CPT-symmetries in the neutral-kaon system. The neutral kaons are produced in $p\bar{p}$ annihilations at rest:

$$p\bar{p} \rightarrow \bar{K}^0 K^+ \pi^-, K^0 K^- \pi^+.\,$$

The observation of the sign of the accompanying charged kaon allows one to determine for each event, whether the neutral kaon is a $\bar{K}^0$ or a $K^0$. This gives to CPLEAR the capacity of extracting relevant physical parameters through time-dependent asymmetries between the rates of initially pure $K^0$ and $\bar{K}^0$ decaying into various final states.

In this work an analysis of $K^0, \bar{K}^0 \rightarrow \pi^0 \pi^0 \pi^0$ decays is presented. This analysis has lead to the determination of the real and imaginary part of the CP-violation parameter $\eta_{000}$ which are measured to be:

$$Re(\eta_{000}) = 0.18 \pm 0.14(stat) \pm 0.06(syst)$$

$$Im(\eta_{000}) = 0.15 \pm 0.20(stat) \pm 0.03(syst).$$

These values, although still compatible with CP-conservation, represent the best sensitivity to CP-violation in this decay mode; they lead to an upper limit $|\eta_{000}| < 0.58$ at 90% confidence level. Using the result on $Re(\eta_{000})$ and $Im(\eta_{000})$ together with unitarity relations in the neutral-kaon system, the imaginary part of the CPT-violation parameter $\delta$ is found to be:

$$Im(\delta) = (1.3 \pm 3.6) \cdot 10^{-5}.$$

This value is in agreement with CPT-invariance; it leads to a mass difference between the neutral kaon and its antiparticle:

$$M_{K^0} - M_{\bar{K}^0} = (1.8 \pm 5.1) \cdot 10^{-19} \text{GeV}/c^2.$$

The limit on this mass difference is of the order of the inverse of the Planck scale and experimentally confirms the CPT-invariance in the neutral-kaon system up to these scales.