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

$$H = M - \frac{i}{2}\Gamma \tag{1}$$

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 2×2 Hamilton operator decomposition

$$H = a\mathbb{1} + \vec{b} \cdot \vec{\sigma} \tag{2}$$

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

$$e^{i\alpha} = \frac{1-\epsilon}{1+\epsilon} \tag{3}$$

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

$$|\psi(t=0)\rangle = \frac{1}{\sqrt{2}}\left(|K^0\rangle_l|\overline{K}^0\rangle_r - |\overline{K}^0\rangle_l|K^0\rangle_r\right) \tag{4}$$

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.