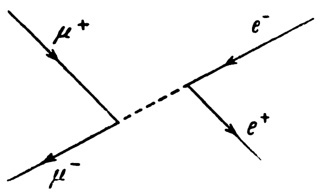

magnetic, then experimental investigation of electrodynamic processes with participation of μ-mesons can give significant information about the limits of applicability of contemporary field theory and the nature of physical laws near these limits, since the Compton wavelength of the μ-meson is comparable 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:

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

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).

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

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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 experimentally that in this case the amplitude of the oscillations of the generator is modulated by the signal $v(t)$, and the frcquency by the signal $u(t)$. These signals are the solution of Bloch's equation[1]. Also, experimentally and theoretically it has been shown that, depending on the parameter α, which determines the stability of the system, there takes place more or less strong cutting off of the upper frequencies of the signal $v(t)$. In the case of relatively stable systems (large α) the signal $v(t)$ is sent through practically without distortion.

The results of this work are easily applied in the case when the oscillating loop is fed from an external generator. The initial system of equations will be as follows

$$\frac{d^2V}{dt^2} + \omega^2 V = \omega^2 E \cos(\omega_0 t - \psi) - \frac{\omega}{Q}\frac{dV}{dt} - A\frac{dM_x}{dt},$$

$$\frac{dW}{dt} + \left[\frac{1}{T_2} + i\gamma H_z\right] W - i\gamma BM_z \frac{dV}{dt} = 0,$$

where E, ω_0 and ψ are the amplitude, frequency and phase of oscillation of the generator, Q is the quality of the loop. For the meaning of the other symbols see reference 5. Applying the method used in reference 5, we obtain for the voltage of the oscillator loop the following:

$$V = \rho \cos(\omega t - \varphi),$$

where

$$\rho = EQ + \rho', \quad \varphi = \psi + \frac{\pi}{2} + \varphi',$$

$$\rho' = {}^1/_4\, \omega\gamma ABEQ \int_{-\infty}^{t} v(\eta) \exp\left\{\frac{\omega}{2Q}(\eta - t)\right\} d\eta,$$

$$\varphi' = {}^1/_4\, \omega\gamma AB \int_{-\infty}^{t} u(\eta)\, d\eta.$$

The above expressions show that when the magnetic field is changed rapidly, additional distortions of the signal $v(t)$ appear. These distortions take form in cutting off the upper frequencies of $v(t)$. They are substantial for small frequencies and for large values of the Q of the oscillator loop.

1 F. Bloch, Phys. Rev. **70**, 460 (1946).

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3 N. Bloembergen and E. M. Purcell, Phys. Rev. **95**, 8 (1954).

4 K. V. Vladimirskii, Dokl. Akad. Nauk SSSR **58**, 1625 (1947).

5 N. M. Pomerantsev, Vestnik Moscow State Univ. **2**, 47 (1955).

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