e^+ - e^- ANNIHILATION AND THE RARER DECAY MODES OF \( \omega \) AND \( \rho \)

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ABSTRACT

Coherent \( \omega - \rho \) interference in the reactions
\( e^+ + e^- \rightarrow \pi^+ + \pi^- \) and \( e^+ + e^- \rightarrow \pi^0 + \gamma \)
is studied as a source of information on the decays 
\( \omega \rightarrow \pi^+ + \pi^- \)
and \( \rho^0 \rightarrow \pi^0 + \gamma \).

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Recently there has been some discussion of the effects of coherent $\rho - \omega$ interference on the leptonic decays of photoproduced vector mesons \(^1,2\) within the framework of the vector dominance model \(^3\).

Here we carry over these ideas to the reactions

\[ e^+ + e^- \rightarrow \pi^+ + \pi^- \] (1)

\[ e^+ + e^- \rightarrow \pi^0 + \gamma \] (2)

in the $\rho$, $\omega$ region. In the vector dominance model these reactions proceed through intermediate $\rho$, $\omega$ states (Fig. 1), which interfere coherently. In principle this should allow a determination of the partial width $\omega \rightarrow \pi^+ \pi^-$, knowing the partial width for $\rho^0 \rightarrow \pi^+ \pi^-$ and a determination of the partial width $\rho^0 \rightarrow \pi^0 \gamma$, knowing the partial width for $\omega \rightarrow \pi^0 \gamma$.

The present evidence on the decay $\omega \rightarrow \pi^+ \pi^-$ is inconclusive. The branching ratio $R_{\omega \rightarrow \pi^+ \pi^-} = \Gamma(\omega \rightarrow \pi^+ \pi^-) / \Gamma(\omega \rightarrow \pi^+ \pi^- \pi^0)$ varies between 3% and 15%, being strongly model dependent. In Fig. 2, we show the theoretical results for the reaction $e^+ + e^- \rightarrow \pi^+ + \pi^-$ for values of $R_{\omega \rightarrow \pi \pi}$ of 3%, 5%, 10% and 15%, together with the experimental results from Novosibirsk \(^5\) and Orsay \(^6\). The $\rho$ parameters have been chosen to fit the Novosibirsk data \(^5\), namely a mass of 765 MeV and a width of 95 MeV, and normalized to that data. The $\omega$ was taken to have a full width of 12 MeV and the photon-vector meson couplings were taken to be related by the exact SU(3) value of

\[ f_{\omega}^2 = 9 f_{\rho}^2 \] (3)

If the broken SU(3) value \(^7\)

\[ f_{\omega}^2 = 15 f_{\rho}^2 \] (4)

is used, then the $\omega$ peak is diminished slightly.
The \( \omega \) peak is clearly seen, even at \( R_{\omega \pi \pi} = 3\% \). It is just possible that the Orsay result is sitting on the edge of the \( \omega \) peak, although with the data at its present level any firm conclusion on this point is premature.

An analysis \(^3\) of the reaction \( \pi^- + p \rightarrow \pi^- + p + \gamma \) has yielded an upper limit for the width for the decay \( \rho \rightarrow \pi \gamma \) of 0.6 \( \pm 0.1 \) MeV, which is consistent with the value of 0.2\( ^{+0.6}_{-0.2} \) MeV obtained from an analysis \(^9\) of low energy photopion production. The results for \( e^+ + e^- \rightarrow \pi^0 + \gamma \) are given in Fig. 3 for \( T_{\rho \pi \gamma} = 0, 0.2, 0.4 \) and 0.6 MeV. The branching ratio for the decay \( \omega \rightarrow \pi \gamma \) was taken to be 10\%, and the other resonance parameters the same as those used above. The effect of the interference is quite striking, increasing the cross-section above the \( \omega \) only value by as much as 50\% in the case when \( T_{\rho \pi \gamma} = 0.6 \) MeV. In this case, the use of the broken SU(3) coupling enhances the effect.

We conclude that the effects of the coherent \( \rho - \omega \) interference are sufficient to enable better information to be obtained on the decays \( \omega \rightarrow \pi^+ \pi^- \) and \( \rho \rightarrow \pi \gamma \) than has hitherto been possible.

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Fig. 1
Fig. 3.