lasing spectra were investigated with a spectrographic having a dispersion 20 Å/mm by burning out the emulsion of a previously exposed and developed photographic film.

The erbium laser generation had a typical spiked character, with individual spikes having durations 1 - 3 μsec. At a slight excess above threshold, the emission was on the λ_1 = 1536 nm line with $\Delta\lambda_1$ = 1.6 - 1.8 nm, followed in succession by weaker lines with λ_2 = 1543 ± 1 nm (1.5 times threshold) and λ_3 = 1538 ± 0.75 nm (∿ 2.5 times threshold).

The threshold pump energy was 5.3 J absorbed per cm³ of the Yb^{3+} - Er^{3+} element. At three times threshold the radiated energy per free-generation pulse was 21 J at a differential conversion coefficient $\eta_d \simeq$ 29%. When Q-switched by a rotating prism (500 rps), the same element emitted 5.1 J in a pulse of ∿ 30 nsec duration. The poor optical quality of the glass produced under laboratory condition did not make it possible to tune the erbium-laser generator with accuracy higher than ±1', which is patently insufficient for effective laser operation. With this taken into account, one can hope that glass of better optical quality will make a conversion efficiency ∿ 40 - 50% perfectly realistic.

[1)] The limiting theoretical value of η is determined by the Stokes shift of the generation frequency relative to the pump frequency and is equal to 0.69.

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INCOHERENT $K_L^0 \to K_S^0$ REGENERATION ON ATOMIC ELECTRONS AT HIGH ENERGIES, AND THE ELECTRIC RADIUS OF THE K^0 MESON

V. L. Lyuboshitz
Joint Institute for Nuclear Research

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It is noted that the cross section for coherent regeneration of K_S^0 mesons when K_L^0 mesons interact with atomic electrons increases rapidly with increasing K_L^0-meson energy. As a result, at very high energies (∿ 100 GeV), the reaction $K_L^0 + e \to K_S^0 + e$ can be used for an experimental determination of the K^0-meson rms radius, which characterizes the electric-charge distribution. The energy spectrum of the relativistic recoil electrons is considered and numerical estimates are given.

The regeneration of short-lived neutral K mesons (K_S^0) when long-lived neutral K mesons (K_L^0) collide with atomic electrons was discussed earlier by Zel'dovich [1] (see also [2]). The amplitude of this process is expressed directly in terms of the electric radius of the K^0 meson. At energies $E_K < m_K$, the effective regeneration cross section $\sigma(K_L^0 + e \to K_S^0 + e)$ increases rapidly with increasing K-meson laboratory energy. In this connection, at very high energies (> 100 GeV), it becomes possible in practice to determine experimentally the electric radius of the K^0 meson by studying the incoherent regeneration of K_S^0 mesons on atomic electrons[1)]. The reaction $K_L^0 + e \to K_S^0 + e$ can be uniquely identified by registering simultaneously the relativistic recoil electrons and the charged pions from the $K_S^0 \to \pi^+\pi^-$ decay.

As is well known, in the Born approximation the differential cross section for elastic scattering of electrons by spinless hadrons is described by the formula (see, e.g., [4]):

$$\frac{d\sigma}{dt} = \frac{\pi a^2}{t_{max}} F^2(t)[(p_a + p_a', p_e + p_e')^2 - t(p_a + p_a')^2]\frac{1}{st^2}. \quad (1)$$

Here p_a and p_a', p_e and p_e' are the 4-momenta of the hadron and electron before and after scattering, respectively ($p_a^2 = p_a'^2 = m_a^2$, $p_e^2 = p_e'^2 = m_e^2$), $s = (p_a + p_e)^2$, $t = -(p_e - p_e')^2 = -(p_a' - p_a)^2$, $\alpha = e^2/\hbar c$ is the fine-structure constant, F(t) is the hadron electromagnetic form factor, and

$$t_{max} = 4\vec{p}^2_{cms} = \frac{4(\gamma^2 - 1)\, m_a^2 m_e^2}{m_a^2 + m_e^2 + 2m_a m_e \gamma}, \tag{2}$$

where $\gamma = p_a p_e / m_a m_e = E_a/m_a$ is the hadron Lorentz factor in the electron rest system.

For neutral K mesons we have

$$F_{K^0}(t) = -F_{\bar{K}^0}(t) \approx \pm \frac{1}{6} t R_K^2, \tag{3}$$

where $R_K = \sqrt{\langle r^2 \rangle}$, $\langle r^2 \rangle$ is the mean-squared charge-distribution radius. If $t_{max} R_K^2 \ll 1$, we can neglect the remaining terms of the expansion of the K^0-meson form factor in powers of t at all values of the momentum transfer.

