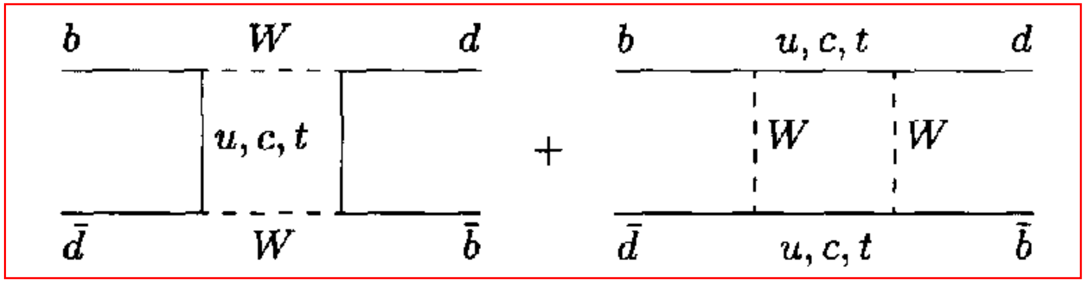
3.6.3 Flavour-Oszillationen

Masse-EZ:

$$\left|P_1\right\rangle = p\left|P\right\rangle + q\left|\overline{P}\right\rangle$$
$$\left|P_2\right\rangle = p\left|P\right\rangle - q\left|\overline{P}\right\rangle$$

Flavour-EZ:

$$\left|P\right\rangle = \frac{1}{2p}\left(\left|P_1\right\rangle + \left|P_2\right\rangle\right)$$
$$\left|\overline{P}\right\rangle = \frac{1}{2q}\left(\left|P_1\right\rangle - \left|P_2\right\rangle\right)$$



Zeitl. Entw.:

$$\left|P_i(t)\right\rangle = e^{-im_i t} \cdot e^{-\frac{1}{2}\Gamma_i t}\left|P_i\right\rangle$$

$$\Gamma_{1,2} = \Gamma \mp 2\,\mathrm{Im}\sqrt{H_{12}H_{21}}$$
$$m_{1,2} = m \pm 2\,\mathrm{Re}\sqrt{H_{12}H_{21}}$$

Zeitentwicklung reiner Flavourzustaende (t=0)

$$\left|\psi(t)\right\rangle_P = f_+(t)\left|P\right\rangle - \frac{q}{p} f_-(t)\left|\overline{P}\right\rangle$$

$$\left|\psi(t)\right\rangle_{\overline{P}} = f_+(t)\left|\overline{P}\right\rangle - \frac{p}{q} f_-(t)\left|P\right\rangle$$

$$f_\pm = \frac{1}{2}\left(e^{-im_1 t}\cdot e^{-\frac{\Gamma_1}{2}t} \pm e^{-im_2 t}\cdot e^{-\frac{\Gamma_2}{2}t}\right)$$

