Exercises for decoherence and open quantum systems  
Sheet 9  
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**Exercise 31**  
Calculate the t-dependence of the strangeness states $|K^0(t)\rangle, \overline{|K^0\rangle}$ from knowledge of mass-eigenstates $|K_S(t)\rangle, |K_L(t)\rangle$ given by the effective-mass Hamiltonian  
\[
H = M - \frac{i}{2} \Gamma  
\]  
with eigenvalues $\lambda_{S,L} = m_{S,L} - \frac{i}{2} \Gamma_{S,L}$.  

**Exercise 32**  
Suppose that at $t = 0$ a $K^0$ beam is produced by strong interactions. Calculate the probability for finding a $K^0, \overline{K^0}$ in the beam at a later time $t > 0$.  

**Exercise 33**  
Compare a general $2 \times 2$ Hamilton operator decomposition  
\[
H = a \mathbb{1} + \vec{b} \cdot \vec{\sigma}  
\]  
with $\vec{\sigma} = (\sigma_x, \sigma_y, \sigma_z)$,  
and the effective-mass Hamiltonian given in Ex. 31. Determine $b_3$ by the CPT theorem and use a convenient parametrization for CP violation  
\[
e^{i\alpha} = \frac{1 - \epsilon}{1 + \epsilon}  
\]  
with $\epsilon \ldots$ CP violation parameter.  
Which Pauli matrix can be identified with the strangeness operator $S$, the $CP$ operator and the $CP$ violation?  

**Exercise 34**  
Suppose that at $t = 0$ an entangled neutral kaon pair is produced  
\[
|\psi(t = 0)\rangle = \frac{1}{\sqrt{2}} \left(|K^0\rangle_l|\overline{K^0}\rangle_r - |\overline{K^0}\rangle_l|K^0\rangle_r\right)  
\]  
Calculate the probability of finding at the left hand side a $K^0$ at $t_l$ and at the right hand side a $\overline{K^0}$ at $t_r$. Also calculate the probability of finding at the left hand side a $K^0$ at $t_l$ and at the right hand side a $K^0$ at $t_r$. 