The $\phi \to \pi^+\pi^-$ decay

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1 Introduction

The interest of the $\phi \to \pi^+\pi^-$ decay is due to the fact that it violates isospin, it is OZI suppressed, and thus it could shed some light on both $\phi - \rho$ and $\phi - \omega$ mixing. In addition, at present there is a strong experimental conflict between the two most recent and precise measurements at VEPP-2M. On the one hand, CMD-2 [1] reports a value of $BR = (2.20 \pm 0.25 \pm 0.20) \times 10^{-4}$ and on the other hand SND [2] provides $BR = (0.71 \pm 0.11 \pm 0.09) \times 10^{-4}$.

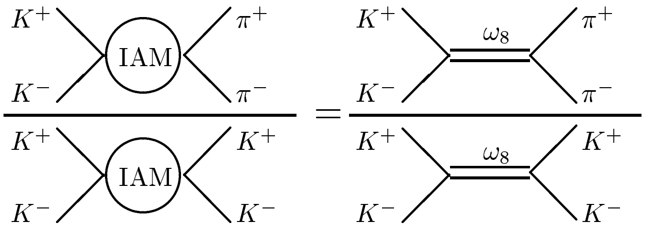
There are two main contributions to this process:

- From $\phi - \rho$ mixing, where, once more, we distinguish:
  - The electromagnetic $\phi - \gamma - \rho - \pi\pi$ contribution. The $g^{\gamma}_{\phi\pi\pi}$ effective coupling is obtained from the vector resonance chiral lagrangian [3]
  - The strong contribution due to kaon loops, where we have used the chiral unitary approach to obtain an effective coupling[4] $g^{K\bar{K}}_{\phi\pi\pi}$.
- From the $\phi - \omega - \rho$ process. We have calculated a $g^{\phi\omega}_{\phi\pi\pi}$ coupling for three different scenarios in the literature: the "Strong $\phi - \omega$ mixing" [5], the "Weak $\phi - \omega$ mixing" [5] and the "Hidden Local Symmetry" scenario [6].

2 The kaon-loop contribution to the $\phi\pi\pi$ effective coupling.

The inverse amplitude method (IAM), based on the standard Chiral Perturbation Theory (ChPT) $O(p^4)$ SU(3) Lagrangian [7], provides a coupled channel unitary T matrix respecting the constraints of chiral symmetry at low energies. It has been very succesful [8] in describing the meson-meson interactions up to 1.2 GeV, generating six resonances. In addition, in the $I = 0$, $J = 0$ partial wave it develops a pole that corresponds to the octet ω_8 resonant state.

By including isospin breaking effects in the ChPT lagrangian, the chiral unitary approach provides a nonvanishing $K^+K^- \to \pi^+\pi^-$ $P - wave$ amplitude. Reinterpreting these amplitudes at the ω_8 pole, in terms of ω_8 exchange, we can obtain the effective $g^{K\bar{K}}_{\phi\pi\pi}$, schematically, as follows:



$$= \frac{g^{K\bar{K}}_{\omega_8 \pi\pi}}{g_{\omega_8 K\bar{K}}} \simeq \frac{g^{K\bar{K}}_{\phi\pi\pi}}{g_{\phi K\bar{K}}},$$

where the first amplitude fraction comes from the chiral unitary approach and $g_{\phi K\bar{K}}$ is known from the vector resonance chiral Lagrangians.

There are other isospin breaking terms including photons, which would involve chiral parameters which are presently unknown. From absorptive calculations [9] their contributions have been estimated to be at most 25% of those due to kaon loops, but with opposite sign.

3 Results

They depend on the $\phi - \omega$ mixing scenario.

- "Strong mixing": $BR = (1.7 \pm 0.3) \times 10^{-4}$ to $(2.5 \pm 0.3) \times 10^{-4}$.
- "Weak mixing": $BR \simeq (0.38 \pm 0.12) \times 10^{-4}$.
- "Hidden Local Symmetry": $BR \simeq (0.3 \pm 0.1 \pm 0.3) \times 10^{-4}$.

The first one is perfectly compatible with the CMD-2 experiment, whereas the other two seem to prefer a value somewhat lower (but still compatible) than that of SND. Therefore, it seems that once the experimental issue is settled it could be used to differentiate between $\phi - \omega$ mixing scenarios.

Acknowledgments

Work partially supported by DGICYT contracts PB96-0753, AEN97-1693 and PB98-0782 and EU TMR Eurodaphne contract ERBFMRX-CT98-0169.

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