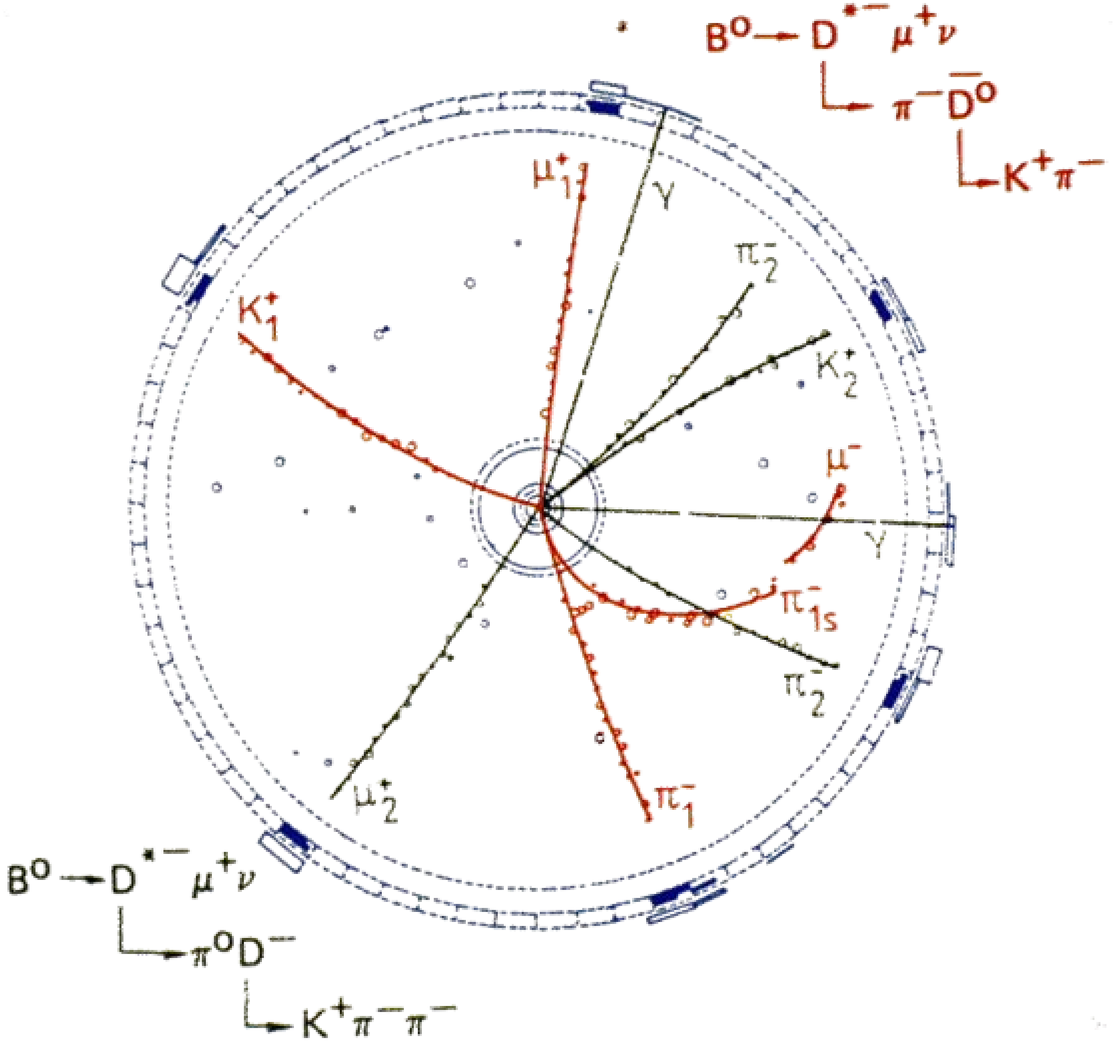
$$prob(P\to P;t) = \quad prob(\overline{P}\to\overline{P};t) = \left|f_+\right|^2 = \frac{1}{4}\left(e^{-\Gamma_1 t} + e^{-\Gamma_2 t} + e^{-\Gamma t}\cos\Delta m\, t\right)$$

$$\left|\frac{q}{p}\right|^2 prob(P\to\overline{P};t) = \left|\frac{p}{q}\right|^2 prob(\overline{P}\to P;t) = \left|f_-\right|^2 = \frac{1}{4}\left(e^{-\Gamma_1 t} + e^{-\Gamma_2 t} - e^{-\Gamma t}\cos\Delta m\, t\right)$$

$$x = \frac{\Delta m}{\Gamma} = \Delta m\,\tau; \qquad y = \frac{\Delta\Gamma}{2\Gamma}$$

