start out from the very well known experimental fact of the strong interaction of pions and nucleons ($g^2/4\pi\hbar c \gg 1$).

If we assume strong interaction of pions and K-mesons (or K mesons and nucleons), then the following possibilities exist for the choice of the space volumes for the "compound particle."

1. Statistical equilibrium between all the secondary particles is established in one and the same volume V_1.† In this case the fraction of created particles relative to the pions and nucleons exceeds that experimentally observed by us.

2. The statistical equilibrium of nucleons, pions and K-mesons is established in the same space volume V_1, but the equilibrium for hyperons is established in a smaller volume. In this case, the fraction of created strange particles is close to the experimental value;[6,7] however, the ratio of the number of K^- and K^+ mesons produced in nucleon-nucleon collisions at $E = 6.2$ Bev is $N^+/N^- \cong 3$. In the works of Chapp et al.,[4] values of N^+/N^- of $100 - 150$ were obtained for momenta of K-mesons of $p \sim 250 - 350$ Mev/c. Even taking the momentum distribution into account, it is difficult to harmonize these differences of two orders of magnitude.‡

3. The volume in which the equilibrium is established for K-mesons is larger than the corresponding volume for nucleons and pions. In this case, it is not possible to obtain experimental agreement either with the number of strange particles created or with the value of the ratio N^+/N^-.

Agreement can be produced between experiment and the results of the statistical theory of multiple particle production only if weak interaction is assumed between the K-mesons and the pions and nucleons. In this case, the statistical equilibrium for K-mesons is established in a smaller space volume than for pions and nucleons. The best agreement is found if, following Gell-Mann, we assume a symmetric interaction of the pions with nucleons and hyperons ($V = V_2$). Thus, the computed effective cross section σ_s of creation of strange particles in π^--nucleon collisions at 4.3 Bev is equal to 3 mb in this case.** The mean experimental value of this cross section is approximately equal to 2.2 mb.[6] If we assume that all the strange particles interact weakly with pions and nucleons ($V = V_3$), then $\sigma_s = 0.3$ mb. The divergence of the theoretical and experimental values in this case exceeds the experimental error.††

The ratio $N^+/N^- \approx 160$ for $V = V_2$ and $N^+/N^- \simeq 8$ for $V = V_3$, i.e., if we assume that all the strange particles interact weakly with the pions and nucleons, then the results of the calculation of N^+/N^- sharply contradicts experiment.

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*A detailed consideration of this question will be given at a later date.

†We use the same notation as in Refs. 1, 2.

‡Exact calculations with account of momentum distribution will be published later in Acta Physica Polonica.

**The calculations were carried out under the assumption that the number of created K^0 and K^+ particles is approximately the same; $E = 5$ Bev. Taking the Fermi energy in the nucleus into account, this energy is close to the experimental energy of 4.3 Bev.

††The experimental error $\lesssim 50\%$; $\sigma_{tot} = (25 \pm 2.5)$ mb.

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*POLARIZATION OF MU-MESON IN COSMIC RAYS**

I. I. GOL' DMAN

Physical Institute, Academy of Sciences, Armenian S.S.R.

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THE recent discovery of nonconservation of parity in weak (decay) interactions leads, in particular, to an asymmetry of the decay of polarized μ-mesons. The measure of asymmetry should then be proportional to the degree of polarization. It can be concluded from the data of Lederman et al.[1]

that μ-mesons emitted by stopped π-mesons are almost totally or even totally polarized in the direction of motion. In the following it will be assumed that the polarization is total in any single event of decay.

It does not follow from the above that the μ-mesons in cosmic rays are totally polarized. In fact, let us consider a vertical flux of μ-mesons with momentum p. A part of these mesons which is injected by decaying π-mesons into the lower hemisphere (in the center of mass system of the pion) is polarized predominantly forwards. The μ-mesons emitted into the upper hemisphere are polarized predominantly backwards. Complete compensation is not attained since the π-meson spectrum is richer in slow particles and, therefore, the probability that after a π-decay process a μ-meson will be found in the lower hemisphere is $> 1/2$.

