Background process in the DESY observation of $\rho'(1100)$

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In connection with the resonant structure observed at DESY in the reaction $\gamma p \rightarrow e^+e^-p$ at a lepton-pair mass 1.1 GeV, we consider a production mechanism that was not taken into account in the reduction of the experimental data. The corresponding amplitude changes strongly in this region.

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New experimental data have recently been published[1,2] on the reaction $\gamma p \rightarrow e^+e^-p$. In the experiment, they measured both the effective cross section as a function of the mass M of the produced pair, and the azimuthal asymmetry of the emission of the produced leptons. The main sources of the e^+e^- pairs are the Bethe–Heitler process (Fig. 1a) and the virtual Compton effect (Fig. 1b).

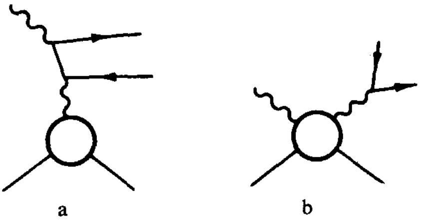

FIG. 1.

The effective cross section is determined by the sum of the squares of the moduli of these amplitudes, and the azimuthal-asymmetry parameter is proportional to the quantity.

$$I = \mathrm{Re}(F_{\mathrm{B.H.}} F_C) = F_{\mathrm{B.H.}} \mathrm{Re}\, F_C \tag{1}$$

$F_{\mathrm{B.H.}}$ is the amplitude of the Bethe–Heitler process and F_C is the amplitude of the Compton effect.

In the reduction of the experimental data, use was made of the Compton-effect amplitude within the framework of the vector-dominance model (Fig. 2a). Allowance for the usual vector mesons ρ, ω, and ϕ provides a fair description of the mass spectrum of the produced pair, but does not suffice for the description of the azimuthal asymmetry. To describe the experimental data within the framework of this mechanism, it is necessary to introduce additional vector mesons with masses 1110, 1240, and 1550 MeV; the first of them is an entirely new object, but can be distinctly seen

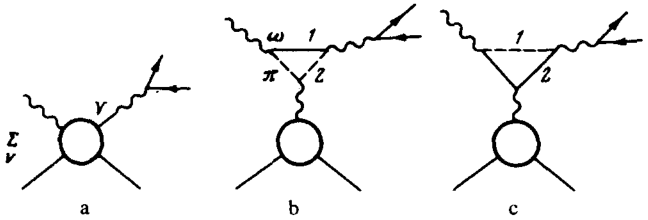

FIG. 2.

against the background of the experimental errors. At the same time, this resonance does not appear with colliding e^+e^- beams.

We wish to note in this connection that there exists another e^+e^- pair-production mechanism in the reaction $\gamma p \to e^+e^-p$ (Figs. 2b, 2c), which can lead to large changes in the asymmetry parameter precisely in the $M_{ee} \sim 1100$ MeV region. For the $\gamma p \to \rho^- p$ reaction, such a mechanism has already been discussed by way of a background (see, e.g.,[3]).

The contribution of this diagram to the real part of the Compton–effect amplitude, which varies rapidly with M_{ee}, can be estimated by replacing the propagators of particles 1 and 2 by corresponding delta functions. The result is

$$\mathrm{Re}\, F_C = \mathrm{Re}\, F_C^{\mathrm{VDM}} + B\, \rho_{\pi\omega}\, F_D\, \mathrm{Re}\, F_{\gamma\pi\omega}\,. \tag{2}$$

Here F_C^{VDM} is the amplitude in the vector-dominance model, $\rho_{\pi\omega}$ is the phase volume of the $\pi\omega$ system, F_D is the amplitude of the Deck effect, for which we assume, as usual, $\mathrm{Re}F_D \gg \mathrm{Im}F_D$; $F_{\gamma\pi\omega}$ is the form factor of the $\gamma^* \to \pi\omega$ transition, the values of $|\gamma\pi\omega|$ are determined from the experimentally observed cross section of $e^+e^- \to \pi^0\omega$, whose phase exerts a critical effect on the form factor F_π of the pion at $M_{\pi\pi} \approx 1$–1.3 GeV.

