70. $\rho(770)$

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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 $\delta_1^1$, or the pole position. It is, therefore, not surprising that a study of $\rho(770)$ dominance in the decays of the $\eta$ and $\eta'$ 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 $\tau$-lepton decays. Analysis of ALEPH [5] showed that the charged $\rho(770)$ parameters measured from $\tau$-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, model-independent comparison of the two-pion mass spectrum in $\tau$ decays, and the $e^+e^- \rightarrow \pi^+\pi^-$ cross section, gave indications of discrepancies between the overall normalization: $\tau$ data are about 3% higher than $e^+e^-$ data [7,9]. A detailed analysis using such two-pion mass spectra from $\tau$ decays measured by OPAL [10], CLEO [7], and ALEPH [11,12], as well as recent pion form factor measurements in $e^+e^-$ annihilation by CMD-2 [13,14], showed that the discrepancy can be as high as 10% above the $\rho$ meson [15,16]. This discrepancy remains after recent measurements of the two-pion cross section in $e^+e^-$ annihilation at KLOE [17,18] and SND [19,20]. This effect is not accounted for by isospin breaking [21–24], but the accuracy of its calculation may be overestimated [25,26].

This problem seems to be solved after a recent analysis in [27] which showed that after correcting the $\tau$ 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 $\tau$ based and $e^+e^-$ based evaluations including more recent BaBar [28] and KLOE [29] data. Further proof of the consistency of the data on $\tau$ decays to two pions and $e^+e^-$ annihilation at KLOE is given by the global fit of the whole set of $\rho$, $\omega$, and $\phi$ decays, taking into account mixing effects in the hidden local symmetry model [30].

References: