$$s' = (\beta_1 - \beta\cos\theta)/\sqrt{(1-\beta\beta_1\cos\theta)^2 - (1-\beta^2)(1-\beta_1^2)} < 1.$$

Here $c\beta_1 = ck/K$ is the speed of the motion of the particle in the original coordinate system.

As is well known, in the decay of a stationary π meson into a μ meson and a neutrino the spin of the μ meson must be directed exactly along the momentum of the μ meson ($s = 1$). But in the laboratory system, relative to which the π meson may be in motion, we have $s' < 1$, and therefore there must be a transverse component of the spin of the μ meson, lying in the plane of the momenta of the π and μ mesons.

We note that for particles with zero rest mass ($k_0 = 0$) the speed is always given by $\beta_1 = 1$. In this case $\theta'_s = \theta'_k$, and therefore the quantity s' is unchanged ($s' = s = 1$). This fact was used by one of us, following the ideas of Lee and Yang, in constructing a theory of the neutrino with oriented spin,[6,7] in which neutrino and antineutrino are characterized by different values of s ($s = 1$ and $s = -1$).

*Analogous expressions for the average value of the spin vector with only positive energies taken into account can be obtained from the work of Tolhoek,[4] and also from that of Alikhanov et al.[5] But the expression for σ_μ^A introduced in reference 5 (see note on page 789),

$$\sigma^A = (K\rho_3\sigma + \rho_2[\mathbf{k}\times\sigma])/k_0 = \sigma + i\rho_2\mathbf{k}/k_0,$$

$$\sigma_4^A = i\rho_3(\sigma\cdot\mathbf{k})/k_0 = \sigma_4 - \rho_2 K/k_0$$

will satisfy neither the law of conservation of total angular momentum nor the law of conservation of the longitudinal component of the spin. For $K > 0$ the results agree, since the average value of ρ_2 is zero.

†This is due to the fact that the momentum four-vector is timelike: $k_\mu k_\mu = -k_0^2$, and the spin is spacelike: $\zeta_\mu\zeta_\mu = k_0^2$, with the two vectors orthogonal to each other: $\zeta_\mu k_\mu = 0$.

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RANDOM FREE PRECESSION OF MAGNETIC MOMENTS OF ATOMIC NUCLEI

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THE free precession of magnetic moments of atomic nuclei in an external magnetic field H_0 is usually observed by measuring the voltage and the frequency $\omega_0 = \gamma H_0$ at the terminals of a receiving coil which contains a sample initially magnetized perpendicularly to H_0. In a sufficiently homogeneous field H_0 the phenomenon is observed as long as the signal which decays with the time constant $T_{||}$ exceeds the noise in the system.

After the signal has decayed the voltage at the terminals of the receiver coil is of a fluctuating nature and is determined on the one hand by the thermal noise in the receiver circuit, and on the other hand by the fluctuations in the magnetization of the sample.

The spectral density of the mean square of the voltage across the load resistor R_0 of the receiver circuit due to thermal noise in the receiver system is given by Nyquist's formula, which in the case under consideration is of the form:[1]

$$(V_T^2)_\omega = \frac{\hbar\omega}{2\pi}\coth\frac{\hbar\omega}{2kT}\frac{RR_0^2}{|Z(\omega)|^2}, \quad (1)$$

where $Z(\omega)$ is the impedance, while R is the effective resistance of the whole receiver circuit. The presence in the receiver coil of a sample containing atomic nuclei with a magnetic moment different from zero and situated in an external field H_0, leads to the appearance of an additional voltage due to the fluctuations of the component of the magnetization of the sample in the direction perpendicular to H_0. The spectral density of the mean square of the component of the magnetization in this direction is given by the expression

$$(M^2)_\omega = (\hbar\chi''/2\pi)\coth(\hbar\omega/2kT), \quad (2)$$

where

$$\chi'' = \frac{1}{2}\chi_0\left(\frac{\omega T_\perp}{1+(\gamma H_0+\omega)^2 T_\perp^2} + \frac{\omega T_\perp}{1+(\gamma H_0-\omega)^2 T_\perp^2}\right) \quad (3)$$

is the imaginary part of the complex nucleus susceptibility, while $T_\perp$ is the transverse relaxation time.