It was shown in[4] that the data on F_π[5] and on $\sigma_{e^+e^-} \to \pi^0\omega$ can be reconciled if the system $\pi\omega$ contains the vector meson $\rho'(1250)$, with $g_{\rho' \to \pi\pi} = 0$, and $F_{\gamma\pi\omega}$ is represented in first-order approximation as a superposition of the contributions of the ρ and ρ' mesons:

$$F_{\gamma\pi\omega} = \frac{g_{\rho\omega\pi}}{g_{\rho\gamma}}\, \frac{m_\rho^{2\,\cdot}}{(m_\rho^2 - s - i\Gamma_\rho m_\rho)} + \frac{g_{\rho'\omega\pi}}{g_{\rho'\gamma}}\, \frac{m_{\rho'}^2}{(m_{\rho'}^2 - s - i\Gamma_{\rho'} m_{\rho'})}\,. \tag{3}$$

It follows therefore that $\mathrm{Re}F_{\gamma\pi\omega}$ has a maximum at $M \sim 1.1$ GeV. A more exact expression for the real part of the form factor $F_{\gamma\pi\omega}$ is

$$\mathrm{Re}\, F_{\gamma\pi\omega} = |\Omega_2| \left[\frac{m_\rho (s_0 - s)(m_{\rho'}^2 - s)}{s_0\, m_{\rho'}^2 (m_\rho^2 - s)} - \frac{\Gamma_{\rho'}(s)}{m_{\rho'}} \left[\frac{p_\pi^3\, s(1-\eta)}{2 p_\omega^3 (1+\eta)} \right]^{1/2} \frac{|F_\pi|}{|\Omega_2|} \right]. \tag{4}$$

Here η is the inealisticity coefficient of the $\pi\pi$ scattering, $s_0 \sim 1$ GeV^2,

$$p_\omega = \{[s-(m_\omega+m_\pi)^2][s-(m_\omega-m_\pi)^2]/4s]^{1/2},$$

$$\Omega_2(s) = m^2_{\rho'}/(m^2_{\rho'} - s - i\Gamma_{\rho'}(s)\, m_{\rho'}),$$

$$\Gamma_{\rho'}(s) = \Gamma_{\rho'} \frac{p^3_\omega(s)}{p^3_\omega(m^2_{\rho'})} \, \frac{R^2 p^2_\omega(m^2_{\rho'})+1}{R^2 p^2_\omega(s)+1} \, \frac{m_{\rho'}}{\sqrt{s}}$$

Using the data of[5,6] for the parameters s_0, m_ρ and Γ_ρ, we obtained in[4]

$$m'_\rho \approx 1150\text{–}1200 \text{ MeV};\ \Gamma'_\rho = 240 \text{ MeV};\ s_0 \approx 0.9 \text{ GeV}^2 \ .$$

Figure 3 shows, in arbitrary scale, the value of $\rho_{\pi\omega}\mathrm{Re}F_{\gamma\pi\omega}$, calculated from formula

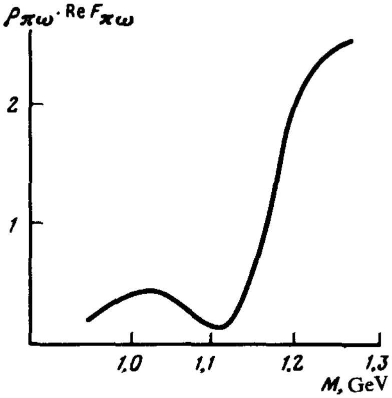

FIG. 3.

(4). It is seen that it varies sharply in the M_{ee} region of interest to us, and this can lead in principle to the appearance of a maximum in the expression (1) for the azimuthal asymmetry. Thus, the peak observed in the vicinity of $M_{ee} \sim 1100$ MeV may be not a manifestation of a new resonance, but can stem from the mechanism considered here. Of course, a final conclusion requires numerical estimates with account taken of the registration efficiency. There is no doubt, however, that the background effects must be analyzed more thoroughly than in[1,2].

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