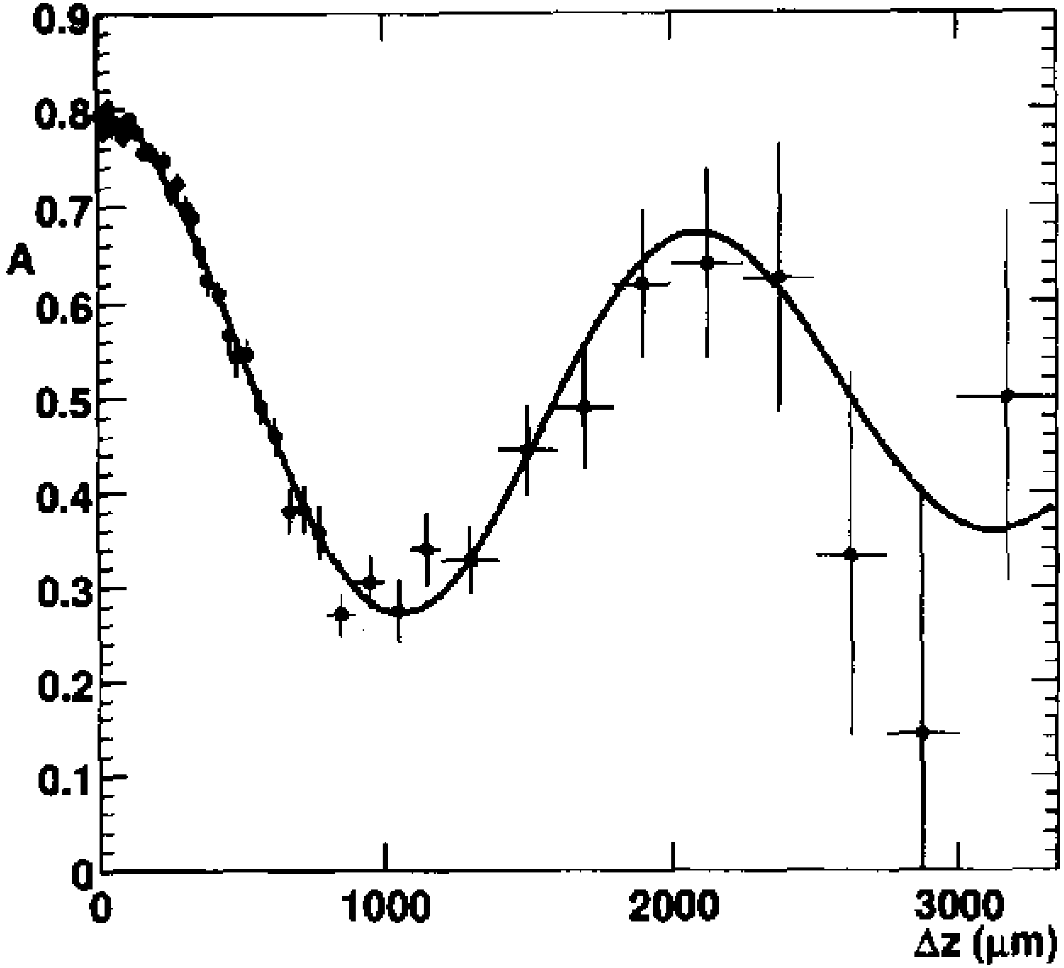
$$\left|f_\pm\right|^2 = \frac{1}{2}e^{-\Gamma t'}\left(\cosh yt' \pm \cos xt'\right), \qquad t' = t/\tau$$

$B^0\overline{B^0}$-Oszillationen



Flavour -Tagging

Zeitaufgeloeste Oszillationen im B^0-System



Zeitintegrierte Mischung

$$r = \frac{\int (P \to \overline{P}; t) dt}{\int (P \to P; t) dt} = \left|\frac{q}{p}\right|^2 \frac{x^2 + y^2}{2 + x^2 - y^2}$$

$$\overline{r} = \frac{\int (\overline{P} \to P; t) dt}{\int (\overline{P} \to \overline{P}; t) dt} = \left|\frac{p}{q}\right|^2 \frac{x^2 + y^2}{2 + x^2 - y^2}$$

