chapter 4 (lecture 4)

7) Most recent measurements on CP violation are performed in the B^0 system at the B-factories in Calfornia (*BaBar* experiment) and in Japan (*Belle* experiment). An interesting category are B^0-decays to CP-eigenstates, $f = \bar{f}$, because both the B^0 and the CP-conjugated B, the $\bar{B}^0$ can decay to this same final state.

   (a) What do the assumptions $|q/p| = 1$ and $|A_f| = |\bar{A}_f|$ imply?

   (b) If we assume $|q/p| = 1$ and $|A_f| = |\bar{A}_f|$, the expression for A_{CP},

   $$A_{CP}(t) = \frac{\Gamma_{P^0(t)\to f} - \Gamma_{\bar{P}^0(t)\to f}}{\Gamma_{P^0(t)\to f} + \Gamma_{\bar{P}^0(t)\to f}},$$

   simplifies considerably. Write the expression for $A_{CP}(t)$ if we in addition assume $\Delta\Gamma \sim 0$.

   (c) Under these three assumptions, is there CP-asymmetry at each value of t?

   (d) Under these three assumptions, what is the time-integrated CP-assymetry?

   (e) Which of these three assumptions is valid for each final state of the B^0?

   (f) Write the general expression for $A_{CP}(t)$ if we assume B^0-decays only.

8) To have observable CP violation in a process resulting from two interfering amplitudes one must have a phase difference between the amplitudes that changes under CP conjugation. The actual requirement is slightly more specific. The goal of this exercise is to formulate the more exact requirement.

   (a) Given a decay process that can proceed through two amplitudes: amplitude A, with $|A| = 1$ and amplitude B with $|B| = 1$ and phase difference $\phi_W = 90^o$ between A and B that is entirely due to phase factors in CKM matrix elements.
   Draw the vector-addition diagram for the total amplitude A+B and calculate the magnitude $|A + B|$

   (b) Now draw the diagram for the CP-conjugate process. (What happens to ϕ_W under CP conjugation?)

   (c) Calculate the magnitude of $|A + B|$. Is it different from $\overline{|A + B|}$? Is there observable CP violation in this process?

   (d) Redo the exercise with the following modification: the phase difference between A and B is now $\phi = \phi_s + \phi_w$, where $\phi_w = 90^o$ is the phase difference due to CKM factors and $\phi_s = 45^o$, which is due to other other physics in amplitudes A and B that is invariant under CP conjugation (typically final state interactions from the strong interaction).