STRANGENESS OSCILLATIONS

- WEAK INTERACTION EIGEN STATES ARE ONES RELEVANT FOR $K^0, \bar{K}^0$ PROPAGATION

- NOTE WE DEFINED K_1^0 & K_2^0 TO BE CP EIGENSTATES

- SHORT & LONG LIVED COMPONENTS OF $K^0, \bar{K}^0$ BEAM NOT CP EIGENSTATES

- DEFINE

$$K_L^0 = \frac{1}{\sqrt{1+|\varepsilon|^2}} \left(K_2^0 + \varepsilon K_1^0 \right)$$

$$K_S^0 = \frac{1}{\sqrt{1+|\varepsilon|^2}} \left(K_1^0 - \varepsilon K_2^0 \right)$$

CP VIOLATION

AS $\varepsilon \to 0$ $\quad K_L^0 \to K_2^0$

$K_S^0 \to K_1^0$

- AMPLITUDE OF K_S IN REST FRAME

$$A_S(t) = A_S(0)\, e^{-\left(\frac{\Gamma_S}{2} + i m_S\right)t}$$

$m_S \rightarrow$ REST MASS OF K_S^0

$\Gamma_S \rightarrow \hbar/\tau_S$ WIDTH OF K_S^0

$$A_L(t) = A_L(0)\, e^{-\left(\frac{\Gamma_L}{2} + i m_L\right).t}$$

- START WITH PURE K^0 BEAM FROM STRONG INTERACTION

DEFINED

$$K_S^0 = \frac{1}{\sqrt{2}}\left(|K^0\rangle + |\bar{K}^0\rangle\right)$$

$$K_L^0 = \frac{1}{\sqrt{2}}\left(|K^0\rangle - |\bar{K}^0\rangle\right)$$

$\varepsilon \rightarrow 0$

FORGET ~~CP~~

PURE K^0 $\quad |K^0\rangle = \frac{1}{\sqrt{2}}\left(|K_S^0\rangle + |K_L^0\rangle\right)$

$$\therefore \quad A_S(0) = A_L(0) = \frac{1}{\sqrt{2}}$$

- K_L^0 + K_S^0 EVOLVE DIFFERENTLY IN TIME.

- AFTER TIME t

$$I(K^0) = \frac{1}{2}\left[A_S(t) + A_L(t)\right]\left[A_S^*(t) + A_L^*(t)\right]$$

$$= \frac{1}{4}\left[e^{-\Gamma_S t} + e^{-\Gamma_L t} + 2e^{-(\Gamma_S + \Gamma_L)t/2} \cos \Delta m \cdot t\right]$$