Mischung fuer: $x \neq 0 \quad \text{und/oder} \quad y \neq 0$

$y = 0 \quad \Rightarrow \quad \Gamma_1 = \Gamma_2$ z.B. wegen aehnlichen Zerfallsmoden, grossem Phasenraume

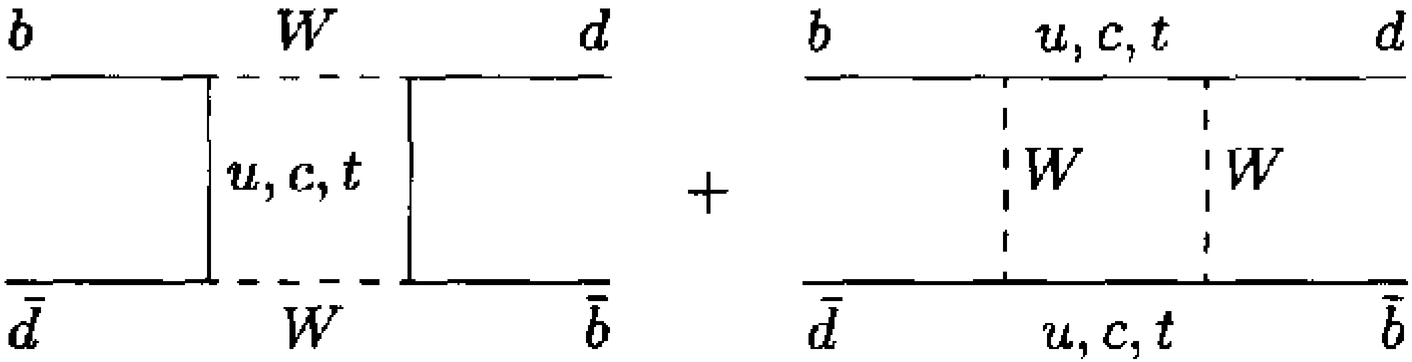
$x = 0 \quad \Rightarrow \quad \text{keine Kopplung}$

K^0-System

$$CP = +1: \quad |K_S^0> \;\approx\; |K_1> \;=\; \frac{1}{\sqrt{2}}\left(|K^0> + |\bar{K}^0>\right) \quad (\tau = 10^{-10}\,\mathrm{s})$$

$$CP = -1: \quad |K_L^0> \;\approx\; |K_2> \;=\; \frac{1}{\sqrt{2}}\left(|K^0> - |\bar{K}^0>\right) \quad (\tau = 5 \cdot 10^{-8}\,\mathrm{s})$$

B-Mischung



Systeme neutraler Mesonen-Antimesonen

description	$K^0/\overline{K}^0$	$D^0/\overline{D}^0$	$B^0/\overline{B}^0$	$B_s/\overline{B}_s$
τ [ps] Γ [s^{-1}] $y = \Delta\Gamma/2\Gamma$	$89.4 \pm 0.1;\ 51700 \pm 400$ $5.61 \cdot 10^9$ -0.9966	$0.413 \pm .003$ $2.4 \cdot 10^{12}$ $\lvert y\rvert < 0.06$	1.548 ± 0.021 $(6.41 \pm 0.16) \cdot 10^{11}$ $\lvert y\rvert \lesssim 0.01^*$	1.49 ± 0.06 $(6.7 \pm 0.3) \cdot 10^{11}$ $-(0.01 \ldots 0.10)^*$
Δm [s^{-1}] Δm [eV] $x = \Delta m/\Gamma$	$(5.300 \pm 0.012) \cdot 10^9$ $(3.49 \pm 0.01) \cdot 10^{-6}$ 0.945 ± 0.002	$< 7 \cdot 10^{10}$ $< 5 \cdot 10^{-6}$ < 0.03	$(4.89 \pm 0.09) \cdot 10^{11}$ $(3.2 \pm 0.1) \cdot 10^{-4}$ 0.76 ± 0.02	$> 15 \cdot 10^{12}$ $> 1.0 \cdot 10^{-2}$ $21 \ldots 40^*$
δ_ϵ $\lvert\eta_m\rvert^2$	$(3.27 \pm 0.12) \cdot 10^{-3}$ 0.99348 ± 0.00024	 $\approx 1^*$	$\sim -10^{-3\,*}$ $1 \ldots 1.002^*$	$\lvert\delta_\epsilon\rvert < 10^{-3\,*}$ $\approx 1^*$

