Exercises for nonlocality, entanglement und geometry of quantum systems
Sheet 7

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Corrections for Sheet 6:

1. In order to have a decay of the Kaons the time evolution of the $|K_{S,L}\rangle$ has to be:

$$|K_{S,L}(t)\rangle = e^{-i\lambda_{S,L}t}|K_{S,L}\rangle$$

⇑ minus sign!

2. The normalization of the $|K_{S,L}\rangle$ when written in the $|K^0\rangle, |\overline{K^0}\rangle$-basis has to be:

$$|K_{S,L}\rangle = \frac{1}{\sqrt{|p|^2+|q|^2}}\left\{p|K^0\rangle \mp q|\overline{K^0}\rangle\right\}$$

⇑ square root!

Sorry about that!

Exercise 19

In exercise 18, we calculated the probability to measure a K^0 on the left hand side at time t_l and a K^0 on the right hand side at time t_r. Show that the probability $P(\overline{K^0}, t_l; \overline{K^0}, t_r)$ is equal to the probability of exercise 18. Also show that the probabilities $P(K^0, t_l; \overline{K^0}, t_r)$ and $P(\overline{K^0}, t_l; K^0, t_r)$ are equal and

$$P(K^0, t_l; \overline{K^0}, t_r) = \frac{1}{8}\left\{e^{-\Gamma_S t_l - \Gamma_L t_r} + e^{-\Gamma_L t_l - \Gamma_S t_r} + 2e^{-\Gamma(t_l+t_r)}\cos(\Delta m \Delta t)\right\}$$

Exercise 20

One can define a function A^{QM} which is sensitive to the correlations of the entangled Kaon system.

$$A^{QM} = \frac{P(K^0, t_l; \overline{K^0}, t_r) + P(\overline{K^0}, t_l; K^0, t_r) - P(\overline{K^0}, t_l; \overline{K^0}, t_r) - P(K^0, t_l; K^0, t_r)}{P(K^0, t_l; \overline{K^0}, t_r) + P(\overline{K^0}, t_l; K^0, t_r) + P(\overline{K^0}, t_l; \overline{K^0}, t_r) + P(K^0, t_l; K^0, t_r)}$$

Why is this function sensitive to the quantum mechanical behaviour of the entangled Kaon system? Show that, if you insert the calculated properties of exercise 18,19 into A^{QM}, the result is

$$A^{QM} = \frac{\cos(\Delta m \Delta t)}{\cosh(\frac{1}{2}\Delta\Gamma\Delta t)}$$

$(\Delta\Gamma = \Gamma_L - \Gamma_S)$