the energy of forward motion is completely transformed into energy of oscillatory motion: $|\dot{r}_1|^2/4 = \Phi(z)$, $\dot{r}_1 = -(\eta/\omega^2)Ee^{i\omega t}$. Now we assume that the particles leave the interaction region when the total velocity vanishes $[\dot{z}(t) + \dot{r}_1(t) = 0]$ at the plane $z = z_0$. Such a separation of particles can be achieved, for example, with an arrangement of conducting walls at a distance $r_{1\,max} = |\eta E(\dot{r}_0)|/\omega^2$ from the average trajectory of the beam. Then the kinetic energy of the particles is returned completely to the field. Moreover, if the system forming the high-frequency field is tuned to resonance and has a high Q, then, as is not difficult to show,[7] a stable oscillatory regime is always attained for a specific choice of the parameters.

Thus it appears to be possible to use the separation of particles for maintaining a given level of high-frequency power in a system. For instance, in containing a plasma blob in a high-frequency potential well inside a resonant cavity, the separation of fast particles at the walls can ensure the required level of high-frequency field for confining the slower particles, if the plasma temperature is kept constant (i.e. if the plasma is heated by some external source). For these purposes it is also possible to introduce an auxiliary beam of particles, i.e., to combine within a single cavity a source of high-frequency oscillations and a confined plasma blob. A similar combination might prove to be useful for several types of the accelerators that employ a high-frequency electromagnetic field to transfer energy from one beam to another.

The separation of particles interacting with an inhomogeneous field also has a quite independent importance as one of the possible methods of generating and amplifying microwaves.

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CIRCULAR POLARIZATION OF INTERNAL γ-BREMSSTRAHLUNG IN β-DECAY AND TIME REVERSAL INVARIANCE

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THE continuous γ-radiation which accompanies β-decay is of current interest in connection with parity nonconservation in weak interactions. A number of authors[1-3] have indicated that instead of observing the electron polarization it may be possible to observe the circular polarization of the γ-photons. The experiments which have been carried out[4] verify parity nonconservation in weak interactions.

In the present note, we present a theoretical analysis of the bremsstrahlung effect in β-decay in connection with the problem of invariance under time reversal.

A pseudoscalar with respect to time reversal can be formed from the electron momentum, the photon momentum, and the neutrino momentum (using the recoil of the nucleus) or from the electron momentum, the photon momentum and the angular momentum of the nucleus. In the first case we obtain the following expression for the distribution over direction of the electron and the neutrino and energy of the electron and γ-photon (in units in which $\hbar = c = 1$):

$$dw = \frac{e^2}{2(2\pi)^7}\frac{(\varepsilon - E - k)^2}{(p\cos\vartheta - E)^2} pdE\, d\Omega\, d\Omega_\nu \frac{dk}{k}\xi\left\{p^2\sin^2\vartheta\left(E + a\frac{\mathbf{p}_\nu}{E_\nu}\mathbf{p} + bm\right) + (1 \mp G)I_1 + (a \mp H)\frac{\mathbf{p}_\nu}{E_\nu}\mathbf{I}_2 \pm K\frac{\mathbf{p}_\nu}{E_\nu}\mathbf{I}_3 \pm L\frac{m[\mathbf{p}\times\mathbf{p}_\nu]\mathbf{k}}{E_\nu}\right\}. \quad (1)$$

Here m, E, **p**, and Θ are respectively the rest mass, energy, and momentum of the electron and the angle formed by it and the γ-photon, ϵ is the difference in mass for the initial and final nucleus, E_ν and $\mathbf{p}_\nu$ are the energy and momentum of the neutrino, k and **k** are the energy and momentum of the photon, and **n** is a unit vector in the **k** direction. The upper sign refers to right-handed circular polarization of the γ-photon, the lower sign refers to left-handed polarization. Further,

$$I_1 = kp^2\sin^2\vartheta + k^2E - k^2p\cos\vartheta,$$
$$\mathbf{I}_2 = k(E - p\cos\vartheta)\mathbf{p} + (p^2 + Ek - pk\cos\vartheta - Ep\cos\vartheta)\mathbf{k},$$
$$\mathbf{I}_3 = m(\mathbf{k}\, p\cos\vartheta - k\mathbf{p});$$
$$H\xi = 2\mathrm{Re}[\mp |M_F|^2 (C_S C_S'^* + C_V C_V'^*) \pm \tfrac{1}{3}|M_{GT}|^2 (C_T C_T'^* + C_A C_A'^*)];$$
$$K\xi = 2\mathrm{Re}\left[-|M_F|^2 (C_S C_V'^* + C_S' C_V^*) + \tfrac{1}{3}|M_{GT}|^2 (C_T C_A'^* + C_T' C_A^*)\right];$$
$$L\xi = 2\mathrm{Im}\left[|M_F|^2 (C_S C_V^* + C_S' C_V'^*) - \tfrac{1}{3}|M_{GT}|^2 (C_T C_A^* + C_T' C_A'^*)\right].$$