In first order in the electromagnetic constant $\alpha = 1/137$, the amplitudes of the regeneration and scattering of neutral K mesons by electrons are connected by the relation

$$f(K_L^0 + e \to K_S^0 + e) = f(K^0 + e \to K^0 + e) = -f(\bar{K}^0 + e \to \bar{K}^0 + e)^{2)}. \tag{4}$$

Substituting (3) in (1) we obtain, taking (4) into account,

$$d\sigma(K_L^0 + e \to K_S^0 + e) = \frac{4\pi}{9} \alpha^2 m_e^2 \gamma^2 R_K^4 \frac{1 - \frac{t}{4m_e^2 \gamma^2}\left(1 + \frac{2m_e \gamma}{m_K}\right)}{1 + \frac{2m_e \gamma}{m_K} + \left(\frac{m_e}{m_K}\right)^2} \frac{dt}{t_{max}}. \tag{5}$$

Discarding in (5) the terms of order $1/\gamma^2$ and $(m_e/m_K)^2$, we arrive at the formula

$$d\sigma(K_L^0 + e \to K_S^0 + e) = \frac{2\pi}{9} \alpha^2 m_e R_K^4 \left(1 - \frac{T}{T_{max}}\right) dT, \tag{6}$$

where $T = t/2m_e$ is the kinetic energy of the recoil electrons,

$$T_{max} \approx \frac{2m_e \gamma^2}{1 + \frac{2m_e \gamma}{m_K}}. \tag{7}$$

The angle between the electron momentum direction and the direction of the momentum of the primary K_L^0 meson is connected with the recoil kinetic energy by the relation

$$\sin\theta = \left(\frac{2m_e(T_{max} - T)}{T_{max}(T + 2m_e)}\right)^{1/2}. \tag{8}$$

Integrating (6) over the spectrum of the recoil electrons from $T_0 = \delta T_{max}$ to T_{max} and substituting the concrete values of m_e, m_K, and α, we obtain the numerical formula

$$\sigma = 5 \cdot 10^{-36} \frac{\gamma^2 R_K^4}{1 + 2 \cdot 10^{-3} \gamma} \left(\frac{1}{2} + \frac{1}{2}\delta^2 - \delta\right), \tag{9}$$

where σ is in cm^2 and R_K in Fermi units. At $\delta T_{max} \gg m_e$ is the maximum electron emission angle (corresponding to an energy $T_0 = \delta T_{max}$)

$$\theta_0 \approx \sqrt{(2m_e/T_0)(1-\delta)}. \qquad (10)$$

In the model of vector dominance with current mixing we have $\langle r^2 \rangle = 0.76\times10^{-27}$ cm^2 [6], i.e., $R_K = 0.275$ F.[3] If we assume this value, then at an energy $E_K = 20$ GeV and $\delta = 1/10$ ($\gamma = 40$, $T_{max} = 1.6$ GeV, $t_{max}R_K^2 = 3\times10^{-3}$, $\theta_0 = 4.3°$) the integral regeneration cross section calculated by formula (9) equals 1.72×10^{-35} cm^2. To estimate the number of events we assume that a liquid-hydrogen target of length L = 300 cm is used, and that the intensity of the K_L^0-meson beam is $I = 10^5$ particles/sec. We can then expect that after 100 hours of continuous accelerator operation there will be registered approximately eight acts of the regeneration $K_L^0 + e \to K_S^0 + e$. At an energy $E_K = 200$ GeV and at the same values of R_K, δ, L, and I (corresponding to $\gamma = 400$, $T_{max} = 90$ GeV, $t_{max}R_K^2 = 0.17$, and $\theta_0 = 0.57°$), the regeneration cross section is already equal to 1×10^{-33} cm^2, and the number of expected events increases to 5 per hour. We note that by choosing targets of dense substances with heavy nuclei it is possible in principle to increase the rate of statistics accumulation by 2 - 3 times (the maximum number of events, with allowance for absorption of the K_L^0 mesons in the medium, is proportional to $(Z/A)A^{1/3}$). In this case, however, the radiation length decreases substantially, and difficulties may arise in the registration of the recoil electrons. The question of the optimal conditions for performing the experiments calls for a special study.

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1) We do not consider here the effect of coherent (refraction) regeneration $K_L^0 \to K_S^0$ on electrons, which was indicated by Ya. B. Zel'dovich [1]. This effect was investigated experimentally by the authors of [3].

2) It can be verified that CPT invariance holds, and Eqs. (4) remain in force also when account is taken of CP-parity nonconservation in neutral K-meson decays [5].

3) According to [3], $R_K = (0.2^{+0.22}_{-0.2})$ F.

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RESONANT PAIR PRODUCTION IN A STRONG ELECTRIC FIELD

V. S. Popov
Institute of Theoretical and Experimental Physics
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Pair production form vacuum by an external electromagnetic field has been evoking considerable interest in recent years (see [1 - 4] and the references cited therein). Experimental observation of this process would mean a verification of one of the important predictions of quantum electrodynamics [5]. Such an experiment will apparently be made possible by progress in laser technology. The e^+e^- pairs are produced in this case by a field F(t) that depends periodically on the time. In this article we wish to call attention to the fact that pair production has in this case certain peculiarities connected with the periodicity of the field.

Let $F(t) = F\phi(\tau)$ be the alternating electric field, F its amplitude, $\tau = \omega t$, $T = 2\pi/\omega$ the period,

$$\phi(\tau + 2\pi) = -\phi(\tau + \pi) = \phi(\tau) \qquad (1)$$

and $|\phi(\tau)| \le \phi(0) = 1$ (i.e., the field is maximal at the instants $t = k\pi/\omega$, $k = 0, \pm1, \pm2, \ldots$). If the conditions

$$\omega \ll m, \; F \ll F_0 = m^2c^3/e\hbar \qquad (2)$$