where

$$\Delta_l(xx') = -i\langle\varphi(x)\varphi(x')\rangle_t,$$

$$D^t_{\mu\nu}(x-y) = \frac{1}{(2\pi)^4}\int \frac{k^2\delta_{\mu\nu} - k_\mu k_\nu}{k^4} e^{ik(x-y)} d^4k;\ D^l_{\mu\nu}$$

$$= \frac{1}{(2\pi)^4}\int \frac{k_\mu k_\nu}{k^2} \Delta_l(k^2) e^{ik(x-y)} d^4k,$$

$\Delta_l(k^2)$ is any positive function of k^2 and $j_\mu = j^t_\mu + j^l_\mu$ are the external sources of the transverse and the longitudinal components of the interaction with the photons (the interaction with an external field being given by $j_\mu A_\mu = j^t_\mu A^t_\mu + j^l_\mu A^l_\mu$).

The use of functional differentiation with respect to the sources of the photon or the electron fields reveals an obvious dependence of Green's functions on the longitudinal component of the field. In particular, from Eq. (16) we obtain the following relations:

$$G(x, y) = G(x, y)_0 \exp\{-ie^2(\Delta_l(0) - \Delta_l(x-y)\},$$

$$\frac{\delta G(x, y)}{\delta j_\mu(z)} = \frac{\delta G(x, y)}{\delta j^t_\mu(z)} + \frac{\delta G(x, y)}{\delta j^l_\mu(z)} = \left(\frac{\delta G(x, y)}{\delta j^t_\mu(z)}\right)_0$$

$$\times \exp\{-ie^2[\Delta_l(0) - \Delta_l(x-y)]\} + ieG(x, y)_0 \times \left[\frac{\partial\Delta_l(x-z)}{\partial z_\mu} + \frac{\partial\Delta_l(y-z)}{\partial z_\mu}\right]$$

where the index 0 denotes that the given quantity represents the unperturbed solution, where the longitudinal component of the interaction is totally absent.

Since the quantity $\delta G(x, x)/\delta j_\mu(z)$ is not dependent on the longitudinal component of the field, according to Eq. (18), the polarization operator is also independent of the longitudinal component. It follows from Eq. (17) that no gauge transformation is capable of removing the infinities which are caused by the transverse component of the interaction, and, therefore, in general, the most convenient choice of a gauge transformation is $\Delta_l = 0$ (see also reference 3).

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* *Translator's note:* The expression "logarithmic accuracy" denotes the following:

$$P/\xi \geq \log\xi,\ P \ll \xi.$$

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Note on Subsequent Transitions in Meson-Atoms

M. I. Podgoretskii
P. N. Lebedev Institute of Physics, Academy of Sciences, USSR

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MUCH experimental work has been done on the study of γ-quanta which are emitted during various transitions in meson atoms, and great precision has been achieved in measuring the energies of these γ-quanta. Of the various transitions which have been studied some are subsequent, for instance $3d \to 2p$ and $2p \to 1s$. However, in practice, the possible connection between the transitions has not been experimentally investigated. During the subsequent radiative transitions in meson atoms noticeable angular correlation between the directions of emission of the γ-quanta should be observed in many cases. According to the general laws for subsequent transitions (see reference 1, Ch. VII) the angular correlation is determined only by the knowledge of the total momenta of the initial, final and intermediate states. Since the orbital momenta of the levels of the meson atoms are well-known, in the given case the correlation is determined only by the magnitude of the meson spin. Thus there exists a possibility of the direct determination of the meson spin by measuring the angular correlation. In principle, this applies to the negative mesons of arbitrary type, and in particular, to the heavy mesons.

As an illustration let us consider μ mesons. By the way, we should note that the commonly assumed opinion that the meson has spin equal to ½ is based not on very dependable, but only on indirect evidence; in reference to the choice between the values ½ and 3/2 for the spin, a choice cannot be made at the present time.

The levels of the meson atoms are degenerate in orbital momentum and this makes the identification of the transitions difficult. However, the effect of the finite size of the nucleus leads to the removal of the degeneracy for large Z. For instance, for the meson atom formed in the nucleus of lead the $2s$ level is approximately 1 mev above the $2p$ level [2]. Consider now the μ meson which got to the $2s$ level during the formation of the meson atom and by subsequent transitions; it goes over into the ground state of the meson atom by the way of the subsequent radiative transitions $2s \rightarrow 2p \rightarrow 1s$. If the spin of the meson is ½ or 3/2, then the angles between the γ-quanta are distributed almost isotropically, i.e., $W(\theta) \sim \sin\theta$. On the other hand, if the spin is zero, $W(\theta) \sim (1 + \cos^2\theta)\sin\theta$. In an analogous way, we can observe the difference between spins of ½ and 3/2. In particular, for the transition $3p \rightarrow 2s \rightarrow 2p$ the angular distribution is exactly isotropic if the spin is ½ and non-isotropic if the spin is 3/2.

During the cascade emission of γ-quanta by nuclei, the angular correlation can in some cases be strongly supressed because of the interaction of the magnetic moment of the nucleus with the magnetic field caused by the electron shell. The estimates given in reference 1 show that this phenomenon does not appear if the lifetime of the intermediate state $t \leq 3 \times 10^{-11}$ sec. Approximately the same estimates are valid in the case under consideration, the only difference being that the role of the magnetic moment of the nucleus is replaced by the magnetic moment of the meson atom. The lifetimes of meson-atom transitions are very small. For instance, for lead the lifetime of the μ meson in $2s$ state is $\sim 10^{-17}$ sec, and for $Z = 25$, $t \sim 2 \times 10^{-13}$ sec[2]. Therefore, as a rule, we can neglect the effect of the electron orbits.

For meson atoms an additional question can arise concerning the interaction of the magnetic moments of the meson atom and the nucelus. We will not consider this question here in detail, but note that in practice it is always possible to study the meson atoms formed in nuclei with zero momentum, where the above interaction is absent. Another complication arises if the mesons experience very large nuclear capture (for instance π-mesons). In this case we must exclude from consideration levels for which the probability of nuclear capture is much greater than the probability of the radiative transition. For not too large Z the above applies only for levels with zero orbital momentum.

The author is thankful to I. S. Shapiro for participating in the discussion.

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Rotation of the Plane of Polarization in a Longitudinal Magnetic Field at a Wavelength of 3 cm

D. I. Mash
P. N. Lebedev Institute of Physics
Academy of Sciences of the USSR

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With the development of radio direction finding and the appearance of ferromagnetic dielectrics[1], the rotation of the plane of polarization in a magnetic field (Faraday effect) has become of great practical importance and has found extensive application in UHF techniques.

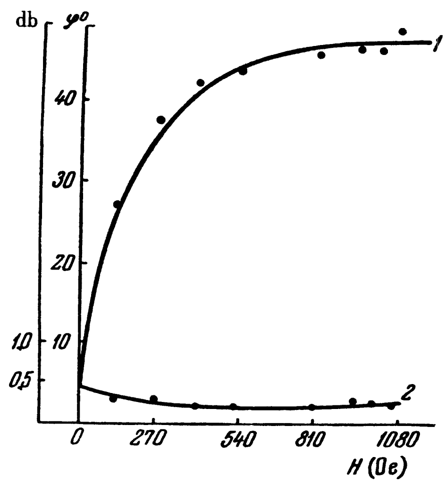

FIG. 1. Dependence of (*1*) angle of rotation of the plane of polarization φ in degrees, (*2*) losses, in decibels, on the magnetic field intensity for a sample of NZ-500 45 mm long.