$\Lambda\eta$ RESONANCE

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IN recent experiments [1] the production of the η meson (a resonance in the three pion system with $T = 0$ and $m = 545$ MeV) has been observed in the reaction $K^- + p \rightarrow \Lambda + \eta$. The cross section for the production of the η meson amounted to $\sigma_\eta = 0.63 \pm 0.11$ mb when the energy E in the barycentric frame exceeded by 20 MeV the threshold value for this reaction, $m_\Lambda + m_\eta = 1660$ MeV, whereas for $E - (m_\Lambda + m_\eta) = 60$ MeV the cross section was $\sigma_\eta < 0.04$ mb. Such a rapid variation of cross section with energy can be explained only on the assumption that the $\Lambda\eta$ system has a resonance whose mass is approximately 1680 MeV and whose half width is $\Gamma/2 < 10$ MeV. It is obvious that the isotopic spin of this resonant state Y must be equal to zero. Since the mass m_Y is only by 20—30 MeV larger than the threshold for the production of Λ and η it is natural to expect that the orbital angular momentum of Λ and η is zero in the resonant state Y and, consequently, that the parity of Y is the same as the parity of η (the parity of Λ is taken to be +1). According to the existing experimental data [1,2] the η meson is either pseudoscalar (0^-) or vector (1^-). In either case the parity of the Y resonance should be negative.

Beside the decay $Y \rightarrow \Lambda + \eta$ the Y resonance should also decay by other modes: $Y \rightarrow \Lambda + \pi + \pi$, $Y \rightarrow \Sigma + \pi$, $Y \rightarrow \Sigma + \pi + \pi$. (The decay $Y \rightarrow \Sigma + \pi$ is forbidden by isotopic spin selection rules.) At that the decay modes $Y \rightarrow \Lambda + \pi + \pi$ and $Y \rightarrow \Sigma + \pi + \pi$ are improbable in view of the small statistical weight (and, in addition, in the decay $Y \rightarrow \Lambda + \pi + \pi$ the two pions are in a state with $l = 1$ relative to Λ).

The decay $Y \rightarrow \Sigma + \pi$ should, apparently, proceed with appreciable probability, which makes it possible to search for this resonance in the $\Sigma + \pi$ system.1) If the η meson is pseudoscalar, then the pion from the decay $Y \rightarrow \Sigma + \pi$ will be in an s or p state, depending on whether the parities of Σ and Λ are the same or opposite. Unfortunately these two possibilities cannot be distinguished experimentally by studying the angular distribution or polarization of the Σ hyperons because in this case the Y has spin $j = 1/2$. If the η meson is vector then the spin of Y may be either $1/2$ or $3/2$. In the latter case the Y hyperons may turn out to be produced aligned so that an anisotropy could be observed in the angular distribution of the decay pions.

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1)The existing experimental data[3] on the $\Sigma\pi$ interaction in the mass region near 1680 MeV are not sufficient to draw any conclusions about the existence of the Y resonance.

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IONIZATION LOSSES OF ULTRARELATIVISTIC ELECTRONS

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THE calculation of the ionization losses of fast charged particles, involving a treatment of the Coulomb scattering on the electrons of the medium, has so far been carried out only in the first approximation of perturbation theory. [1] The general character of the ionization-momentum relation may change appreciably when the second-order approximation of perturbation theory, i.e., radiative corrections, are taken into account. [2,3] The contribution of such corrections may be comparable in magnitude to the effect of the relativistic increase in the ionization losses, which in dense media is strongly reduced by the density effect. [4]

An essential feature of the radiative corrections, calculated according to the diagram of Fig. 1, is that in the given case the virtual photon propagates not in a vacuum but in a medium with refractive

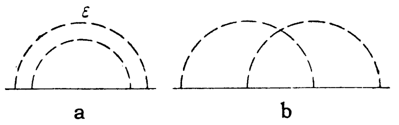

FIG. 1. Irreducible diagrams contained in the mass operator. The imaginary parts of these operators describe radiation and scattering phenomena.

index $n(\omega)$ different from unity and in general complex. In addition, we should take into account the fact that the main contribution to the primary ionization process (i.e., the ionization directly along the particle track) is due to scattering with a relatively small energy transfer, of the order of 1—10 keV.[1)] For such collisions, the main contribution to the radiative correction is due to the macroscopic range of frequencies of the virtual photon for which $n(\omega) \neq 1$. In this connection, the total magnitude of the radiative correction is considerably larger than that expected from the known calculations based on Coulomb scattering of two free electrons.[5]

A detailed theoretical calculation is given in [2,3]. In the present article we compare the theoretical estimate with available experimental results. The relative correction can be written in the form[2)]

$$\frac{W - W_0}{W_0} = -\frac{e^2}{\pi\hbar c}\,\Delta\left(\frac{\varepsilon_p}{mc^2}\right), \tag{1}$$

where W_0 are the ionization losses in the first approximation of the theory, ϵ_p is the energy, and m the mass of the particle under consideration, and $\Delta > 0$ is a monotonically increasing function of the energy, which attains asymptotically saturation ($\Delta = \Delta_\infty$) as $\epsilon_p/mc^2 \to \infty$.

