The $\omega\rho\pi$ coupling in the VMD model revisited

David García Gudiño[1] and G. Toledo Sánchez
Instituto de Física, Universidad Nacional Autónoma de México
AP 20-364, México D.F. 01000, México

We determine the value of the $\omega - \rho - \pi$ mesons coupling ($g_{\omega\rho\pi}$), in the context of the vector meson dominance model, from radiative decays, the $\omega \to 3\pi$ decay width and the $e^+e^- \to 3\pi$ cross section. For the last two observables we consider the presence of a contact term as mimic by a heavier resonance and find its magnitude to be close to other approaches. Our global average is $g_{\omega\rho\pi} = 13.8 \pm 0.1$ ($g_{\omega\rho\pi} = 11.3 \pm 1$) without (with) contact term. Although the value obtained is sensitive to the inclusion of the contact term, the current precision allows to accommodate its effects within the error bars.

1 Introduction

The coupling between the ω, ρ and π mesons ($g_{\omega\rho\pi}$) encodes the strength of the strong interaction between them. It is required in processes where the vertex appear as a subdiagram; some of these processes have an increasing experimental accuracy because of their implications in observables like the muon magnetic moment [1]. The direct determination of its magnitude would require the observation of the ω decaying into the others, but since there is not enough phase space to allow for the three particles to be on the mass shell, it must be extracted by indirect means. In the vector meson dominance (VMD) model it can be obtained from a set of different vectorial radiative decays, or in processes containing this vertex, for example the decay of the ω meson into three pions, which is well known to be dominated by the $\rho\pi \to 3\pi$ channel [2]. In this process the presence of a possible contact term contributing to the decay may strongly influence the determination of $g_{\omega\rho\pi}$ coupling. In this work we determine the value of $g_{\omega\rho\pi}$ in the context of the VMD model from radiative processes, from the $\omega \to 3\pi$ decay and from the $e^+e^- \to 3\pi$ cross section. These last two processes allow the presence of a contact term. A contact term and a pinched diagram due to the presence of a heavier meson in the intermediate state have the same Lorentz structure; in fact, it has been suggested this last one as the origin of the contact term itself. Here we explore at which extent the vector meson $\rho'(1450)$ can mimic a truly contact term under the VMD idea in the low energy regime. We also examine the effects of this term in the $g_{\omega\rho\pi}$ determination.

[1]davidgarcia@fisica.unam.mx

2 The $g_{\omega\rho\pi}$ coupling from different processes.

- In the VMD scheme $g_{\omega\rho\pi}$ can be obtained from several radiative processes such as $\rho^- \to \pi^-\gamma$, $\rho^0 \to \pi^0\gamma$, $\omega \to \pi^0\gamma$ and $\pi^0 \to \gamma\gamma$ from which we can directly obtain the $g_{\rho\pi\gamma}$ or $g_{\omega\pi\gamma}$ coupling and then relate them to the $g_{\omega\rho\pi}$ through the VMD relations

  (1) $$g_{\omega\rho\pi} = g_{\rho\pi\gamma} g_\omega / e \qquad g_{\omega\rho\pi} = g_{\omega\pi\gamma} g_\rho / e,$$

  where g_V is the VMD coupling, accounting for the probability of the photon transmutation into V, and can be determined from the $V \to e^+e^-$ decay. The results from these processes have been averaged and the final result is shown in the Table 1 as the VMD$_{radiative}$ prediction.

- Consider the $\omega(q) \to \pi^+(p_1)\pi^-(p_2)\pi^0(p_3)$ decay, whose amplitude is given by:

  (2) $$\mathcal{M}_D = \imath\epsilon_{\mu\alpha\beta\gamma}\eta^\mu p_1^\alpha p_2^\beta p_3^\gamma \left(6g_{3\pi} + 2g_{\omega\rho\pi}g_{\rho\pi\pi} \sum_{a=\{+,-,0\}} D^{-1}\left[\rho^a, p_i + p_j\right] \right)$$

  where, $D[\rho, Q] = Q^2 - m_\rho^2 + im_\rho\Gamma_\rho$ and $g_{3\pi}$ is the contact term; the heavier mass of the ρ' allows us to make the approximation $|g_{3\pi}| \approx \frac{g_{\omega\rho'\pi}g_{\rho'\pi\pi}}{m_{\rho'}^2} (= 49 \pm 24\ GeV^{-3})$. It is remarkable that this simple approach can mimic the contact term in the same magnitude as predicted in other approaches [3]. To obtain the $g_{\omega\rho\pi}$ from this decay we require to reproduce the experimental value of the total width by adjusting the coupling in both cases: with and without a contact term. Our results for these adjustments are presented in Table 1.

- Finally, we consider the $e^+e^- \to \omega \to 3\pi$ process, which has an expression closely related to Eqn. 2. To obtain the $g_{\omega\rho\pi}$ coupling, we have computed the cross section for this process ensuring the reproduction of the experimental data [4] by adjusting the coupling constant in both cases with and without the contact term. Our results are presented in Table 1.

	Without contact	With Contact (ρ')
VMD$_{radiative}$	11.6 ± 0.2	$--$
$\Gamma(\omega \to 3\pi)$	15.7 ± 0.1	12.6 ± 1.3
$\sigma(e^+e^- \to 3\pi)$	13.1 ± 0.1	9.8 ± 1.4
Weighted Average	13.8 ± 0.1	11.3 ± 1

Table 1: Final values for the $\omega\rho\pi$ coupling (GeV^{-1}).

3 Discussion

Table 1 shows the different values for the $g_{\omega\rho\pi}$ coupling obtained from the processes discussed above. The VMD$_{radiative}$ prediction do not posses information about a contact term and for this reason it is only considered without this contribution. As it can be seen, the value obtained for $g_{\omega\rho\pi}$ is sensitive to the inclusion of the contact term. Our final results are the weighted average. A more detailed version of this work can be found in [5].

Acknowledgments

We acknowledge the support of CONACyT, Mexico.

References

[1] M. Benayoun, P. David, L. DelBuono, O. Leitner Eur. Phys. Jour C **65** 211(2010) ; ibid **68** 355(2010).

[2] M. Gell-Mann, D. Sharp, W. G. Wagner, Phys. Rev. Lett. 8 (1962) 460.

[3] S. Rudaz, Phys. Lett. B 145 281(1984).

[4] R.R. Akhmetshin et al. Phys. Lett. B **578** 285(2004).

[5] D. García Gudiño and G. Toledo Sánchez, arXiv:1106.1467v1 [hep-ph]