The proper time evolution of an initially ($t = 0$) pure B^0 or $\overline{B}^0$ is given by

$$|B^0_{\rm phys}(t)\rangle = \exp(-\Gamma t/2)\exp(-iMt) \times \{\cos(\Delta Mt/2)|B_0\rangle + i(q/p)\sin(\Delta Mt/2)|\overline{B}^0\rangle\} \ ,$$

$$|\overline{B}^0_{\rm phys}(t)\rangle = \exp(-\Gamma t/2)\exp(-iMt) \times \{i(p/q)\sin(\Delta Mt/2)|B_0\rangle + \cos(\Delta Mt/2)|\overline{B}^0\rangle\} \ . \quad (4)$$

The probability that an initial B^0 ($\overline{B}^0$) decays as a $\overline{B}^0$ (B^0) is thus

$$P(t) = \tfrac{1}{2}e^{-\Gamma t}(1 - \cos(\Delta Mt) \quad (5)$$

where we have used $|p/q| = 1$ which is true when we neglect the effects of $\Delta\Gamma$. Time-dependent mixing measurements are now beginning to be done; earlier experiments measured the time-integrated mixing, which is parameterized by a parameter χ_d for B_d (*i.e.*, B^0) and χ_s for B_s (*i.e.*, B^0_s). The quantity χ measures the total probability that a created B^0 decays as a $\overline{B}^0$; it is given by

$$\chi_q = \int_0^\infty P_q(t)dt = \frac{x_q^2}{2(1+x_q^2)} \ . \quad (6)$$

Here quantity x_q is the ratio of the $B^0-\overline{B}^0$ oscillation frequency to the decay rate $x_q = \frac{\Delta M_q}{\Gamma_q}$, $q = d, s$. The value of x_d is about 0.7, not very different from the similar quantity for the K^0 which is 0.48. The value of x_s is expected to be much larger, so that the quantity χ_s will be close to its upper limit of 0.5. This means that one cannot determine x_s accurately by measuring χ_s. It will require excellent time resolution to resolve the time-dependent mixing of the B^0_s system, and thereby determine $\Delta M_{B^0_s}$ [2].

In the B^0–$\overline{B}^0$ mixing section of the B^0 Full Listings, we list the χ_d measurements, most of which come from $\Upsilon(4S)$ data, and the Δm_{B^0} measurements, which come from Z data. We convert both of these sets of measurements and list them in the x_d section. The x_d values obtained from Δm_{B^0} measurements have a common systematic error due to the error on τ_{B^0}. The averaging takes this common systematic error into account.

In the B^0_s–$\overline{B}^0_s$ mixing section of the B^0_s Full Listings, we give measurements of χ_B at high energy and of χ_s obtained by combining the χ_B and χ_d measurements using

$$\chi_B = f_d\,\chi_d + f_s\,\chi_s \ , \quad (7)$$

where f_d and f_s are the fractions of b hadrons that are produced as B^0 and B^0_s mesons respectively. We also convert the average χ_B and χ_d values to χ_s assuming $f_d = 0.391$ and assuming $f_s = 0.117$, obtaining $\chi_s = 0.62 \pm 0.13$, consistent with the maximum allowed value $\chi_s = 0.5$. This χ_s value and error, when converted to an x_s lower limit, yields $x_s > 1.5$. There is now a limit on $\Delta m_{B^0_s}$ from an ALEPH time-dependent B^0_s–$\overline{B}^0_s$ mixing measurement which provides slightly stronger limit, $x_s > 2.0$, than that obtained from the time-independent measurements.

***CP* violation in *B* decays—Standard Model predictions**: There are three symmetries of the strong interactions that are not conserved in weak processes. These are the symmetries C, charge conjugation, which relates particle to antiparticle, P, parity, which relates a left-handed particle to a similar right-handed one, and T, time-reversal invariance, which relates a process or state to the time-reversed process or state. In all field theories the product of these three operations, CPT, is an exact symmetry of the equations of motion. All weak decays violate P and C, and a very small part of the weak decays also violate the product CP (and thus T). In the Standard Model this CP violation occurs because there is a single phase that remains in the Cabibbo-Kobayashi-Maskawa (CKM) matrix after all possible field redefinitions that can remove such phases have been made. In a minimal two-generation Standard Model no such phase occurs. The presence of CP-violating effects in K decays was interpreted by Kobayashi and Maskawa in 1973 to suggest a third quark generation. Other extensions beyond the minimal Standard Model, such as theories with additional Higgs multiplets, give further ways to introduce CP violation into the theory. Hence it is of great interest to study whether the pattern of CP-violating effects that can be observed in B decays follows the predictions of the minimal Standard Model, or instead requires the introduction of beyond Standard Model effects. In what follows the predictions given are all those of the minimal Standard Model. Cosmologists attempting to understand the process by which the matter-antimatter asymmetry of the universe arose suggest that additional sources of CP violation may be needed to give the observed baryon to photon ratio of the universe [3]. Many models which go beyond the Standard Model indeed introduce such possibilities (see "Beyond Standard Model effects " below.)

The CKM matrix is the matrix of weak couplings in the three generation Standard Model, expressed in the basis of quark mass eigenstates. This matrix, which must be unitary if the three generations are the complete theory, is discussed in some detail in a separate article in this *Review*, here we need only remind ourselves of some notation that is commonly used in this context. The matrix can be written

$$V = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} \quad (8)$$

$$\simeq \begin{pmatrix} 1-\lambda^2/2 & \lambda & A\lambda^3(\rho - i\eta) \\ -\lambda & 1-\lambda^2/2 & A\lambda^2 \\ A\lambda^3(1-\rho-i\eta) & -A\lambda^2 & 1 \end{pmatrix} + O(\lambda^4) \ .$$

The second expression here is a parameterization due to Wolfenstein [4] with $\lambda = \sin(\theta_{\rm Cabibbo})$, which is frequently used in discussing CP-violating effects. It is given here up to