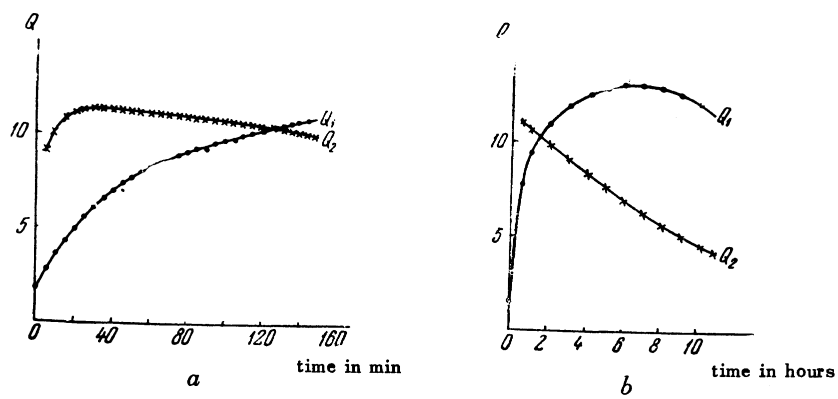


FIG. 2. Dependence of the charge-discharge quantities of electricity Q_1 and Q_2 on the increase of number of superimposed pulses with $E = 75$ volts/cm and $T = 18°C$. (Q is in units of 5.4×10^{-8} coulombs). Duration of interval between pulses is 10 seconds. At *a* the duration of each pulse is 5 minutes. At *b* the duration of each pulse is 1 hour.

of 50 to 100 volts/cm, residues in discharging which considerably surpass the residues in charging.

Fig. 2 shows the change of charge-discharge residues with an increase of number of impulses, according to the sign and magnitude of the electrical impulses. As is apparent from the adduced facts, the average rate of establishing polarizations and depolarizations changes over wide ranges in its dependence on the duration of action of the polarizing force. The smallest rate of establishing polarization results in a practically final value in no more than 5 minutes. Complete discharge is initially provided by isolating the sample for ten seconds, even in the case of the largest variation of accumulated charge produced from preceding impulses. This complete discharge results in an initial increase of the rate of establishing polarization. Subsequently, the rate of establishing polarization and depolarization decreases until the sample practically does not discharge, even with greater intervals of isolation. In this case superposition of sequential pulses of the opposite sign in fact produces overcharging. The result is that after the uninterrupted continuous action of the applied potential difference, the overcharging is able in turn to cause considerable delayed action.

The investigations showed that considerable unipolarity is inherent on most of the specimens and that this unipolarity is a permanent characteristic. However, prolonged action of electrical polarization is able to alter the unipolarity considerably, in particular to cause its disappearance. The disappearance of unipolarity indicates a transition from an "inherent" condition, in which the sample exists predominantly in one direction of spontaneous polarization, to a condition in which the forward and reverse directions of spontaneous polarization are equally likely. The maximum change of condition shows itself by a change of the predominant orientation of domains into opposition. The mechanisms of the processes, taking place in the samples over such a long interval of time, still remain insufficiently explained.

[1] J. Valasek, Phys. Rev. **24**, 560 (1924).

[2] G. Oplatke, Physik. Z. **34**, 296 (1933).

[3] M. S. Kosman, J. Exper. Theoret. Phys. USSR **19**, 899 (1949).

[4] I. V. Kurchatov, *Rochelle-Electricity*, 1933.

[5] W. G. Cady, *Piezoelectricity* (Mc Graw-Hill Book Company, Inc., New York, 1946).

[6] M. S. Kosman and A. N. Sozina, J. Exper. Theoret. Phys. USSR **20**, 1116 (1950).

[7] K. N. Karmen, J. Exper. Theoret. Phys. USSR **26**, 370 (1954).

