A second type of phase can appear in scattering or decay amplitudes even when the Lagrangian is real. Such phases do not violate CP, since they appear in A_f and $\overline{A}_{\overline{f}}$ with the same sign. Their origin is the possible contribution from intermediate on-shell states in the decay process, that is an absorptive part of an amplitude that has contributions from coupled channels. Usually the dominant rescattering is due to strong interactions, hence the designation "strong phases" for the phase shifts so induced. Again only the relative strong phases of different terms in a scattering amplitude have physical content, an overall phase rotation of the entire amplitude has no physical consequences.

Thus it is useful to write each contribution to A in three parts: its magnitude A_i, its weak-phase term $e^{i\phi_i}$, and its strong phase term $e^{i\delta_i}$. Then, if several amplitudes contribute to $B^0 \to f$, the amplitude A_f (see (1.20)) and the CP conjugate amplitude $\overline{A}_{\overline{f}}$ (see (1.21)) are given by:

$$A_f = \sum_i A_i e^{i(\delta_i+\phi_i)}, \quad \overline{A}_{\overline{f}} = e^{2i(\xi_f-\xi_B)} \sum_i A_i e^{i(\delta_i-\phi_i)}, \tag{1.45}$$

where ξ_f and ξ_B are defined in 1.2.2. (If f is a CP eigenstate then $e^{2i\xi_f} = \pm 1$ is its CP eigenvalue.) The convention-independent quantity is then

$$\left|\frac{\overline{A}_{\overline{f}}}{A_f}\right| = \left|\frac{\sum_i A_i e^{i(\delta_i-\phi_i)}}{\sum_i A_i e^{i(\delta_i+\phi_i)}}\right|. \tag{1.46}$$

When CP is conserved, the weak phases ϕ_i are all equal. Therefore, from Eq. (1.46) one sees that

$$|\overline{A}_{\overline{f}}/A_f| \neq 1 \quad \Longrightarrow \quad CP \text{ violation.} \tag{1.47}$$

This type of CP violation is here called *CP violation in decay*. It is often also called *direct CP violation*. It results from the CP-violating interference among various terms in the decay amplitude. From Eq. (1.46) it can be seen that a CP violation of this type will not occur unless at least two terms that have different weak phases acquire different strong phases, since:

$$|A|^2 \Leftrightarrow |\overline{A}|^2 = \Leftrightarrow 2 \sum_{i,j} A_i A_j \sin(\phi_i \Leftrightarrow \phi_j) \sin(\delta_i \Leftrightarrow \delta_j). \tag{1.48}$$

Any CP asymmetries in charged B decays,

$$a_f = \frac{\Gamma(B^+ \to f) \Leftrightarrow \Gamma(B^- \to \overline{f})}{\Gamma(B^+ \to f) + \Gamma(B^- \to \overline{f})}, \tag{1.49}$$

are from CP violation in decay. In terms of the decay amplitudes

$$a_f = \frac{1 \Leftrightarrow |\overline{A}/A|^2}{1 + |\overline{A}/A|^2}. \tag{1.50}$$

CP violation in decays can also occur for neutral meson decays, where it competes with the other two types of CP violation effects described below. There is as yet no unambiguous experimental