Analysis has shown that in the actual case where the condition $1 \ll \Delta^{1/2} \ll (\pi\hbar c/e^2)^{1/2}$ is satisfied, the correction can be represented by an approximate expression (with accuracy to terms of the order of $\sqrt{\Delta/2}$)

$$\Delta_\infty = 2\ln^2\zeta, \tag{2}$$

where ζ is a function of the total concentration N of the electrons of the medium and of all natural frequencies ω_{si}. Moreover, the asymptotical value of the correction Δ_∞ is in practice attained at energies

$$\varepsilon_p / mc^2 \gg \varepsilon_p^* / mc^2 = 1/\zeta. \tag{3}$$

An analytical expression for ζ can be obtained only for the case of non-overlapping absorption bands of the medium; we have then

$$\zeta = \frac{e^2}{\hbar c}\frac{\omega_0}{\langle\omega_s\rangle}\ln\frac{c}{\langle v\rangle}, \tag{4}$$

where $\langle\omega_s\rangle$ is the effective natural frequency of the atomic electrons, $\langle v\rangle$ is their mean velocity, and $\omega_0^2 = 4\pi Ne^2/m$. For the case of photographic emulsion, using the values of ionization potentials in AgBr (see, e.g., [6]), we obtain for ζ^{-1} an estimate within the limits of 100 to 200. From Eqs. (2) to (4) we then conclude that the asymptotic value of the radiative correction should amount to 8—10%, and that it is attained for $\epsilon_p \gg 100$—$200\ mc^2$.

The measurements of the specific ionization of ultrarelativistic electrons in photographic emulsion carried out so far are neither numerous[7] nor very accurate. The required accuracy of individual measurements (with an error of 2—3%) can be attained only for sufficiently long (≥ 1 cm) electron tracks and if the variation of the emulsion sensitivity with the depth of the layer and other factors are sufficiently well known.

Such an accuracy was attained in two series of measurements: one carried out using NIKFI-R emulsions irradiated by 8.7 BeV proton beam[8] in the Joint Institute for Nuclear Research, and second using Ilford G-5 emulsions irradiated by 19 BeV protons at CERN. The relative blob density was measured on the tracks of secondary electrons, every time calibrating it by means of primary-proton tracks found nearby.

Preliminary results are shown in Fig. 2, where

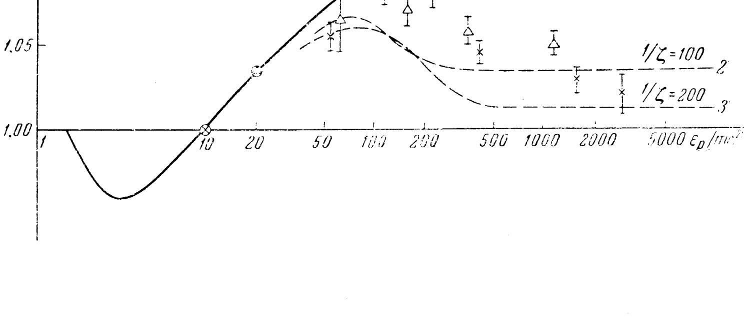

FIG. 2. Experimental data for NIKFI-R (x) and Ilford G-5 (Δ) emulsions concerning the blob density along the tracks as a function of electron energy. 1 – theoretical curve[7] neglecting radiative correction (for a maximum energy transfer of 20 keV), 2, 3 – asymptotic theoretical curves taking radiative corrections into account. Dashed curves represent assumed theoretical functions in the region where an exact calculation is difficult because of complicated dependence of the index of refraction on the frequency. Experimental calibration points for each emulsion are encircled.

each of the experimental points has been obtained by averaging the data for 10—15 electron tracks belonging to a given interval of the logarithmic energy scale.

As can be seen from Fig. 2, a satisfactory agreement with the experiment is observed of the expected effect of the radiative correction on the ionization losses, both as to the sign and the magnitude of the correction Δ_∞, and the region in which the correction attains saturation.

In conclusion, the authors would like to thank E. L. Feĭnberg for a helpful discussion of the results, and also the team of laboratory assistants for carrying out the preliminary reduction of data.

[1)] The upper limit of the energy transfer determines basically the difference in the energy dependence of the two quantities: ionization and ionization loss.

[2)] Similar corrections were calculated also for heavy particles (the final results of the calculation depend only on ϵ_p/mc^2).

