POLARIZATION OF INCOHERENT RADIATION OF RELATIVISTIC ELECTRONS UNDER PLANE CHANNELING IN A CRYSTAL

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The cross section of radiation by relativistic electrons in an oriented crystal can be written as the sum of the cross sections for coherent and incoherent emission [1]. The attention was mainly paid earlier to the coherent effects in radiation, because the coherent spectrum contains sharp maxima with high intencity and polarization of radiation in them. The cross section of incoherent radiation does not strongly differ from the Bethe - Heitler's (BH) cross section for the electron radiation in an amorphous medium.

Let us consider the linear polarization of incoherent radiation of a particle moving under small angle θ to the densily packed with atoms crystallographic plane (the (y, z) plane, see Fig. I). This polarization is given by

$$P = \frac{d\sigma_1 + d\sigma_2}{d\sigma_1 + d\sigma_2},$$

(1)

where $d\sigma_1$ and $d\sigma_2$ are the cross sections for the emission of photons polarized in (y, z) and (x, z) planes, respectively.

In the paper [2] it is demonstrated that in the case $\theta \gg \theta_c$, where θ_c is the crytical angle of the plane channeling, the polarisation of incoherent radiation can be estimated as

$$P \approx \frac{1}{30}\frac{\theta_c^2}{\theta^2}, \qquad (2)$$

and the radiation of electrons is polarized in the (x, z) plane, while for positrons it is polarised perpendicularily to this plane.

The most interesting is the case of plane channeling of electrons, because the particles in this case spend a large part of time in the region of high gradient of potential. In paper [3] it was considered the case when we approximate the uniform potential of the crystallographic plane by a rectangular potential pit (see Fig. 2). The polarization for electrons with the energy $\varepsilon \leq 1GeV$ was estimated by a value $\sim 5\%$, and the radiation is polarized in the plane (y, z).

In a more realistic case, when the uniform plane potential is obtained by averaging of the atomic potentials taken in a form of screened Coulomb potential:

$$U(x) = -\frac{2\pi Z e^2 R}{a_y a_z} e - |x|/R, \qquad (3)$$

(see Fig. 3), where for Si crystal with (110) plane as (y, z) plane Z = 14, the lattice constants $a_x = a_y = 1{,}9 \times 10^{-8}$ cm, $a_z = 5{,}\ 43 \times 10^{-8}$ cm, the screening radius $R = 2 \times 10^{-9}$ cm, numeric calculations for channeling electrons with $\varepsilon = 1$ GeV yield the estimation:

$$P = \alpha A(x_0), \qquad (4)$$

where the value $A(x_0)$ for the points of electron's enter into channel $x_0 = 0$ and $x_0 = a_x/200$ is plotted on Fig. 4 as a function of θ / θ_c, and the value

$$\alpha = \frac{d\sigma_{BH}}{d\sigma_1 + d\sigma_2} \qquad (5)$$

is the coefficient of redistribution of the flux density of incident particles in a crystal (in thin crystals $\alpha \sim 0{,}5$ [4]). We can see that on the most part of the interval $0 < \theta < \theta_c$ the radiation is polarized in (y, z) plane and reaches the value of 5 - 7 %. The polarization of collimated radiation can be about two times larger than in noncollimated case.

This effect can be observable in that parts of radiation spectrum, where incoherent part of radiation makes the main contribution; it demonstrates new ability to obtain polarized photon beams on the electron accelerators on the energy of order of some hundred MeV.

These results qualitatively coinside with the results of experiment [5], but in the experiment the coherence length of radiation l_{coh} [1] was of order of the mean free path between collisions of an electron with lattice atoms l_c, while in our theory $l_{coh} \gg l_c$.

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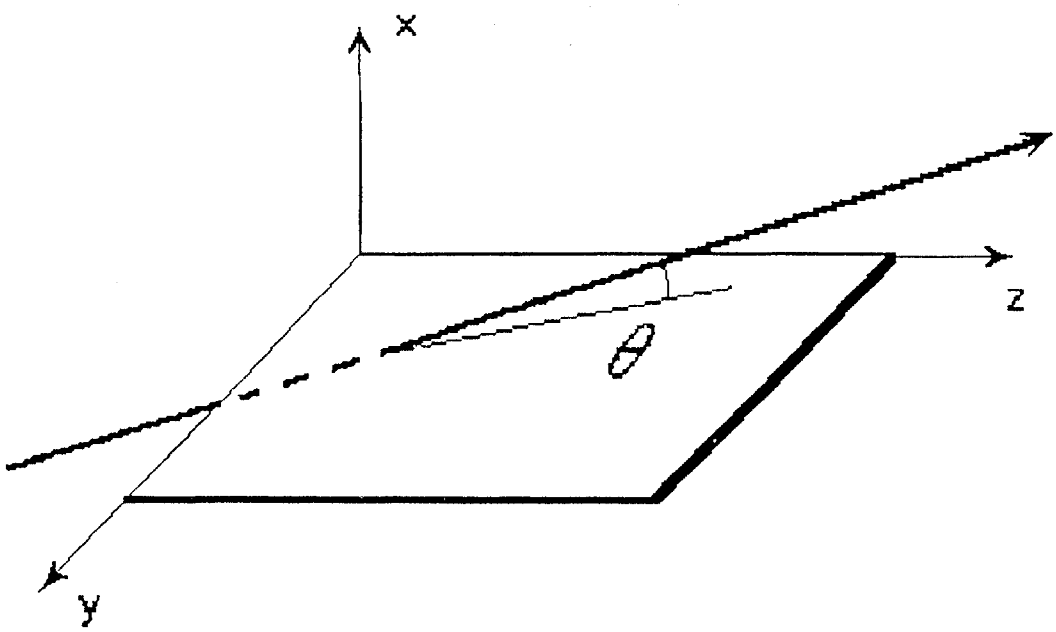

Fig. 1.