For calculation of the degree of polarization, let us consider a μ-meson with momentum p and energy E produced as the result of decay of a π-meson (p', E'). The direction of polarization of the μ-meson forms an angle α with its momentum. The direction of polarization is determined by the direction of spin in the frame of reference in which the μ-meson is at rest. Let us denote the momentum and energy of the π-meson in that system by P' and $\mathcal{E}'$. It can be easily seen that

$$P' = (m'^2 - m^2)/2m, \quad \mathcal{E}' = (m'^2 + m^2)/2m.$$

Writing the four-dimensional invariants of the momenta of the π- and μ-mesons we find the angle α (which is that between $\mathbf{P}'$ and $\mathbf{p}$):

$$\cos\alpha = (\mathcal{E}'E - mE')/pP'. \qquad (1)$$

We shall note now that the most important region of μ-meson energies (at the moment of production) is ultar-relativistic. We can neglect therefore the difference between p and E and the small angle between the momenta of the π- and μ-meson in the laboratory system. The mean value of polarization η has the direction of p and is equal in its absolute value to the mean value of $\cos\alpha$. Averaging Eq. (1) over the π-meson spectrum, we obtain

$$\eta = \int_{p'_{min}}^{p'_{max}} f_\pi(p') \frac{\mathcal{E}'E - mE'}{pP'} \frac{dp'}{p'^2} \Big/ \int_{p'_{min}}^{p'_{max}} f_\pi(p') \frac{dp'}{p'^2},$$

where the notation is that of Ref. 2. If we approximate the spectrum of π-mesons in air by power function $f_\pi \sim p^{1-\gamma}$ (the production spectrum of the π-mesons, under certain assumptions,[2] is then $p^{-\gamma}$) we obtain finally

$$\eta = \frac{1}{v} - \frac{\gamma}{\gamma-1}\frac{1-v}{v}\left[1 - \left(\frac{1-v}{1+v}\right)^{\gamma-1}\right] \Big/ \left[1 - \left(\frac{1-v}{1+v}\right)^{\gamma}\right],$$

where

$$v = P'/\mathcal{E}' = (m'^2 - m^2)/(m'^2 + m^2) = 0.26.$$

The above expression is simplified for $\gamma = 2$ ($\eta = v$) and $\gamma = 3$ ($\eta = 4v/(3+v^2)$). The results can be generalized for the case of $K_{\mu 2}$ decay.

The degree of polarization of μ-mesons in cosmic rays is:

	$\gamma = 2$	$\gamma = 3$
$\pi \to \mu + \nu$	0.26	0.34
$K \to \mu + \nu$	0.91	0.96.

The value of γ for π-mesons is $2 - 2.3$.[2] The polarization of μ-mesons produced by K-mesons is almost complete, while for those originating in π-meson decay amounts only to ~ 0.3. Measurements of the degree of polarization of μ-mesons in cosmic rays would make it possible to determine the ratio between the numbers of K- and π-mesons produced in the upper layers of the atmosphere. Since there is much more K^+-mesons than K^-, one should expect also that the degree of polarization of μ^+-mesons is greater than that of μ^-. If the excess of μ^+-mesons in cosmic rays ($N_+/N_- \sim 1.3$)[3] is due only to the excess of K^+, then the degree of polarization of μ^+-mesons in cosmic rays should amount to $40 - 50\%$ at least.

In conclusion, a few remarks concerning the depolarization of μ-mesons. Depolarization in passage through matter is due to multiple scattering and is most marked in the sub-relativistic region where the kinetic energy is of the order of the rest mass. Calculations show that depolarization is proportional to the atomic number of the medium and amounts to $\sim 1\%$ for air.

More important is the case of depolarization after the particle has stopped. The degree of depolarization depends then on the chemical properties of the medium, and can be obtained from the available experimental data on the asymmetry of the $\pi - \mu - e$ decay.

The author takes the advantage to express his gratitude to Prof. A. I. Alikhanian for interesting discussions.