The spectral density of the mean square of the fluctuations in the corresponding voltage is of the form:

$$(V_M^2)_\omega = 16\pi^2 S^2 N^2 c^{-2} \omega^2 R_0^2 |Z(\omega)|^{-2} (M^2)_\omega, \qquad (4)$$

where N is the number of turns, S is the cross section of the coil placed perpendicular to the field H_0.

By utilizing (2) we obtain:

$$(V_M^2)_\omega = 8\pi\chi'' S^2 N^2 \omega^2 c^{-2} \hbar R_0^2 |Z(\omega)|^{-2} \coth(\hbar\omega/2kT). \qquad (5)$$

As may be seen from (5) the voltage fluctuations have a resonance character, and as a result of the large value of the relaxation time $T_\perp$ attain a sharp maximum in the field $H_0 = \pm\omega/\gamma$.

If one takes for water $\gamma = 2.8 \times 10^4$ gauss-sec, $\chi_0 = 3.3 \times 10^{-10}$ and $T_\perp = 3$ sec, then the ratio of the spectral densities (5) and (1) for $H_0 = \omega/\gamma$ has the form:

$$\eta = (V_M^2)_{\gamma H_0} / (V_T^2)_{\gamma H_0} = 6.3 \cdot 10^{-8} S^2 N^2 H_0^2 / R, \qquad (6)$$

where R is the effective resistance of the receiver circuit in ohms. In the case $N = 10^3$ turns, $S = 100\ \text{cm}^2$ in the earth's magnetic field $H_0 = 0.6$ gauss, $\eta = 220/R$.

Thus, in this case under appropriate conditions one may separate from the spectrum of thermal noise the signal due to the random free precession of magnetic moments of atomic nuclei. The ratio η in the case of resonance is proportional to $(\gamma H_0)^2$. This last consideration may be used as the basis of the theory of self excitation of a spin generator.[2]

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PRODUCTION OF STRANGE PARTICLES IN 3-Bev p-p COLLISIONS

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In references 1 — 3, the statistical theory of multiple production of strange particles was considered. In the case of π-N collisions, this theory describes the experiments satisfactorily, if the energy of the colliding particles is sufficiently high.[4,5] Comparison between theoretical calculations and experiments can now also be carried out for p-p collisions.

If we assume that the effective inelastic cross section for 3-Bev p-p collisions is equal to 26 mbn,[6] then the cross section for production of K^+-particles in p-p collisions calculated according to references 1 — 3 is $\sigma^+ = 1.0$ mbn for the variant $V = V_2$ (the K mesons being produced in a volume of radius $r_k = \hbar/m_k c = 0.4 \times 10^{-13}$ cm; all other particles in a volume of radius $r_\pi = \hbar/m_\pi c = 1.4 \times 10^{-13}$ cm), and $\sigma^+ = 0.05$ mbn for the variant $V = V_3$ (all strange particles produced in a volume of radius r_k; all other particles, in a volume of radius r_π). The calculated cross section for production of all strange particles $\sigma_{st} = 1.5$ mbn for $V = V_2$ and $\sigma_{st} = 0.07$ mbn for $V = V_3$.

Baumel et al.[7] obtained the value $\sigma_{exp} = (4.5 \pm 0.9) \times 10^{-32}$ cm²/sterad-Mev for the cross section for the production of K^+ particles of momentum $1.9 m_\pi$ ($m_\pi = 140$ Mev) at $\theta = 180°$ (center-of-mass-system) in 3 Bev p-p collisions. In order to integrate the cross section over all momenta, we calculated the momentum distribution of the K mesons produced. Assuming an isotropic angular distribution in the c.m.s., for $V = V_2$, $\sigma^+ = 0.33$ mbn.* An analogous calculation for the variant $V = V_3$ gives nearly the same value. However, this quantity is an order different from the cross section calculated for $V = V_3$ from only the statistical weights without use of σ_{exp} and the momentum distribution. Thus, as in the case of π-N collisions, the variant $V = V_3$ leads to contradictions. For the variant $V = V_2$, the value of σ^+ calculated taking into account the momentum distribution is three times smaller than that calculated only on the basis of statistical weights without employing σ_{exp} and the momentum distribution. This difference can be explained by the fact that at low energies $E \leq 3$ Bev, the energy of the strange particles produced in N-N collisions is near to threshold, and the number of them is not appreciable. Hence, statistical methods can give only