

Flavor Physics – Exercise Sheet 8 – SomSem 2014

Discussion: 27/06 during the tutorial

Exercise 1: CP-Violation in Mixing

CP-Violation in neutral meson mixing can be measured using flavor specific decays $M^0 \rightarrow f$ and $\overline{M}^0 \rightarrow \overline{f}$ 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 $M^0 \rightarrow \overline{f}$ of a meson which was produced at $t = 0$ as M^0 indicates that the meson has oscillated before its decay: $M^0 \rightarrow \overline{M}^0 \rightarrow \overline{f}$.

The wrong-sign decay asymmetry

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

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

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 $\Gamma(\overline{M}^0 \rightarrow f)(t)$ is proportional to $|p/q|^2$.