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Direct CP violation in $K^0 \rightarrow \pi\pi$: Standard Model Status

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In 1988 the NA31 experiment presented the first evidence of direct CP violation in the $K^0 \rightarrow \pi\pi$ decay amplitudes. A clear signal with a 7.2σ statistical significance was later established with the full data samples from the NA31, E731, NA48 and KTeV experiments, confirming that CP violation is associated with a $\Delta S = 1$ quark transition, as predicted by the Standard Model. However, the theoretical prediction for the measured ratio ε'/ε has been a subject of strong controversy along the years. We review the current status, discussing in detail the different ingredients that enter into the calculation of this observable and the reasons why seemingly contradictory predictions were obtained in the past by several groups. An update of the Standard Model prediction is presented and the prospects for future improvements are analysed. Taking into account all known short-distance and long-distance contributions, one obtains $\text{Re}(\varepsilon'/\varepsilon) = (15 \pm 7) \cdot 10^{-4}$, in good agreement with the experimental measurement.

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