differs somewhat for different samples, and this may be due, in particular, to differences in n_0 (see Formula (1)).

Measurements of luminescence polarization in a transverse magnetic field gave the following lifetimes of the oriented spin [2 - 4]: $\approx 5 \times 10^{-10}$ sec for the exciton (band A), and 1.2×10^{-9} sec for the donor (band B). Obviously, this time is determined in either case mainly by the spin-relaxation time. One can thus conclude that the spin relaxation differs for an electron bound at a donor or in an exciton.

The maximum degree of polarization of band B was ≈ 0.03. This corresponds to an orientation of $\approx 6\%$ of all electrons at the donors. From Formula (1) we can estimate the penetration depth L_s of the orientation. In our case $L_s \approx 1.0$ μ, making the estimated electron mobility at 4.2°K of the order of (or lower than) 10^3 V-cm^2/sec.

The experiments have shown that in n-type semiconductors it is possible to obtain a noticeable orientation of the electrons at the donor levels even at excitation intensities such that the density of the non-equilibrium carriers is smaller than the density of the equilibrium electrons.

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COHERENT RADIATION OF CHARGED PARTICLES CHANNELLED IN A CRYSTAL

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It is known that coherent photon radiation is produced when a charged particle moves on a straight line in a medium having a dielectric constant that varies periodically in space. This radiation is similar to Cerenkov radiation [1] and its frequencies constitute a set of approximately integer harmonics. We consider in this paper this radiation, which is sometimes called resonant, in the case of charged particles moving in single crystals. We show that, unlike Cerenkov radiation and resonant radiation in media with a macroscopic variation of ε, the intensity of resonant radiation in single crystals has a strong temperature dependence and decreases with increasing crystal temperature, while the intensities of the higher harmonics are strongly suppressed compared with the intensity of the first harmonic.

The most favorable conditions for resonant radiation occur when a charged particle is channelled (self-trapped) in a crystal [2]. We shall consider

therefore the radiation of a charged particle trapped in a crystal channel. The energy loss of the particle is minimal in this case and the motion of the particle in the crystal, can be regarded as linear and uniform over sufficiently great lengths in first approximation. An elementary kinematic analysis, with account taken of the coherence of the photons emitted from the lattice sites, leads to the following well-known relation for resonant radiation

$$\frac{d}{c_{ph}}\omega\left(\cos\theta - \frac{c_{ph}}{v}\right) = 2\pi s, \qquad (1)$$

where $c_{ph} = c/\sqrt{\varepsilon}$ is the phase velocity of the radiated photon of frequency ω in the crystal, v the particle velocity, θ the angle between the particle velocity and the photon propagation direction, d the period of the structure in the particle-motion direction, and s an integer. Let $f(\vec{v}\vec{\rho}\omega\vec{k})$ be the amplitude of coherent emission of a photon with frequency ω and wave vector $\vec{k}$ by an atom having an impact parameter $\vec{\rho}$ relative to the particle trajectory. Then the total cross section for the emission of a photon by a particle moving along the axis of the crystal channel can be represented in the form

$$\frac{d\sigma}{d\Omega_k} = \left|\sum_{r_{\vec{\rho}}} f(v\,\vec{\rho}\,\omega\,k)\exp[i(k_p - k)r_{\vec{\rho}}]\right|^2$$

$$= \left|\sum_{\rho} f(v\,\vec{\rho}\,\omega\,k)\exp[i(k_p - k)R_{\vec{\rho}}]\right|^2 \left|\sum_{\ell}\exp[i(k_p - k)r_{\ell}]\right|^2 e^{-2W}, \qquad (2)$$

where $\vec{k}_p = (\vec{v}/v^2)\omega$, and the vectors $\vec{r}_{\vec{\rho}}$ and $\vec{R}_{\vec{\rho}}$ determine respectively the instantaneous and the equilibrium positions of the atom with impact parameter $\vec{\rho}$ in the elementary layer (see below), r_{ℓ} determines the position of the elementary layer, ℓ numbers the elementary layers, and exp(-2W) is the Debye-Waller factor. The second part of (2) shows in explicit form the dependence of the cross section on the crystal structure and on the thermal lattice vibrations. The first structure factor in this part shows separately the sum over the crystal layer perpendicular to the trajectory, containing all the impact parameters $\vec{\rho}$ encountered for the given structure and having the smallest thickness; this layer will be called elementary. The structure factor causes the intensity of radiation at a fixed angle θ and at wavelengths $\lambda \lesssim a$, (a is the interatomic distance) to depend on the orientation $\vec{k}$ relative to the crystallographic directions. The second factor in (2) contains a sum over the elementary layers. It is precisely this factor that leads to the condition (1) that limits the possible frequencies and direction of radiation. The thickness of the elementary layer gives the value of the parameter d in (1). The third factor, taking relation (1) into account and assuming isotropy of the thermal vibrations of the atoms, can be represented in the form

$$e^{-2W} = \exp\left(-\frac{1}{3}|k_p - k|^2 \langle r^2\rangle\right) = \exp\left\{-\frac{1}{3}\langle r^2\rangle\left[\left(\frac{2\pi s}{d}\right)^2 + k^2\sin^2\theta\right]\right\}, \qquad (3)$$

where $\langle r^2\rangle$ is the mean square of the thermal lattice vibrations of the atoms.

