PRODUCTION OF POLARIZED BREMSSTRAHLUNG

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As is well known, the bremsstrahlung of a relativistic electron is polarized perpendicular to the plane containing the momenta of the incident electron and γ quantum [1]. The polarization reaches a maximum at angles $\alpha \approx mc^2/E$ to the direction of electron motion (m - rest mass of the electron and E its energy). Therefore, to obtain beams of polarized bremsstrahlung one can use targets in which the electron multiple scattering angle does not exceed α. In the opposite case, multiple scattering scrambles the directions and the polarization vanishes. This imposes stringent limitations on the thickness of the targets in which the radiation is generated. In particular, for electron accelerators rated 0.5 - 1 GeV the target thickness must not exceed about 10^{-3} radiation units. Yet in most electron synchrotrons the targets used are thick, of the order of 0.1 radiation units, in order to ensure optimal bremsstrahlung intensity. Since polarized radiation can be obtained only by separating the peripheral part of the bremsstrahlung flux, such a method leads to inevitable loss of intensity, by at least a factor 10^3 [2].

In cyclic accelerators it is possible to realize multiple passages through the target [3]. In the ideal case, the number of such passages is limited by the lifetime of the electrons due to the bremsstrahlung on the target. However, successive passages through the target excite betatron oscillations of the beam particles, i.e., they increase the angular spread of the particles. This spread exceeds ultimately the maximum polarization angle, and by the same token causes the polarization to vanish. Thus, multiple passages by themselves do not ensure the production of polarized radiation of optimal intensity.

The key to the solution of the problem may be the use of the properties of radiation friction, which greatly influences the dynamics of the beam in electron synchrotrons at energies on the order of several hundred MeV. The friction causes damping of the oscillations and by the same token counteracts the increase of the angular spread of the electrons. If the target thickness or the number of passages through the target are chosen such that the multiple-scattering angle accumulated in a time τ does not exceed α, this ensures by the same token conditions for the conservation of the polarization. The electron spreading angle inherent in such a setup should be sufficiently small (see, e.g., [4]). The total target thickness traversed during the time τ will not exceed $\sim 10^{-3}$ radiation units. Therefore, to obtain optimal intensity, the multiple passage should continue for a time $\sim 100\tau$, in order that the total target thickness reach several tenths of a radiation unit.

We note in conclusion that since τ can reach several milliseconds [5], the discussed method of obtaining the polarized bremsstrahlung can be realized in practice in installations in which the operating cycle is sufficiently long, such as the FIAN 680-MeV pulsed synchrotron, or storage rings.

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INTERACTION OF VORTEX FILAMENTS IN SUPERCONDUCTORS OF THE SECOND KIND WITH THE ELASTIC DEFORMATION FIELD

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The large critical currents (10^5 - 10^6 A/cm^2) attained presently in superconductors of the second kind with large κ [1] are attributed [2] to the presence of various crystal-lattice defects or other inhomogeneities in such superconductors. These hinder the viscous motion of the vortex filaments in the mixed state [3] under the action of the Lorentz force produced by the transport current. Such "blocks" to the vortex filaments may be, in particular, dislocations (see [4] and the bibliography in the review [5]) and other elastic inhomogeneities.

The interaction of vortices with the elastic field is determined by two principal factors. In the mixed state of a deformed superconductor, owing to the difference between the elastic moduli of the superconducting and normal states, an additional elastic energy [4] (quadratic in the deformations) is produced as a result of the alternation of the normal regions in the vortex lattice. At the same time, owing to the contribution of the magnetic and kinetic energies of the superconducting condensate to the pressure, there is also a magnetoelastic interaction which is linear in the deformations. At atomic distances near the dislocation line, both contributions to the energy are in general comparable in magnitude. Actually, however, owing to the macroscopic coherence of the electronic states, which is characteristic of superconductors, the elastic dislocation field is effectively smoothed out over distances on the order of the electron correlation radius, which greatly exceeds the atomic radius of the dislocation core. The main role should therefore be played by the magnetoelastic interaction that is linear in the deformation, whereas the quadratic terms should be negligibly small.*

To calculate this interaction it is sufficient to determine the change in the energy of the vortex lattice under the influence of the elastic field. It is known [3] that at large κ and not too strong magnetic fields, $H \ll H_{c2}$, the vortices can be described (see [3,6]) by the London local equations [7]:

$$\mathrm{curl}\,\mathbf{H} = 4\pi N_s e \mathbf{v}_s\,;\; \mathrm{curl}\,\mathbf{v}_s = -(e/m)\,\mathbf{H}, \tag{1}$$

where $\vec{v}_s = (\nabla\chi - 2\vec{e}\cdot\vec{A})rm$ is the velocity of the superconducting condensate ($\hbar = c = 1$), χ is the phase of the ordering parameter, $\vec{H} = \mathrm{curl}\,\vec{A}$, and N_s is the density of the superconducting electrons. In the same approximation, the energy is equal to