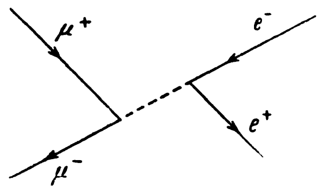
Translated by L. A. D'Asaro
236

Formation of a μ-Meson Pair in Positron Annihilation

V. B. BERESTETSKII AND I. IA. POMERANCHUK
Academy of Sciences, USSR

(Submitted to JETP editor September 29, 1955)
J. Exper. Theoret. Phys. USSR **29**, 864
(December, 1955)

IF there is no specific interaction peculiar to μ-mesons more essential than the electro-



magnetic, then experimental investigation of electrodynamic processes with participation of μ-mesons can give significant information about the limits of applicability of contemporary field theory and the nature of physical laws near these limits, since the Compton wavelength of the μ-meson is comparable with those dimensions near which one can expect fundamental modifications in space-time concepts[1]. The transformation of an electron-positron pair into a pair of μ-mesons can serve as one such process. The minimum energy E_n required of the positron for the formation of such a pair by collision with an electron at rest is given by $E_n = (2\mu/m)\,\mu c^2 \approx 4 \times 10^{10}$ ev (μ = μ-meson mass, m = electron mass) This process, as well as two-quantum annihilation, appears to be a second-order process in the sense of perturbation theory. The effective cross section σ is expressed in the following form:

$$\sigma = \frac{\pi}{6}\frac{e^4}{mc^2E}\left(1 + \frac{E_n}{2E}\right)\left(1 - \frac{E_n}{E}\right)^{1/2}. \qquad (1)$$

Near the threshold of the reaction ($E - E_n \ll E_n$)

$$\sigma = (\pi / 8)\,(e^2 / \mu c^2)^2\,[1 - (E_n / E)]^{1/2}.$$

For $E \gg E_n$

$$\sigma = (\pi / 12)\,(e^2 / \mu c^2)^2\,(E_n / E).$$

The maximum cross section (for $E \approx 1.7\, E_n$) per atom is given by

$$\sigma_{\max} \approx Z\,(\pi / 6)\,e^4 / mc^2E$$

$$= Z\,(\pi / 12)\,(e^2 / \mu c^2)^2 \approx 5Z \cdot 10^{-31}\ \text{cm}^2$$

It is approximately 70 times smaller than the cross section for two-photon annihilation σ_γ for such energies:

$$\sigma_\gamma = Z\,(\pi e^4 / mc^2E)\ln(2E / mc^2)$$

$$\approx \pi Z\,(e^2 / \mu c^2)^2 \ln(4\mu^2 / m^2).$$

The information referred to above would be contained in any deviation of experimental data from Eq. (1).

[1] I. Ia. Pomeranchuk, Dokl. Akad. Nauk SSSR **103**, 1005; **104**, 51 (1955).

Translated by H. Royden
282

Relaxation Processes in the Interaction of Nuclear Magnetic Moments with an Oscillator Loop

N. M. POMERANTSEV
Moscow State University
(Submitted to JETP editor April 4, 1955)
J. Exper. Theoret. Phys. USSR **29**, 375-376 (September, 1955)

DURING experiments on the magnetic resonance of atomic nuclei, a sample material is usually placed in the coil of an oscillator loop which is in a magnetic field[1,2]. The precession at resonance of the vector of the total magnetic moment induces an electromotive force in the coil of the oscillator loop.

Bloembergen and Purcell[3] considered the fact that the dissipation of energy which takes place in the oscillator loop will, independent of other factors, contribute to the attenuation of this precession. They also considered the interactions of the total magnetic moment vector with the oscillator loop for the case of free Larmor precession, and also for the case in which the loop is placed in a constant magnetic field and fed with high frequency voltage of constant amplitude. However, in practice, the magnetic field does not remain constant, but is modulated in most cases by an alternating field of audio frequency. In this case an oscillation of the amplitude of the precession of the total magnetic momentum vector takes place and changes the form of the signals in such a way that they have the form of damping oscillating functions[4]. Solutions obtained in reference 3 cannot answer the question of how the form of the signals is influenced by the interaction of the system of nuclear magnetic moments with the oscillator loop when the longitudinal component of the magnetic field is modulated.

The question of the interaction of the nuclear magnetic moments with the oscillator loop when the loop is connected to an automatic oscillating system, was considered by the author in reference 5. It has been proven theoretically and experiment-