Observation of time-reversal violation in B meson transitions

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In the standard model of elementary particle physics, charge-parity (CP) violation in the quark sector of weak interactions arises from the single physical phase of the three-generation Cabibbo-Kobayashi-Maskawa matrix. This mechanism has been validated by more than a decade of intense experimental work probing CP violation, particularly with the studies with B mesons at B factories, BABAR at SLAC (USA) and Belle at KEK (Japan). The success of the three-generation theory was recognized by the award of a share of the 2008 Nobel Prize in Physics to Kobayashi and Maskawa. Since the standard model is CPT invariant, it predicts a time-reversal (T) symmetry breaking matching the large observed CP asymmetry in B mesons. However, until recently, there has been no direct experimental observation of the expected, large T asymmetry. In this colloquium we shall first review the role of time symmetries in the laws of physics and the difficulties the experiments, using either stable or transition systems, have to afford to study directly fundamental time-reversal violation. In the second part we shall discuss how the decays of entangled neutral B mesons produced at B factories allow comparisons between the rates of four different transitions between quantum states and their inverse, as a function of the time evolution of the B meson. This technique, used by the BABAR experiment at the SLAC National Accelerator Laboratory, has lead to the first time-dependent, direct observation with high significance of T violation in transitions that can solely be related by a T symmetry transformation.