The upper sign in the last three expressions refers to electron decay, the lower sign refers to positron decay. The remaining notation is the same as that used by Jackson, Treiman, and Wyld.[5] The appearance of a term proportional to L is inconvenient because of the fact that the Fierz interference terms are contained in L.

The following expression for the probability of internal bremsstrahlung in β-decay of oriented nuclei is obtained when we integrate over direction of neutrino emission:

$$dw = \frac{e^2}{2(2\pi)^7}\frac{(\varepsilon - E - k)^2}{(p\cos\vartheta - E)^2} pdE\, d\Omega \frac{dk}{k}\xi\left\{p^2\sin^2\vartheta\left(E + A\frac{\langle\mathbf{J}\rangle}{J}\mathbf{p} + bm\right) + (1 \mp G)I_1 + \frac{\langle\mathbf{J}\rangle}{J}(A \mp N)\mathbf{I}_2 \pm \frac{\langle\mathbf{J}\rangle}{J}(Q\mathbf{I}_3 + Rm[\mathbf{p}\times\mathbf{k}])\right\}. \quad (2)$$

$\langle\mathbf{J}\rangle$ is the expectation value for the angular momentum of the initial nucleus,

$$N\xi = 2\mathrm{Re}\left[|M_{GT}|^2\lambda_{J'J}\tfrac{1}{2}(|C_T|^2 + |C_A|^2 + |C_T'|^2 + |C_A'|^2) \pm \delta_{J'J}|M_F||M_{GT}|\left(\frac{J}{J+1}\right)^{1/2}(C_S C_T^* + C_V C_A^* + C_S' C_T'^* + C_V' C_A'^*)\right];$$
$$Q\xi = 2\mathrm{Re}\left[\pm |M_{GT}|^2\lambda_{J'J}(C_T C_A^* + C_T' C_A'^*) + \delta_{J'J}|M_F||M_{GT}|\left(\frac{J}{J+1}\right)^{1/2}(C_S C_A^* + C_V C_T^* + C_S' C_A'^* + C_V' C_T'^*)\right];$$
$$R\xi = 2\mathrm{Im}\left[\pm |M_{GT}|^2\lambda_{J'J}(C_T C_A'^* + C_T' C_A^*) + \delta_{J'J}|M_F||M_{GT}|\left(\frac{J}{J+1}\right)^{1/2}(C_S C_A'^* + C_S' C_A^* - C_V C_T'^* - C_V' C_T^*)\right].$$

Expressions containing the imaginary parts of the coupling constants are also obtained in an analysis of electron polarization in β-decay of oriented and nonoriented nuclei in the same cases as in ordinary β-decay.[5] The results of calculations of β-decay with the emission of γ-photons will be published in Изв. высших учебных заведений (News of the Higher Educational Institutions). Here we present the probability for transition into a state in which the electron has an energy in the interval dE, the γ-photon has an energy in the interval dk, the electron momentum **p** lies in the solid angle dΩ, and the polarization of the electron is given by the unit vector ξ (the polarization directions for the γ-photon are summed and the nuclei are nonoriented):

$$dw = \frac{2e^2}{(2\pi)^6}\frac{(\varepsilon - E - k)^2}{(p\cos\vartheta - E)^2} pdE\, d\Omega \frac{dk}{k}\xi\left\{k^2(E - p\cos\vartheta) + (E + k)p^2\sin^2\vartheta \right.$$
$$\left. + bmp^2\sin^2\vartheta + G\left[(\boldsymbol{\zeta}\cdot\mathbf{p})\left(p^2\sin^2\vartheta + \frac{kp^2}{E+m}\sin^2\vartheta + k^2 + mk + \frac{k^2p}{E+m}\cos\vartheta\right) - m(\boldsymbol{\zeta}\cdot\mathbf{k})(k + p\cos\vartheta)\right]\right\}. \quad (3)$$

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