Flavor Physics – Exercise Sheet 7 – SomSem 2015

Exercise 1: CP-Violation in Mixing

CP-Violation in neutral meson mixing can be measured using flavor specific decays $M^0 \to f$ and $\overline{M^0} \to \overline{f}$ correspondingly. Flavor-specific decays are decays where the charges of the daughter particles clearly define the flavor of the meson at the time of the decay. Examples are semi-leptonic decays of K and B mesons.

The detection of the "wrong-sign" decay $M^0 \to \overline{f}$ of a meson which was produced at $t = 0$ as M^0 indicates that the meson has oscillated before its decay: $M^0 \to \overline{M^0} \to \overline{f}$.

The wrong-sign decay asymmetry

$$A_f(t) = \frac{\Gamma\left(\overline{M^0}_{t=0} \to f\right)(t) - \Gamma\left(M^0_{t=0} \to \overline{f}\right)(t)}{\Gamma\left(\overline{M^0}_{t=0} \to f\right)(t) + \Gamma\left(M^0_{t=0} \to \overline{f}\right)(t)}$$

is a measure of CP-violation in the mixing of $M^0 \Longleftrightarrow \overline{M^0}$.

Show that the wrong-sign decay asymmetry A_f can be expressed by the mixing parameters,

$$\left|\frac{q}{p}\right| \quad \text{and} \quad \epsilon = \frac{p - q}{p + q}$$

as follows

$$A_f(t) = \frac{1 - \left|\frac{q}{p}\right|^4}{1 + \left|\frac{q}{p}\right|^4} \approx 4\Re(\epsilon).$$

Hint:

- Show that for $|\epsilon| \ll 1$:

$$\left|\frac{q}{p}\right|^2 \approx 1 - 4\Re(\epsilon)$$

- According to the lecture the time-dependent wrong-sign decay rate $\Gamma\left(\overline{M^0} \to f\right)(t)$ is proportional to $|p/q|^2$.