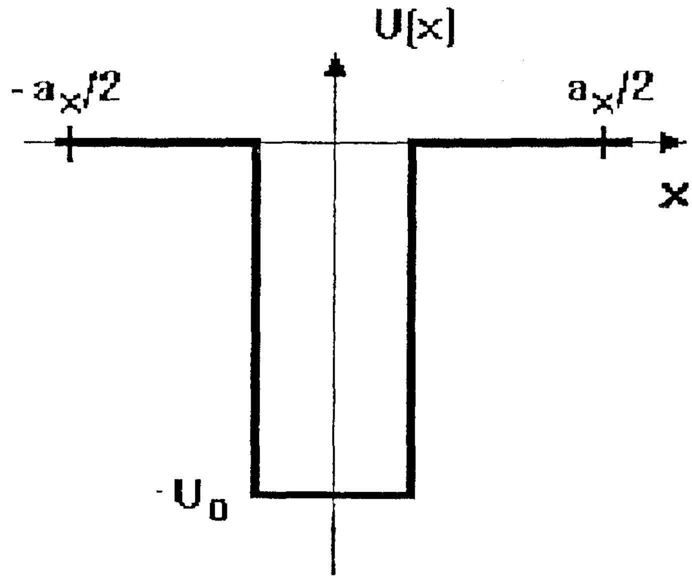

Fig. 2.

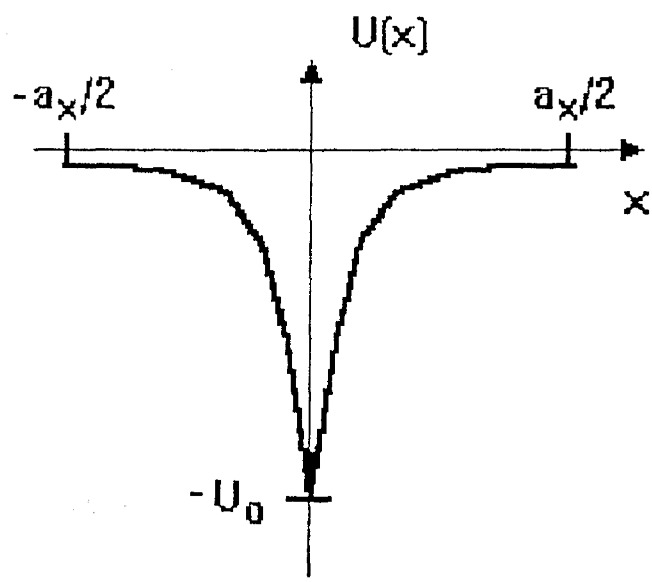

Fig. 3.

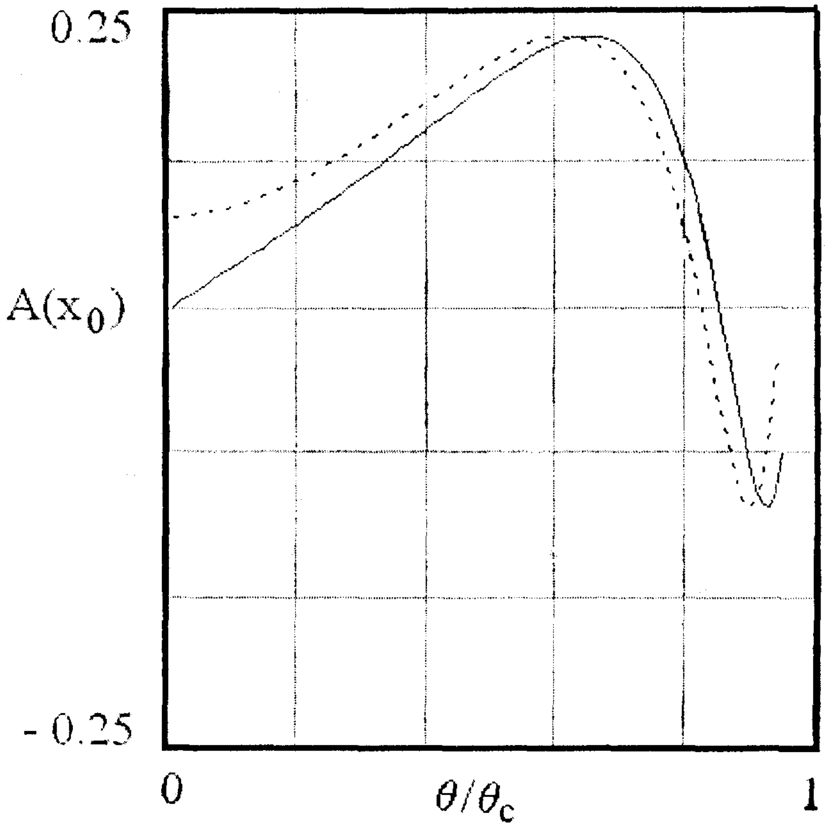

Fig. 4.

x = 0 - solid line; x = a /200 - dashed line