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DIMENSIONAL EFFECT IN A METAL IN MULTIPLES OF A CERTAIN MAGNETIC FIELD

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A new dimensional effect has been discovered on measurement of the dependence of the surface impedance of tin on a 1—5 Mc magnetic field at helium temperatures.

A flat sample was placed in a coil of rectangular cross section which was part of an oscillating circuit. A constant magnetic field was applied along the plane of the sample. The frequency of the oscillator f varied with the magnitude of the field because of variation of the reactance X of the sample. The dependence of the frequency on the field was measured by a modulation method; the field modulation frequency was 20 cps.

The sample was a single crystal of high-purity tin (about $10^{-4}\%$ impurities) grown from the melt in a demountable quartz mold. The sample surface was perpendicular to the [100] axis. The thickness of the plate was 0.39 mm, the electron mean free path reached $(1-3) \times 10^{-1}$ cm at helium temperatures, and the skin-effect depth was 10^{-4} cm at 1—5 Mc.

In a field $H_0 = 2cp/ed$ (p is the half-width of the extremal electron orbit in the momentum space along a direction at right angles to the magnetic field and to the sample-surface normal; d is the plate thickness), when the width of the electron trajectory on the extremal cross section of the Fermi surface becomes equal to the plate thickness, a singularity[1] appears on the X(H) curve and this singularity can be used to measure the Fermi surface cross section. Further experiments have shown that singularities on the X(H) curve appear also in fields that are multiples of H_0 (we found them up to a field $5H_0$) when the thickness of the plate is equal respectively to 2, 3, or more widths of the electron trajectory. Figure 1 shows curves on which the singularities are clearly visible in fields of $2H_0$ and $3H_0$.

The reason for the appearance of these singularities in multiple fields is as follows. Electrons in an orbit passing through the skin layer experience a systematic increase in velocity Δv due

ERRATA

Vol	No	Author	page	Correction
15	6	Turov	1098	The article contains an erroneous statement that weak ferromagnetism cannot exist in any cubic crystal (with collinear or weakly noncollinear antiferromagnetic structure. This was found to be true only for crystal classes T and T_h, and for others weak ferromagnetism will appear in antiferromagnets with magnetic structure type $3^+ 4^-$, and only due to invariants of third and higher orders in the antiferromagnetism vector L. Consequently a line (14) should be added to the table on p. 1100: 14 | 207-230 | Cubic | $3^+, 4^-$ | $M_x L_x (L_y^2 - L_z^2) + M_y L_y (L_z^2 - L_x^2) + M_z L_z (L_x^2 - L_y^2)$ | VI The Cartesian axes are directed here parallel to the fourfold symmetry axes. The tensors $g^{(1)}$ and $g^{(2)}$ for this (sixth) group of weakly ferromagnetic structures will be identically equal and isotropic: $g_{\alpha\beta}^{(1)} = g_{\alpha\beta}^{(2)} = g\delta_{\alpha\beta}$
16	1	Valuev	172	At the end of the article there are incorrect expressions pertaining to $K\mu_3$ decay. The correct formula can be easily obtained from the main formula of the article by putting $g_S = g_T = 0$. The tangent of the angle between the $\|m\|^2$ curve and the $\cos\theta$ axis will be $\approx \beta_e$ if $g_{V_2}/g_{V_1} = -0.5$ and ≈ 0 if $g_{V_2}/g_{V_1} = 4.5$ and $\beta_e \sim 1$, so that in fact the difference in the angle correlations between these cases is even somewhat stronger than indicated in the article.
16	1	Zhdanov et al	246	The horizontal parts of curves 2 and 3 in Fig. 2 should be drawn with solid lines (they correspond to the asymptotic calculated values of the ionization losses, i.e., to the region in which the theory describes the relation between g/g_0 and the particle energy exactly).
16	1	Deutsch	478 & 481	When account is taken of thermoelectric processes it is necessary to add in the first curly bracket of (24) the term $A = 3v_0^2 H_y c(\alpha_{xz} - \alpha_{zx})/2$ and in Eq. (31) the term A/9.
16	1	Nguyen	920 Eqs. (4), (6), (7), & (8)	The combinations $V^1 \pm V^2$, $A^1 \pm A^2$, and $I^1 \pm I^2$ should be divided by $\sqrt{2}$.
16	1	Gershtein et al	1097 Eq. (1)	Reads $G/\sqrt{2}$, should read G/2
16	5	Gurevich		An error has crept into Eq. (30). The right half of this formula is actually equal to $\varepsilon_E \frac{\delta_{kz}}{2\pi E}\left[F_0(\varepsilon) + 2\varepsilon \frac{d}{d\varepsilon} F_0(\varepsilon)\right].$