* Standard Model expectation [33]

Oszillationen in K^0- und D^0-Systemen

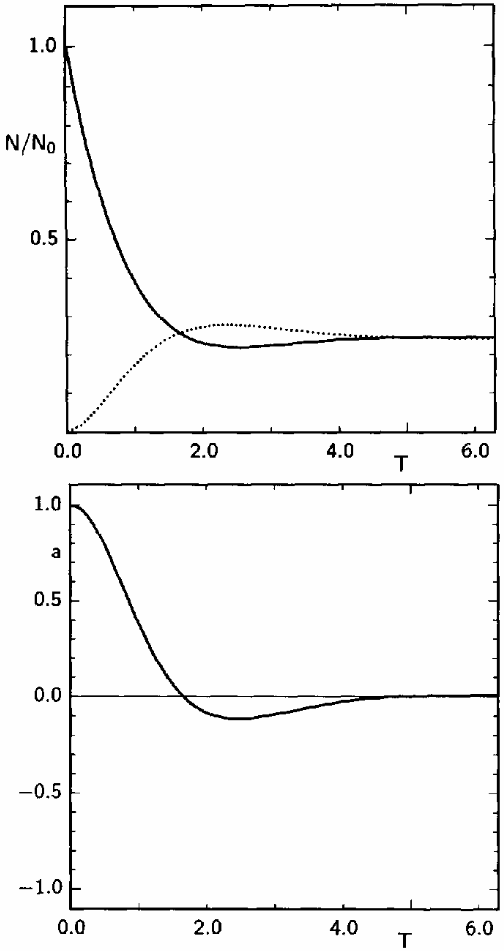


Figure 3: $K^0/\overline{K}^0$ mixing is determined l the parameters $x = 0.945$, $y = 0.997$, ar $|\eta_m|^2 = 0.994$ (see table 1). $T = t/\bar{\tau}$ is tl lifetime in units of $\bar{\tau} \approx 2\tau_S$, the inverse of tl average width of K_L^0 and K_S^0. The upper diagra shows the number of K^0 (solid) and $\overline{K}^0$ (dotte as a function of T for a sample starting wi 100% K^0 mesons. The lower diagram shows tl asymmetry $a = (N_K - N_{\overline{K}})/(N_K + N_{\overline{K}})$. Tl relaxation process soon dominates, leaving on K_L^0 after not much more than one oscillation.

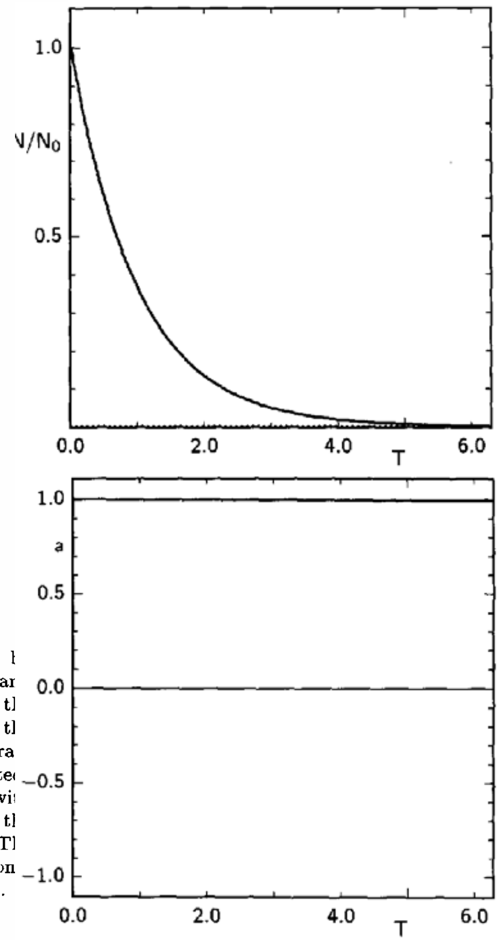


Figure 4: $D^0/\overline{D}^0$ oscillations have not yet been observed, and are hardly visible even with $x = 0.02$ which is about 10 times the expected value and was used for these plots together with $y = 0$ and $|\eta_m| = 1$.