$\Delta m = m_L - m_S$

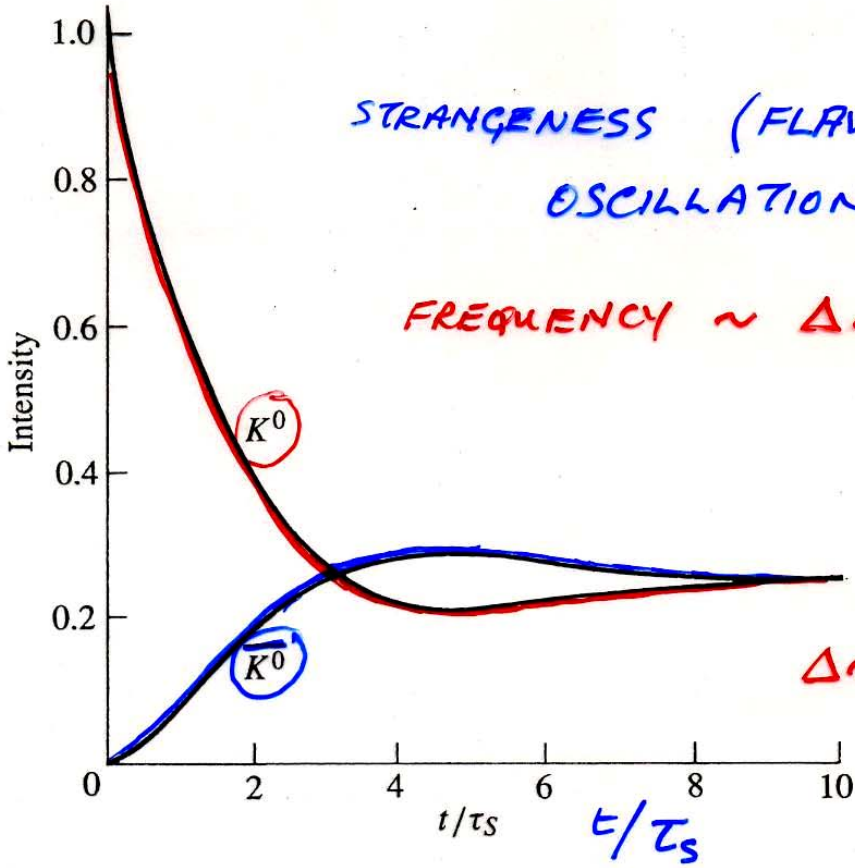
OSCILLATION DEPENDS ON MASS DIFFERENCE

SIMILARLY

$$I(\bar{K}^0) = \frac{1}{4}\left[e^{-\Gamma_S t} + e^{-\Gamma_L t} - 2e^{-(\Gamma_S + \Gamma_L)\cdot t/2} \cos \Delta m t\right]$$

$\Delta m \rightarrow$ OSCILLATION FREQUENCY

$K^0 \Leftrightarrow \bar{K}^0$



STRANGENESS (FLAVOUR) OSCILLATIONS

FREQUENCY ~ Δm

$$\Delta m = \frac{0.5}{\tau_S}$$

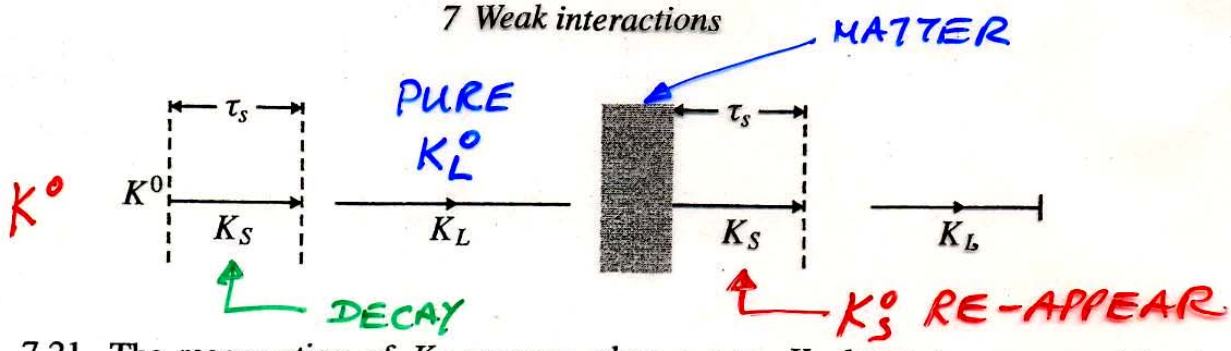
• FOR $K^0 \bar{K}^0$ SYSTEM

$$\Delta m = (3.491 \pm 0.009) \times 10^{-12} \text{ MeV}$$

$$\frac{\Delta m_{K^0}}{m_{K^0}} = 7 \times 10^{-15}$$

VERY SENSITIVE TO SMALL Δm

? DO LEPTON FLAVOUR OSCILLATIONS EXIST ? → YOU BET !



g. 7.21. The regeneration of K_S mesons when a pure K_L beam traverses a slab of Material (shaded).

- PURE $|K^0\rangle$ COASTING IN VACUUM

"DECAYS" $\rightarrow$ PURE $|K_0^L\rangle$

$$|K_L^0\rangle = \frac{1}{\sqrt{2}}\left(|K^0\rangle - |\bar{K}^0\rangle\right) \quad (1)$$

INTERACT DIFFERENTLY IN MATERIAL

- AFTER MATTER

$$|\bar{K}^0\rangle \rightarrow \bar{f}\,|\bar{K}^0\rangle$$

$$|K^0\rangle \rightarrow f\,|K^0\rangle$$

$$\bar{f} < f < 1$$

$$(1) \rightarrow \frac{1}{\sqrt{2}}\left(f|K^0\rangle + \bar{f}\,|\bar{K}^0\rangle\right) = \frac{1}{2}(f+\bar{f})|K_L^0\rangle + \frac{1}{2}(f-\bar{f})|K_S^0\rangle$$