where we have also taken into account the influence of the temperature oscillations of the lattice atoms. If $\sigma\mu(\omega_1 - \omega_2)/E \ll 1$ (the longitudinal transmitted wavelength exceeds the lattice constant), then the emission cross section is given by

$$d\sigma^{cr}(\omega_2) = d\sigma^{am}(\omega_2) N_{\parallel}\left\{1 - \left[1 + 3\left(1 - \frac{E}{\mu\omega_2 N_{\parallel} a}\right)^2\right] \Big/ 4\left(1 - \frac{E}{\mu\omega_2 N_{\parallel} a}\right)^3\right\},$$

where $d\sigma^{am}(\omega_2)$ is the cross section for emission in an amorphous medium. For a thin single crystal ($N_{||} < E/\mu\omega a$), the quantum-emission cross section increases appreciably compared with the amorphous medium. The ratio of the cross sections in the crystal and in the amorphous medium is

$$d\sigma^{cr}(\omega_2) / d\sigma^{am}(\omega_2) \sim N_{\parallel} \gg 1.$$

The indicated mechanism of radiation from a heavy relativistic particle in a single crystal predominates in the frequency region

$$\omega < m(\mu/m)^2.$$

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PRODUCTION OF NEUTRAL VECTOR MESONS IN THE PROCESSES $e^- + e^+ \to \rho^0(\omega^0, \phi^0) + \gamma$

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At the present time, experiments on colliding electron-positron beams, performed in Novosibirsk and in Orsay [1, 2], offer evidence that the cross sections of the processes $e^-e^+ \to \pi^-\pi^+$, $e^-e^+ \to \pi^-\pi^+\pi^0$, and $e^-e^+ \to K_L^0 K_S^0 (\pi^-\pi^+\pi^0)$ have a resonant character at a summary initial-particle energy near the masses of the ρ^0, ω^0, and ϕ^0 messons, respectively. With increasing energy, the cross sections of these processes go outside the resonant region and drop rapidly, in view of the strong decrease of the electromatnetic form factors. The radiative corrections to the resonant annihilation of the electron and positron at an initial-particle energy close to the mass of the vector resonance were considered in [3]. It was shown there that the radiative correction contains, besides the electromagnetic constant α, also a large factor $\ln s/m_e^2$, where $s = 4E^2$, E is the energy of the initial particle in the c.m.s. of the electron and positron, and m_e is the electron mass. In addition, the emission of a photon causes the production of the pseudoscalar mesons to proceed via a vector resonance even if the total energy of the initial particles does not coincide with the mass of the vector mesons.

2. The foregoing considerations remain in force also with increasing energy E, when a hard photon is emitted. We are interested in this paper in

the energy region in which $s - m_V \gtrsim m_V$, where m_V is the mass of the vector meson. Then, by virtue of the fact that $m_V >> \Gamma_V$, where Γ_V is the width of the decay of the vector mesons into pseudoscalar mesons, we can consider the production of real vector mesons in the processes:

$$e^- + e^+ \to \rho^0(\omega^0,\ \phi^0) + \gamma. \tag{1}$$

We shall first carry out all the calculations for the processes with the ρ meson, the amplitude of which is determined by the Feynman diagrams for two-quantum annihilation of an electron-positron pair, where one photon goes over into the ρ meson. We introduce the angle θ_1 between the momenta of the ρ meson and of the electron in the c.m.s. of the initial particles, and we put $x = \cos\theta_1$. Then the angular distribution of the ρ mesons takes the form

$$\frac{d\sigma}{dx} = 2D\gamma^{-2}(1 - x^2 + 4m_e^2/s)^{-1}\left\{1 + x^2\gamma^2 - 16\frac{m_e^2 m_\rho^2}{(s + m_\rho^2)^2}(1 - x^2 + 4m_e^2/s)^{-1}\right\} \tag{2}$$

where

$$D = (\pi\alpha^3/\ 12s^2)(s - m_\rho^2)\left(\frac{m_\rho}{\Gamma_\rho}\right)\left(1 - 4\frac{m_\pi^2}{m_\rho^2}\right)^{3/2};\quad \gamma = \frac{s - m_\rho^2}{s + m_\rho^2};\quad \alpha = 1/137 \tag{3}$$

and the pion mass is denoted by m_π. Integrating the angular distribution, we obtain the total cross section of the process under consideration, at $s - m_\rho^2 \gtrsim m_\rho^2$, in the form

$$\sigma = 4D(s - m_\rho^2)^{-2}(s^2 + m_\rho^4)\left[\ln(s/m_e^2) - 1\right], \tag{4}$$

where D is given by (3). If we take $s = 30m_\rho^2$, corresponding to E = 1.8 GeV, then we obtain for the process (1) from formula (4) $\sigma \approx 0.8 \times 10^{-33}$ cm^2, and for the process $e^-e^+ \to \rho^0\pi^0$ we get $\sigma \approx 10^{-35}$ cm^2 [4]. Using formulas (3) and (4), we can represent the ratio of the cross section of the process (1) to the cross section of the process of electron-electron annihilation into two pions in the form