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MAGNETIC DOUBLE REFRACTION OF MICROWAVES IN PARAMAGNETICS

F. S. IMAMUTDINOV, N. N. NEPRIMEROV and L. Ia. SHEKUN

Kazan State University

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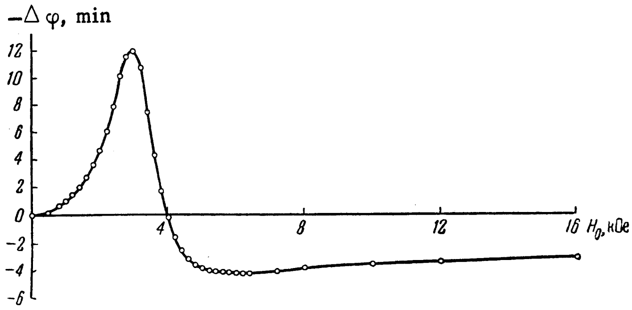
THE rotation of the plane of polarization of the H_{11} wave was studied at a frequency of 9375 megacycles in a circular waveguide filled with a paramagnetic salt. The directional dependence of the external static magnetic field H_0, applied perpendicularly to the direction of propagation of the radio wave was investigated. As a polarizer, we employed a smooth transition of a standard rectangular waveguide to the circular (d = 23 mm). For an analyzer, we used a rotating turnstile junction, two arms of which were connected to a matched load, while at the two others were placed crystal detectors with approximately equal characteristics, connected in opposition by a bridge circuit. Balancing of the system was observed on a type M-95 galvanometer. Because of the small values of the angles of rotation observed, the mechanical rotation of the turnstile junction was employed only for calibration of the scale of the galvanometer.

2. It was established that the angle of rotation $\Delta\psi$ does not depend on the sign of $\mathbf{H}_0$, but does depend on the angle ψ which the field $\mathbf{H}_0$ forms with the magnetic field H of the radio wave before establishing it in the paramagnetic according to the law $\Delta\psi \sim \sin 2\psi$, so that the maximum effect was observed for $\psi = 45°$. As an example, we have shown the curve of the specific rotation of a powdered specimen $MnCl_2H_2O$ in the Figure.

3. The observed laws can be understood if we assume that the rotation of the plane of polarization takes place as a consequence of the anisotropy of the magnetic susceptibility μ. There is then a difference of the phenomenon under consideration



from the ordinary (optical) Cotton-Mouton effect, which is determined by the anisotropy of the constant ϵ.

It is known that the tensor of the high frequency magnetic susceptibility of a paramagnetic magnetized along the z axis has the form:

$$\{\chi\} = \begin{Bmatrix} \chi & -i\delta & 0 \\ i\delta & \chi & 0 \\ 0 & 0 & \chi_z \end{Bmatrix},$$

where χ, δ, χ_Z are complex quantities dependent on H_0, the frequency of the radio wave ω and the relaxation time τ in the paramagnetic. A calculation carried out by one of the authors shows that in the case of wave propagation perpendicular to the applied field, the rotation angle (for not very small ψ) is given by

$$\Delta\psi = -(\pi\omega\sqrt{\varepsilon}/c)\, l\, \{\chi'' - \chi_z''\} \sin 2\psi. \quad (1)$$

Here l is the thickness of the layer of the paramagnetic, χ'' and χ_Z'' are the imaginary parts of χ and χ_Z. The calculation is carried out for free space; ϵ was considered real. As is known, χ'' and χ_Z'' are the absorption coefficients for the cases $H_0 \perp H$ ("perpendicular field") and $\mathbf{H}_0 \parallel \mathbf{H}$ ("parallel field"), respectively, and do not depend on the sign of $\mathbf{H}_0$.

4. Some of the qualitative regularities pointed out in Sec. 2 have already been observed by other authors.[1,2] As concerns the form of the curve $\Delta\psi(H_0)$, it was not observed in sufficient detail.

For $H_0 = 0$, $\Delta\psi = 0$, since $\chi'' = \chi_Z''$. It is also known that at frequencies of the order of 10 kilomegacycles, χ'' has a well-defined maximum at $\gamma H_0 = \omega$ and practically disappears for $\gamma H_0 > (2-3)\omega$, while χ_Z'' decreases slowly and monotonically with increase in H_0.[3] This suffices to explain the observed form of the curve in the Figure. A quantitative estimate on Eq. (1) shows excellent agreement with experimental data.

5. At the present time, the theory does not give precise expressions for χ'' and χ_Z'' in solids. In order to obtain some estimate of these quantities, we can make use of the theory for a paramagnetic gas, consisting of monatomic atoms with spin $\frac{1}{2}$.