Oszillationen in B^0- und B_s-Systemen

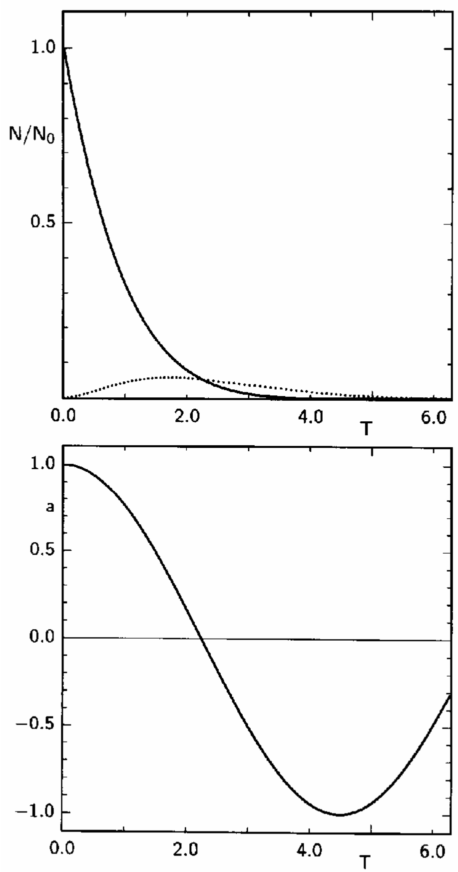


Figure 5: $B^0/\overline{B}^0$ evolution is dominated by the oscillating part, with the parameters $x = 0.70$, $y = 0$, and $|\eta_m| = 1$. The ratio of the areas under the dotted and solid curve in the upper plot is the mixing probability χ. The zero transition in the asymmetry, which marks the crossover point in the upper plot, is at $T = \frac{\pi}{2x}$.

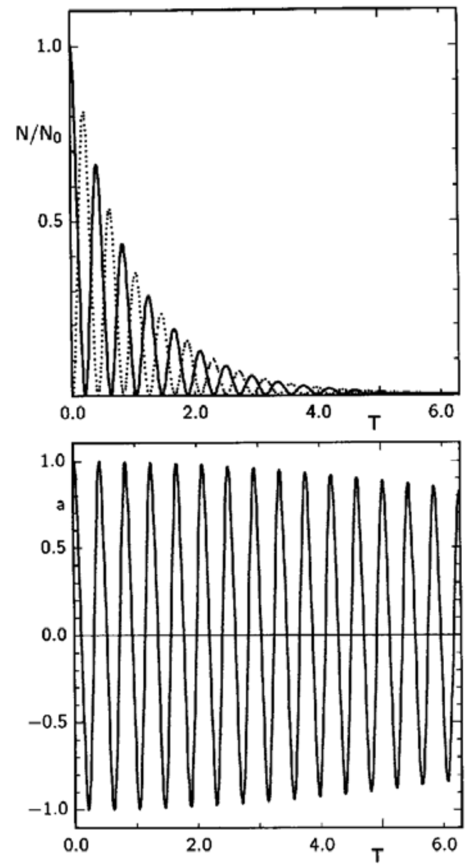


Figure 6: $B_s/\overline{B}_s$ is expected to be the most rapidly oscillating system, with a longer relaxation time. This plot assumes $x_s = 15$, $y_s = 0.10$, and $|\eta_m| = 1$.