region 0.9 - 1.4 GeV with a maximum at 1.1 - 1.2 GeV, this being characteristic of coherent-production processes. The effective-mass distribution of the $\pi^+\pi^-$ combinations reveals a distinct peak in the ρ-meson mass region.

In conclusion, the authors consider it their pleasant duty to thank the scanning and measurement groups of the Nuclear Problems Laboratory and of the Computational Techniques and Automation Laboratory of the Joint Institute for Nuclear Research, for processing the photographs from the meter propane chamber.

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CONTRIBUTION TO THE THEORY OF THE OPTOELECTRIC EFFECT IN A MAGNETIC FIELD

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In [1] there was investigated the electric field (which we shall call "optoelectric") produced in a conducting medium in which electromagnetic waves propagate. This field is due to the momentum transferred by the flux of electromagnetic waves to the free carriers.

A recent paper [2] reports experimental observation of the optoelectric emf in bismuth in an external magnetic field. In the present paper we investigate in greater detail the influence of the magnetic field on this effect. We confine ourselves here to the case of waves of low frequency ω, satisfying the condition $\omega\tau < 1$, where τ is the relaxation time. In the approximation linear in the wave field ($\vec{E}_1$, $\vec{H}_1$) the equation for the correction f_1 to the equilibrium distribution function of the carriers is*

$$\frac{\partial f_1}{\partial t} + \mathbf{v}\nabla f_1 + \frac{e}{mc}[\mathbf{vH}]\frac{\partial f_0}{\partial \mathbf{v}} + \frac{e\mathbf{E}_1}{m}\frac{\partial f_0}{\partial \mathbf{v}} = -\frac{f_1}{\tau} .$$

Consequently f_1 is equal to

*$[\vec{v}\vec{H}] \equiv \vec{v} \times \vec{H}$.

$$f_1 = e\tau \frac{\left(\left\{\mathbf{E}_1 + \frac{e\tau}{mc}[\mathbf{E}_1\mathbf{H}] + \left(\frac{e\tau}{mc}\right)^2 \mathbf{H}(\mathbf{E}_1\mathbf{H})\right\} \mathbf{v}\right)}{1 + \left(\frac{e\tau}{mc}H\right)^2}.$$

It is easy to show that in the approximation of second order in the field ($\vec{E}_1$, $\vec{H}_1$) it is possible to disregard the dependence of τ on the carrier energy ε; the discarded terms make no contribution to the optoelectric effect. Then the kinetic equation for the correction is

$$\frac{\partial f_2}{\partial t} + \mathbf{v}\nabla f_2 + \frac{e}{mc}[\mathbf{v}\mathbf{H}]\frac{\partial f_2}{\partial \mathbf{v}} + \frac{1}{2}\frac{e}{m}\mathrm{Re}\left\{\left(\mathbf{E}_1 + \frac{1}{c}[\mathbf{v}\mathbf{H}]\right)\frac{\partial f_1^*}{\partial \mathbf{v}}\right\} = -\frac{f_2}{\tau}. \tag{1}$$

If we consider a sample that is not too thick, we can neglect the term $\vec{v} \cdot \nabla f_2$. Substituting f_1 in (1), we obtain

$$f_2 = 4\pi\left(-\frac{\partial f_0}{\partial \epsilon}\right)\frac{e^2\tau^2}{mc^2}\frac{\left(\left\{\mathbf{I} + \frac{1}{2}\frac{e\tau}{mc}\left[3 + \left(\frac{e\tau}{mc}H\right)^2\right][\mathbf{I}\mathbf{H}] + \left(\frac{e\tau}{mc}\right)^2\mathbf{H}(\mathbf{I}\mathbf{H})\right\}\mathbf{v}\right)}{\left[1 + \left(\frac{e\tau}{mc}H\right)^2\right]^2},$$

where I is the flux density inside the sample. Calculation of the current density yields

$$\mathbf{j} = \chi\mathbf{I} + (\chi_1 + \chi_2 H^2)[\mathbf{I}\mathbf{H}] + \chi_3\mathbf{H}(\mathbf{I}\mathbf{H}), \tag{2}$$

where χ, χ_1, χ_2, and χ_3 are given by

$$\chi = A\int_0^\infty\left(-\frac{\partial f_0}{\partial \epsilon}\right)\frac{\tau^2}{[1 + (\Omega\tau)^2]^2}\epsilon^{3/2}d\epsilon; \quad \chi_1 = \frac{3}{2}A\int_0^\infty\left(-\frac{\partial f_0}{\partial \epsilon}\right)\frac{\frac{e}{mc}\tau^3}{[1 + (\Omega\tau)^2]^2}\epsilon^{3/2}d\epsilon,$$

$$\chi_2 = \frac{1}{2}A\int_0^\infty\left(-\frac{\partial f_0}{\partial \epsilon}\right)\frac{\left(\frac{e}{mc}\right)^3\tau^5}{[1 + (\Omega\tau)^2]^2}\epsilon^{3/2}d\epsilon; \quad \chi_3 = A\int_0^\infty\left(-\frac{\partial f_0}{\partial \epsilon}\right)\frac{\left(\frac{e}{mc}\right)^2\tau^4}{[1 + (\Omega\tau)^2]^2}\epsilon^{3/2}d\epsilon,$$

$$A = \frac{8\sqrt{2}e^3}{3\pi\hbar^3 m^{1/2}c^2}; \quad \Omega = \frac{eH}{mc}.$$

