ON A POSSIBLE TEST OF THE WEISSKOPF-WIGNER APPROXIMATION AT DAΦNE

G.V. DASS, W. GRIMUS, PLB521 (2001) 267

SEE ALSO

P.H. EBERHARD, 2nd DAΦNE PHYSICS HB

MOTIVATION:

$K^0\bar{K}^0$, $B^0\bar{B}^0$, ... SYSTEMS

$\longrightarrow$ ENVIRONMENT FOR THE INVESTIGATION OF CP, T, CPT, QM, $\Delta F = \Delta Q$ RULE ETC.

ANALYSES BASED ON

WEISSKOPF - WIGNER APPROXIMATION
LEE - OEHME - YANG THEORY

$\boxed{\text{CAN ONE TEST WWA + LOY THEORY ?}}$

CORRELATED DECAY OF

$$|\psi\rangle = \frac{1}{\sqrt{2}} \, |M^0 \otimes \bar{M}^0 - \bar{M}^0 \otimes M^0\rangle$$

$M^0 =$
$K^0, B^0_{d,s}, D^0$

INTO TWO SCALARS $S_1 S_2$

$$S_1 S_2 \xleftarrow{t_\ell} |\psi\rangle \xrightarrow{t_r} S_1 S_2$$

TIME DEPENDENCE OF DECAY RATE
DETERMINED EXCLUSIVELY BY WWA+LOY

$$R(t_\ell, t_r) \propto e^{-\Gamma t_+} \left\{ \cosh \tfrac{1}{2} \Delta\Gamma t_- - \cos \Delta m t_- \right\}$$

$t_\pm = t_\ell \pm t_r$, $\Gamma = \frac{1}{2}(\Gamma_H + \Gamma_L)$, $\Delta\Gamma = \Gamma_H - \Gamma_L$, $\Delta m = m_H - m_L$

H = heavy, L = light

$\longrightarrow$ TEST OF WWA + LOY

REALISTIC EXAMPLE:

$$\boxed{\phi(1020) \longrightarrow K^0 \bar{K}^0 \longrightarrow 2(\pi^+\pi^-)}$$

$\pi^0 \pi^0$

TIME DEPENDENCE OF $R(f, t_\ell; g, t_r)$:

$$\boxed{\begin{array}{c} \text{LOY: } |M_{H,L}\rangle = p_{H,L}|M^0\rangle \pm q_{H,L}|\bar{M}^0\rangle \xrightarrow{t} \Theta_{H,L}(t)|M_{H,L}\rangle \\ \text{LACK OF VACUUM REGENERATION} \end{array}}$$

$$\boxed{\text{WWA: } \Theta_{H,L}(t) = \exp(-i\lambda_{H,L} t), \quad \lambda_{H,L} = m_{H,L} - \tfrac{i}{2}\Gamma_{H,L}}$$

$$|\Psi\rangle = \frac{1}{\sqrt{2}\, D} \left| M_L \otimes M_H - M_H \otimes M_L \right\rangle$$

$$D \equiv p_H q_L + q_H p_L$$

$$\mathcal{A}(f, t_\ell; g, t_r) =$$

$$\frac{1}{\sqrt{2}\, D} \left\{ A_L(f) e^{-i\lambda_L t_\ell} A_H(g) e^{-i\lambda_H t_r} - A_H(f) e^{-i\lambda_H t_\ell} A_L(g) e^{-i\lambda_L t_r} \right\}$$

FACTORIZATION OF $\mathcal{A}$ INTO AMPLITUDES × TIME DEP.:

NECESSARY CONDITION $A_L(f) A_H(g) = A_H(f) A_L(g)$

1. PARTICLE CONTENT OF f AND g MUST BE THE SAME
2. MOMENTUM AND SPIN CONFIGURATIONS ALSO (APART FROM TRIVIAL ROTATIONS)

CONSEQUENCE : f, g MUST HAVE SAME <u>SCALARS</u> $S_1 S_2$

$$\Rightarrow \boxed{R(t_\ell; t_r) = \frac{|A_H|^2 |A_L|^2}{|D|^2} e^{-\Gamma t_+} \left\{ \cosh \tfrac{1}{2}\Delta\Gamma t_- - \cos \Delta m t_- \right\}}$$

ESTIMATE OF R FOR $(K^0\bar{K}^0)_{C=-1} \rightarrow 2(\pi^+\pi^-)$:

$$|M_H\rangle \equiv |K_L\rangle\,, \quad |M_L\rangle \equiv |K_S\rangle$$

$$\frac{|A_L|^2|A_S|^2}{|D|^2} \simeq |A_S|^4 \left|\frac{A_L}{A_S}\right|^2 =$$

LEADING ORDER

$$= \left[\Gamma_S \; Br(K_S \rightarrow \pi^+\pi^-)\right]^2 |\eta_{+-}|^2$$

5×10^{-6}

SUPPRESSION DUE TO $\cancel{CP}$

CONCLUSIONS:

BENEFITS OF $\phi \to K^0 \bar{K}^0 \to 2(\pi^+\pi^-) / 2(\pi^0\pi^0)$

1. TEST OF WWA BY MEASURING TIME DEPENDENCE OF $R(t_l; t_r)$

2. TEST OF QM CORRELATION OVER MACROSCOPIC DISTANCES:

   $R(t;t) = 0$ INDEP. OF WWA + LOY

3. TEST IF EVERYTHING WORKS AS EXPECTED