$$R_{min} = \frac{(B_2 - B_1)^2}{4} \int_{-\ell}^{\ell} dz \left[\rho_o^2 \left(\frac{d\rho_o}{dz}\right)^2 \ln \frac{\ell}{\rho_o(0)\sqrt{u}} + \gamma\rho_o(\rho_m - \rho_o)\right] =$$

$$= \frac{\pi(B_2 - B_1)^2}{16\sqrt{2}} \Delta_o^3 \frac{1}{\gamma^{5/2}} \left(\ln \frac{1}{\gamma\mu}\right)^{1/2}, \quad (8)$$

$$\frac{z}{\rho_m} = \frac{\pi}{2}\left(\frac{1}{2\gamma} \ln \frac{1}{\gamma\mu}\right)^{1/2} \left[\arcsin\left(1 - \frac{\rho_o}{\rho_m}\right) + \frac{1}{\rho_m}\sqrt{\rho_o(\rho_m - \rho_o)}\right]. \quad (9)$$

The energy barrier R_{min} can change in a very wide range. It is easy to visualize the situation when at T = 1°K the barrier $R_{min} \ll T$. Apparently the thermal activation of the nuclei is possible under the conditions of the experiments of Condon and Walstedt [4]. We note that in this experiment the supercooling was observed only at sufficiently low temperatures.

Similar results for ferromagnets were obtained in a paper by the author [6].

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"TRANSITION ACCELERATION" OF A CHARGED PARTICLE PASSING THROUGH A BOUNDARY OF AN INVERTED DIELECTRIC

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In connection with progress in quantum radiophysics, the question arises of the possibility of transferring energy from inverted media directly to charged particles moving in them. The acceleration of the particle in such media as a result of Cerenkov radiation was considered in [1]. In the present paper we wish to call attention to the possible inversion of the so-called transition radiation [2], which arises when a particle passes through the boundary between vacuum and a dielectric. As will be shown below, on crossing the boundary between vacuum and an inverted dielectric, the ordinary radiation losses can give way to a new effect, wherein energy is transferred to the particle; this effect can be called "transition acceleration."

The interaction between a charged particle and a dielectric medium is described by a system of equations consisting of Maxwell's equations and the equation of motion of the medium. In the linear approximation ($\vec{E} \sim \vec{p}$) for a two-level system, the equation of motion of the medium determines the dielectric constant $\varepsilon(\omega)$, which enters in Maxwell's equations. We shall use for $\varepsilon(\omega)$ the expression

$$\epsilon(\omega) = 1 \pm \frac{\omega_p^2}{\Omega^2 - \omega^2}, \quad \omega_p^2 = \frac{8\pi d^2 N\Omega}{\hbar}, \tag{1}$$

where Ω is the resonant frequency of the medium, N is the number of active centers, and d is the electric dipole moment of one center. The upper and lower signs in (1) correspond to the normal and inverted states of the medium.

Let us consider the case of a thick plate, when the fields that appear when its boundaries are crossed do not interfere. This case is simple because, by virtue of the symmetry (we have the same medium (vacuum) on the right and on the left of the plate) we can disregard the macroscopic renormalization of the particle mass, as in the case of one boundary [3, 4]. Let a particle with charge e move normally to the plate with a velocity $v = \beta c$. Let us find the work W performed by the field on the particle, using, for example, a method analogous to [5]. Discarding terms proportional to the path length, on which the work of the transition-radiation field should not depend, we obtain the expression

$$W = 2\frac{ie^2}{\pi v^2}\int_{-\infty}^{\infty}\omega\, d\omega \int_0^{\kappa_0} \frac{(\epsilon-1)^2\left\{\left[\kappa^2 + \frac{\omega^2}{v^2}(1-\beta^2-\beta^2\epsilon)\right]^2 - \beta^2\frac{\omega^2}{c^2}\epsilon\beta_1\beta_2\right\}\kappa^3 d\kappa}{\epsilon(\epsilon\beta_1+\beta_2)\left[\kappa^2+\frac{\omega^2}{v^2}(1-\beta^2)\right]^2\left[\kappa^2+\frac{\omega^2}{v^2}(1-\beta^2\epsilon)\right]^2}, \tag{2}$$

$$\beta_1 = \sqrt{\kappa^2 - \frac{\omega^2}{c^2}}, \quad \beta_2 = \sqrt{\kappa^2 - \epsilon\frac{\omega^2}{c^2}}. \tag{3}$$

The integration limit κ_0 is chosen, as usual, from the conditions for the applicability of the macroscopic approach (see, e.g., [6]). Two poles contribute to the integral (2): the first-order pole $\varepsilon = 0$, and the second-order pole $\kappa^2 + (\omega^2/v^2)(1 - \beta^2\varepsilon) = 0$. In the frequency region over which the integration is carried out, the value of ε depends strongly on the frequency, increasing rapidly for frequencies close to Ω:

$$\epsilon = 1 \pm \frac{\omega_p^2}{\Omega^2-\omega^2} \approx 1 \pm \frac{\omega_p^2}{2\Omega}\frac{1}{(\Omega-\omega)} \approx \pm\frac{\omega_p^2}{2\Omega}\frac{1}{(\Omega-\omega)}. \tag{4}$$

Taking these remarks into account and carrying out the integration in (2), we obtain

$$W = \mp\frac{e^2}{c}\frac{\omega_p^2}{\Omega}\left[\frac{\pi}{2\beta}\frac{1}{\sqrt{1 \pm \frac{\omega_p^2}{\Omega^2}}} + \frac{1}{5}(2-\beta^2)\beta^3\right], \tag{5}$$

where the upper and lower signs correspond to expressions (1). Thus, in the case of a dielectric with normal level population, the particle loses energy on passing through the plate (upper sign), and in the case of inverted population it acquires energy (lower sign). Analogous phenomena occur when the particle crosses a boundary with a paramagnet in a state with negative spin temperature.

We note that during the time of flight of the particle through the plate (t), the particle should cover a path longer than the radiation-formation zone z_f, and at the same time t should be much smaller than the lifetime of the levels τ. Thus, the thickness of the plate a should satisfy the inequality

$$\tau\beta c >> a \geqslant z_f = \frac{\Delta\beta}{1 - \epsilon\beta\cos\theta}. \quad (6)$$

The energy stored in the active medium can be drawn more effectively by passing the particle through several plates (a stack): if the distance between neighboring plates exceeds the radiation-formation zone, then the particle energy will be increased by each plate by the same amount. Another possibility is based on the coherence that occurs when a sufficiently small bunch of particles is passed through.

For a more exact analysis of the problem, it is necessary to use nonlinear equations that take into account the change of the population of the two-level system interacting with the charged particle passing through the boundary of such a system (in the linear approximation employed by us, the level population is assumed constant). This nonlinear analysis can be carried out by using, for example, the procedure described in [7].

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