Formula (2) shows that in the case of a flux not parallel to the magnetic field, the optoelectric current component proportional to their vector product consists of two terms. The second, characterized by the coefficient $\chi_2 H^2$, is larger than the first in the ratio $(\mu H/c)^2$ (where μ is the mobility); this ratio can be appreciable in a strong magnetic field.

In a bounded sample not connected in a closed electric circuit there is produced an optoelectric field connected with the current density (2) by the relation

$$\mathbf{E} = -\rho\mathbf{j} - \rho_1[\mathbf{j}\mathbf{H}] - \rho_2\mathbf{H}(\mathbf{j}\mathbf{H}), \tag{3}$$

where the resistivities ρ, ρ_1, and ρ_2 are given by

$$\rho = \frac{\sigma}{\sigma^2 + \sigma_1^2 H^2}\ ; \quad \rho_1 = -\frac{\sigma_1}{\sigma^2 + \sigma_1^2 H^2}\ ; \quad \rho_2 = \frac{\sigma_1^2 - \sigma_2 \sigma}{(\sigma^2 + \sigma_1^2 H^2)(\sigma + \sigma_2 H^2)}$$

σ, σ_1, and σ_2 are respectively the conductivity, the Hall, and the focusing terms.

Using (2) and (3) we can easily obtain the resultant optoelectrical field, which is equal to

$$\mathbf{E} = \gamma \mathbf{I} + \gamma_1 [\mathbf{I}\,\mathbf{H}] + \gamma_2 \mathbf{H}(\mathbf{I}\,\mathbf{H}), \tag{4}$$

where the optoelectrical coefficients γ, γ_1, and γ_2 are equal to

$$\left.\begin{aligned} \gamma &= -\rho\chi + \rho_1(\chi_1 + \chi_2 H^2) H^2 \\ \gamma_1 &= -\rho(\chi_1 + \chi_2 H^2) - \rho_1 \chi \\ \gamma_2 &= -\rho\chi_3 - \rho_1(\chi_1 H^2 + \chi_3) - \rho_2(\chi + \chi_3 H^2) \end{aligned}\right\} . \tag{5}$$

It follows from (5) that the coefficient γ is independent of H in a strong magnetic field if $\mu H/c > 1$.

Taking into account the temporal dispersion, the solutions for χ, χ_1, χ_2, and χ_3 take the form

$$\chi = A\int_0^\infty \left(-\frac{\partial f_0}{\partial \epsilon}\right) \frac{\tau^2[1 + (\omega^2 + \Omega^2)\tau^2]}{[1 + (\Omega\tau)^2]\{[1 + (\Omega^2 - \omega^2)\tau^2]^2 + 4(\omega\tau)^2\}} \epsilon^{3/2} d\epsilon,$$

$$\chi_1 = \frac{2}{3} A\int_0^\infty \left(-\frac{\partial f_0}{\partial \epsilon}\right) \frac{\frac{e}{mc}\tau^3[1 + (\Omega^2 + \frac{1}{3}\omega^2)\tau^2]}{[1 + (\Omega\tau)^2]\{[1 + (\Omega^2 - \omega^2)\tau^2]^2 + 4(\omega\tau)^2\}} \epsilon^{3/2} d\epsilon,$$

$$\chi_2 = \frac{1}{2} A\int_0^\infty \left(-\frac{\partial f_0}{\partial \epsilon}\right) \times$$

$$\times \frac{\left(\frac{e}{mc}\right)^3 \tau^5[1 + (\Omega^2 - 3\omega^2)\tau^2]}{[1 + (\Omega\tau)^2]\{[1 + (\Omega^2 - 3\omega^2)\tau^2]^2 + (\omega\tau)^2[3 + (\Omega^2 - \omega^2)\tau^2]\}} \epsilon^{3/2} d\epsilon,$$

$$\chi_3 = A\int_0^\infty \left(-\frac{\partial f_0}{\partial \epsilon}\right) \frac{\left(\frac{e}{mc}\right)^2 \tau^4[1 + (\Omega^2 + \omega^2)\tau^2]}{[1 + (\Omega\tau)^2]\{[1 + (\Omega^2 - \omega^2)\tau^2]^2 + 4(\omega\tau)^2\}} \epsilon^{3/2} d\epsilon .$$

These values hold true also, in order of magnitude, in the high-frequency case (when $\omega\tau > 1$) for waves whose propagation velocity is of the order of c.

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