The most clearcut experiments would be those that measure asymmetries between B^0 and $\overline{B}^0$ decays. The time-dependent rate to a CP eigenstate a is given by

$$\Gamma_a \sim e^{-\Gamma t}\Big(\left[1+|r_a|^2\right] \pm \left[1-|r_a|^2\right]\ \cos(\Delta M t) \mp 2\eta_a \mathrm{Im}\ r_a\ \sin(\Delta M t)\Big)\ , \tag{29.5}$$

where the top sign is for B^0 and the bottom for $\overline{B}^0$, η_a is the CP eigenvalue and

$$r_a = (q_B/p_B)\ \overline{A}_a/A_a\ . \tag{29.6}$$

The quantity (q_B/p_B) comes from the analogue for B^0 of Eq. (29.1); however, for B^0 the eigenstates have a negligible lifetime difference and are distinguished only by the mass difference ΔM; also as a result $|q_B/p_B| \approx 1$ so that $\widetilde{\epsilon}_B$ is purely imaginary. A_a $(\overline{A}_a)$ are the decay amplitudes to a for B^0 $(\overline{B}^0)$. If only one quark weak transition contributes to the decay $|\overline{A}_a/A_a| = 1$ so that $|r_a| = 1$ and the $\cos(\Delta M t)$ term vanishes. The basic goal of the B factories is to observe the asymmetric $\sin(\Delta M t)$ term. For B^0 $(\overline{B}^0) \to \psi K_s$ from the transition $b \to c\overline{c}s$, one finds in the Standard Model the asymmetry parameter

$$-2\mathrm{Im}\ r_a = \sin 2\beta\ . \tag{29.7}$$

The asymmetry is given directly in terms of a CKM phase with no hadronic uncertainty and is expected to be between 0.2 and 0.8. For B^0 $(\overline{B}^0) \to \pi^+\pi^-$ from the transition $b \to u\overline{u}d$

$$-2\mathrm{Im}\ r_a = \sin 2(\beta+\gamma)\ . \tag{29.8}$$

(This result has some hadronic uncertainty due to penguin contributions, but these should be able to be estimated from other observations.) While either of these asymmetries could be ascribed to $B^0 - \overline{B}^0$ mixing (q_B/p_B or $\widetilde{\epsilon}_B$), the difference between the two asymmetries is evidence for direct CP violation. From Eq. (29.6) (with $\overline{A}_a/A_a = 1$) it is seen this corresponds to a phase difference between $A_{\psi K_S}$ and $A_{\pi^+\pi^-}$. Thus this is analogous to ϵ'. In the standard phase convention 2β in Eq. (29.7) and (29.8) arises from $B^0 - \overline{B}^0$ mixing whereas the 2γ comes from V_{bu} in the transition $b \to u\overline{u}d$.

CP violation in the decay amplitude is also revealed by the $\cos(\Delta M t)$ in Eq. (29.5) or by a difference in rates of B^+ and B^- to charge-conjugate states. These effects, however, require two contributing amplitudes to the decay (such as a tree amplitude plus a penguin) and also require final-state interaction phases. Predicted effects are very uncertain and are generally small.

For further details, see the notes on CP violation in the K_L^0, K_S^0, and B^0 Full Data Listings of the full *Review*.