$$\frac{\alpha}{s}\left(\frac{m_\rho}{\Gamma_\rho}\right)\frac{s^2 + m_\rho^4}{s - m_\rho^2}\ln\frac{s}{m_e^2} \Big/ |F_\pi(s)|^2,$$

where F_π is the electromagnetic form factor of the pion. It follows therefore that the cross section of both processes are of the same order already when $s - m_\rho^2 \approx m_\rho^2$, and the cross section of process (1) is much larger when $s >> m_\rho^2$. Taking into account the connection, predicted by SU(3) symmetry, between the constants of the transitions of γ quanta into vector mesons, namely $g_{\rho\gamma}:g_{\omega\gamma}:g_{\phi\gamma} = 1:\sin\theta/\sqrt{3} : \cos\theta/\sqrt{3}$, where θ is the angle of the φω mixing, it is easy to derive from formulas (2) - (4) the corresponding results for the production of ω^0 and ϕ^0 mesons.

3. Let us consider the polarization parameters of the vector mesons. Since the vector-meson density matrix is symmetric, the dipole polarization is equal to zero. If we choose the momentum of the vector meson as the 3 axes and locate the 1 axis in the plane of the momenta of the vector meson and of the initial electron, then the independent components of the quadrupolization

tensor in the case when $\theta_1 \gg m_e/\sqrt{s}$ and $\pi - \theta_1 \gg m_e/\sqrt{s}$ take the following form for the case of ρ-meson production

$$r_{ik} = \alpha_{ik} - D\beta_{ik}/(d\sigma/dx), \tag{5}$$

where dσ/dx and D are given by formulas (2) and (3), and the tensors α_{ik} and β_{ik} are given by

$$\alpha_{11} = \alpha_{22} = 2/3; \quad \alpha_{12} = \alpha_{13} = \alpha_{23} = \beta_{12} = \beta_{23} = 0,$$

$$\beta_{11} = 2\frac{1 + x^2/\gamma^2}{1 - x^2}; \quad \beta_{22} = 2\frac{1 + x^2\gamma^2}{\gamma^2(1 - x^2)}; \quad \beta_{13} = 4\frac{x m_\rho \sqrt{s}}{\gamma^2(s + m_\rho^2)\sqrt{1 - x^2}} \tag{6}$$

with γ given by formula (3). In the liniting case $s \gg m_\rho^2$, we obtain from (5) and (6) $r_{11} - r_{22} = -1/3$ and $r_{13} = 0$. This means that the ρ-meson spin is fully aligned parallel and antiparallel to its momentum. Such a result can be attributed to the fact that when $s \gg m_\rho^2$ it is possible to neglect the mass of the ρ meson and its polarization state should coincide with the polarization state of the photon.

4. In view of the fact that the lifetime of the vector mesons is short, let us consider the annihilation of an electron and positron into two π or K mesons and a photon. If we disregard the hypothetical σ meson discussed in [5 - 7] and remain within the framework of the C-invariant theory, then it suffices, in the energy region under consideration, to take into account only the contributions of the diagrams in which the photon is emitted from the electron and positrol lines. We introduce the angle θ_2 between the momenta of the pion and the initial electron in the c.m.s. of the two pions. If we introduce $z = \cos\theta_2$ and designate by ω^2 the mass of the system of two pions, then it is easy to show that at all values of ω^2 the angular distributions of the pions is determined by the factor $1 - z^2$. Integrating the angular distribution with respect to z, we obtain the differential cross section in the approximation in which $\ln(s/m_e^2) \gg 1$, in the form

$$\frac{d\sigma}{d\omega^2} = \frac{\alpha^3(\omega^2 - 4m_\pi^2)^{3/2}(s^2 + \omega^4)m_\rho^4 \ln(s/m_e^2)}{3s^2(s - \omega^2)\,\omega^4\sqrt{\omega^2}[(\omega^2 - m_\rho^2)^2 + m_\rho^2\Gamma_\rho^2]}. \tag{7}$$

If we take into account the relation $\omega^2 = s - 2\sqrt{s}\varepsilon_\gamma$, where ε_γ is the energy of the γ quantum in the c.m.s. of the initial particles, then it is easy to obtain from (7) the energy distribution of the γ quanta in the processes considered by us, observation of which would make it possible to investigate vector mesons with colliding beams at higher energies than used in [1, 2].

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NONLINEAR PASSAGE OF ELECTROMAGNETIC WAVES THROUGH A PURE METAL

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The purpose of the present work is to call attention to the possibility of a unique nonlinear passage of electromagnetic waves through a metal. This effect is connected with the free flight of electrons from one surface of a metal plate to the other, and is analogous to the plasma-echo effect investigated in a number of works. In particular, we have calculated [1] the plasma echo for the case of transverse electromagnetic waves in a plasma. The phenomenon dealt