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ЛАБОРАТОРИЯ ВЫСОКИХ ЭНЕРГИЙ

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$K^{\circ}_{L} \to K^{\circ}_{S}$ INCOHERENT REGENERATION ON ATOMIC ELECTRONS AT HIGH ENERGIES AND ELECTRIC RADIUS OF K° - MESON

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The process of the short-lived neutral K-meson (K_S^0) regeneration in the interaction of long-lived neutral K-meson (K_L^0) with atomic electrons has been discussed earlier by Zel'dovich /1/ (see also /2/). The amplitude of this process is expressed directly through the K^0 electric radius. At energies of $E_K \lesssim m_K$ the regeneration cross-section $\sigma(K_L^0 + e \to K_S^0 + e)$ is very small /1/. However, it is essential that the magnitude of $\sigma(K_L^0 + e \to K_S^0 + e)$ increases rapidly with increasing the K_L^0 energy in the laboratory reference frame. Therefore at very high energies ($\gtrsim$100 Gev) it is practically possible to determine experimentally the K^0 electric radius by studying the incoherent K_S^0 regeneration on atomic electrons.[x] The $K_L^0 + e \to K_S^0 + e$ reaction can be identified exactly by coincident registration of relativistic recoil electrons and charged π-mesons from the $K_S^0 \to \pi^+ \pi^-$ decay.

It is known that in a Born approximation the differential cross section of the electron elastic scattering on spinless hadrons is described by the formula (see, for example, /4/):

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

In (1) p_a and p_a' are the 4-momenta of hadron before and after scattering; p_e and p_e' are those for electron ($p_a^2 = p_a'^2 = m_a^2$, $p_e^2 = p_e'^2 = m_e^2$), $S = (p_a + p_e)^2$, $t = -(p_e' - p_e)^2 = -(p_a' - p_a)^2$, $\alpha = e^2/\hbar c$ is the fine structure constant, $F(t)$ is the hadron

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x/ Here we don't consider the effect of the coherent (i.e. refraction) $K_L^0 \to K_S^0$ regeneration on electrons, which is pointed out by Zel'dovich /1/. Experimentally this effect was being studied by the authors of /3 /.

electromagnetic formfactor, and

$$t_{max} = 4\vec{P}^2_{c.m.} = \frac{4(\gamma^2 - 1)m_a^2 m_e^2}{m_a^2 + m_e^2 + 2m_a m_e \gamma}, \quad (2)$$

where $\gamma = \frac{p_a p_e}{m_a m_e} = \frac{E_a}{m_a}$ is hadron Lorentz factor in the rest frame of the electron.

For neutral K-mesons

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

where $R_K = \sqrt{<r^2>}$, $<r^2>$ is the mean-square radius of the charge distribution. When $t_{max}R_K^2 \ll 1$, the other terms of the expansion of the K^0 formfactor in the power of t can be neglected at any possible momentum transfer.

To a first approximation in the electromagnetic constant of coupling α, the amplitudes of the regeneration and scattering of neutral K-mesons on electrons are connected by the relation

$$f(K_L^0 + e \to K_S^0 + e) = f(K^0 + e \to K^0 + e) = -f(\bar{K}^0 + e \to \bar{K}^0 + e). \text{ x/} \quad (4)$$

Substituting (3) into (1) and using (4) one obtains:

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

By neglecting the terms of the order $1/\gamma^2$ and $(m_e/m_K)^2$ the formula follows

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

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

$$T_{max} \approx \frac{2m_e\gamma^2}{1+2m_e\gamma/m_K}. \quad (7)$$

The angle between the directions of electron and primary K_L^0 momenta is connected with recoil kinetic energy by the relation

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

After integrating the expression (6) over the spectrum of recoil electrons and after substituting the concrete values of m_e, m_K, and α, one derives the quantitative formula

$$\sigma = 5.10^{-36}\frac{\gamma^2 R_K^4}{1+ 2.10^{-3}\gamma}\left(\tfrac{1}{2} + \tfrac{1}{2}\delta^2 - \delta\right), \quad (9)$$

where σ is in cm^2, R_K is in fermi. When $\delta T_{max} \gg m_e$ the maximum flight angle of the electron (corresponding to the energy $T_0 = \delta T_{max}$) is

$$\theta_0 = \sqrt{\frac{2m_e}{T_0}(1-\delta)}. \quad (10)$$

In the current-mixing model of the vector dominance $<r^2> = 0.76 \cdot 10^{-27}\ cm^2$ /6/, i.e. $R_K = 0.275$ fm x/. If this value is taken at the energy $E_K = 20$ Gev and $\delta = 1/10$ ($\gamma = 40$, $T_{max} = 1.6$ Gev, $t_{max}R_K^2 = 3 \cdot 10^{-3}$, $\theta_0 = 4.3^\circ$), the integral regeneration cross

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x/ One can see that the equations (4) will also be correct taking into account CP-parity nonconservation in the neutral K-meson decays if CPT - invariance exists./5/

x/ According to /3/, $R_K = (0.2 \begin{smallmatrix}+ 0.22 \\ - 0.2\end{smallmatrix})$ fm.

section calculated by formula (9) will be equal to $1.72 \cdot 10^{-35}$ cm^2. To estimate the number of events, let us assume that a liquid hydrogen target with the length L = 300 cm is used and the intensity of the K^0-meson beam is $J = 10^5$ particles/sec. Then one can expect that about 8 acts of regeneration will be registered for 100 hours of accelerator continuous work. At E_K = 200 Gev and the same values of R_K, δ, L, and J (which corresponds to γ = 400, T_{max} = 90 Gev, $t_{max} R_K^2 = 0.17$, $\theta_0 = 0.57^o$) the regeneration cross section is already equal to $1 \cdot 10^{-33}$ cm^2, and the number of expected events increases up to 5 per hour. It should be noted, that in principal it is possible to increase the velocity of grouth of statistics by 2-3 times using dense targets of heavy nuclei because the maximum number of events taking into account the absorption of K_L^0-mesons in the medium is proportional to $(Z/A)A^{1/3}$. But in this case the radiation length essentially decreases and difficulties can arise to detect recoil electrons. The question on optimum conditions of experiment performance requires special consideration.

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