

$\rho(770)$

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The determination of the parameters of the $\rho(770)$ is beset with many difficulties because of its large width. In physical region fits, the line shape does not correspond to a relativistic Breit-Wigner function with a P -wave width, but requires some additional shape parameter. This dependence on parameterization was demonstrated long ago [1]. Bose-Einstein correlations are another source of shifts in the $\rho(770)$ line shape, particularly in multiparticle final-state systems [2].

The same model dependence afflicts any other source of resonance parameters, such as the energy dependence of the phase shift δ_1^1 , or the pole position. It is, therefore, not surprising that a study of $\rho(770)$ dominance in the decays of the η and η' reveals the need for specific dynamical effects, in addition to the $\rho(770)$ pole [3,4].

The cleanest determination of the $\rho(770)$ mass and width comes from e^+e^- annihilation and τ -lepton decays. Analysis of ALEPH [5] showed that the charged $\rho(770)$ parameters measured from τ -lepton decays are consistent with those of the neutral one determined from e^+e^- data [6]. This conclusion is qualitatively supported by the later studies of CLEO [7] and Belle [8]. However, comparison of the two-pion mass spectrum in τ decays from OPAL [9], CLEO [7], and ALEPH [10,11], and the $e^+e^- \rightarrow \pi^+\pi^-$ cross section from CMD-2 [12,13], showed significant discrepancies between the two shapes which can be as high as 10% above the ρ meson [14,15]. This discrepancy remains after measurements of the two-pion cross section in e^+e^- annihilation at KLOE [16,17,18,19], SND [20,21], BaBar [22] and, more recently BESIII [23]. The effect is not accounted for by isospin breaking [24,25,26,27], but the accuracy of its calculation may be overestimated [28,29].

This problem seems to be solved after a recent analysis in [30] which showed that after correcting the τ data for the missing $\rho - \gamma$ mixing contribution, besides the other known isospin symmetry violating corrections, the $\pi\pi$ $I=1$ part of the hadronic vacuum polarization contribution to the muon $g - 2$ is fully compatible between τ based and e^+e^- based evaluations. The global fit of the whole set of the ρ , ω , and ϕ decays, taking into account mixing effects in the hidden local symmetry model, also showed consistency of the data on τ decays to two pions and e^+e^- annihilation [31,32]. However, because of the progress in e^+e^- data, the τ input is now less precise and less reliable due to additional theoretical uncertainties [33] decreasing importance of τ versus e^+e^- comparison for the determination of $\rho(770)$ parameters and other applications, like, e.g., calculations of hadronic vacuum polarization.

References:

1. J. Pisut and M. Roos, Nucl. Phys. **B6**, 325 (1968).
2. G.D. Lafferty, Z. Phys. **C60**, 659 (1993).
3. A. Abele *et al.*, Phys. Lett. **B402**, 195 (1997).
4. M. Benayoun *et al.*, Eur. Phys. J. **C31**, 525 (2003).
5. R. Barate *et al.*, Z. Phys. **C76**, 15 (1997).
6. L.M. Barkov *et al.*, Nucl. Phys. **B256**, 365 (1985).
7. S. Anderson *et al.*, Phys. Rev. **D61**, 112002 (2000).

8. M. Fujikawa *et al.*, Phys. Rev. **D78**, 072006 (2008).
9. K. Ackerstaff *et al.*, Eur. Phys. J. **C7**, 571 (1999).
10. M. Davier *et al.*, Nucl. Phys. (Proc. Supp.) **B123**, 47 (2003).
11. S. Schael *et al.*, Phys. Reports **421**, 191 (2005).
12. R.R. Akhmetshin *et al.*, Phys. Lett. **B527**, 161 (2002).
13. R.R. Akhmetshin *et al.*, Phys. Lett. **B578**, 285 (2004).
14. M. Davier *et al.*, Eur. Phys. J. **C27**, 497 (2003).
15. M. Davier *et al.*, Eur. Phys. J. **C31**, 503 (2003).
16. A. Aloisio *et al.*, Phys. Lett. **B606**, 12 (2005).
17. F. Ambrosino *et al.*, Phys. Lett. **B670**, 285 (2009).
18. F. Ambrosino *et al.*, Phys. Lett. **B700**, 102 (2011).
19. D. Babusci *et al.*, Phys. Lett. **B720**, 336 (2013).
20. M.N. Achasov *et al.*, Sov. Phys. JETP **101**, 1053 (2005).
21. M.N. Achasov *et al.*, Sov. Phys. JETP **103**, 380 (2006).
22. B. Aubert *et al.*, Phys. Rev. Lett. **103**, 231801 (2009).
23. M. Ablikim *et al.*, Phys. Lett. **B753**, 629 (2016).
24. R. Alemany *et al.*, Eur. Phys. J. **C2**, 123 (1998).
25. H. Czyz and J.J. Kuhn, Eur. Phys. J. **C18**, 497 (2001).
26. V. Cirigliano *et al.*, Phys. Lett. **B513**, 361 (2001).
27. V. Cirigliano *et al.*, Eur. Phys. J. **C23**, 121 (2002).
28. K. Maltman and C.E. Wolfe, Phys. Rev. **D73**, 013004 (2006).
29. C.E. Wolfe and K. Maltman, Phys. Rev. **D80**, 114024 (2009).
30. F. Jegerlehner and R. Szafron, Eur. Phys. J. **C71**, 1632 (2011).
31. M. Benayoun *et al.*, Eur. Phys. J. **C72**, 1848 (2012).
32. M. Benayoun *et al.*, Eur. Phys. J. **C73**, 2453 (2013).
33. M. Davier *et al.*, Eur. Phys. J. **C77**, 827 (2017).