When s = 0, Formulas (1) - (3) describe Cerenkov radiation. When $s \neq 0$ the radiation frequency given by (1), depending on the particle velocity and on s, may turn out to be either in the optical or in the higher-frequency region of the spectrum, and the condition $v > c_{ph}$ need not be satisfied in order for

radiation to exist. Unlike Cerenkov radiation, for which the Debye-Waller factor (3) reduces to the expression $\exp[-(\langle r^2\rangle/3)k^2\sin^2\theta] \approx 1$, and the intensity of the resonant radiation turns out to depend strongly on the temperature regardless of the wavelength. In this case the argument of the exponential in (3) contains a term $(\langle r^2\rangle/3)(2\pi s/d)^2$ which in general is not small compared with unity and depends on the temperature. The same term in the argument of the exponential leads to a strong suppression of the intensity of the higher harmonics, since it is proportional to s^2. Another cause of suppression of the higher harmonics is that the characteristic polarization frequencies excited by the particle at the atoms closest to the trajectory are equal to $(v/a) \times (1-\varepsilon v^2/c^2)^{1/2}$. Therefore any harmonic with a higher frequency is suppressed because the corresponding frequency is missing from the polarization of the crystal atoms.

Since the frequencies of the resonant radiation are of the order of sv/a, contributions to radiation of particles that are not too fast are made, for the same reason, only by the atoms closest to the particle trajectory. In the case of sufficiently high frequencies, we obtain from (2) the following expression for the intensity of the resonant radiation per unit trajectory length

$$\frac{d\sigma}{d\Omega_k} = \sum_s \left| \int f_e(v\vec{\beta}\omega k)\, e^{-ik_t\vec{\rho}}\, n_s\vec{\tau}(\vec{\rho})\, d\vec{\rho} \right|^2 \delta\left(\frac{\omega}{v} - k\cos\theta - s\tau\right), \qquad (4)$$

where k_{tr} is the wave vector component perpendicular to the trajectory, $n_{\vec{\tau}}(\vec{\rho}) = (1/d)\int n(x, y, z)\exp(-i\tilde{\tau}z)dz$ is the component of the Fourier expansion of the electron density in the crystal with respect to the direction z specified by the particle velocity, $\vec{\tau} = (\vec{v}/v)(2\pi/d)$ is the reciprocal-lattice vector, and $f_e(\vec{v}\vec{\rho}\omega\vec{k})$ is the amplitude of photon emission per electron, which can be related, say by the pseudophoton method, to the cross section for Compton scattering by the electron. In the case of resonant radiation at an optical frequency, by connecting the photon-emission amplitude with the dielectric constant and using (2), it is possible to obtain the following estimate for the ratio of the intensity of the resonant radiation to the intensity of the Cerenkov radiation at the same frequency:

$$\frac{I_P}{I_B} = \left(\frac{a}{\lambda}\right)^2\left(\frac{v_B}{v_P}\right)^2\left(\frac{\epsilon_\tau}{\epsilon-1}\right)^2 \exp\left(-\frac{4\pi^2}{3}\frac{\langle r^2\rangle}{d^2}\right) \approx \left(\frac{\epsilon_\tau}{\epsilon-1}\right)^2 \exp\left(-\frac{4\pi^2}{3}\frac{\langle r^2\rangle}{d^2}\right), \qquad (5)$$

where ε_τ is the Fourier component of the expansion of the dielectric constant, and is analogous to the quantity n_τ used above.

We note in conclusion that a recent paper [3] reports observation of coherent γ-quantum emission via positron channelling. The frequencies and the angular distribution of the γ quanta agree with the radiation mechanism discussed here (see formulas (1) and (3)). To establish unequivocally the nature of this radiation, however, it is necessary to have more information concerning the energy and angular distributions of the radiation, and also to know the temperature dependence of the radiation intensity.

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POSSIBILITY OF OBTAINING A POWERFUL NEUTRON SOURCE BY ACTION OF A LASER PULSE ON A COMPOUND TARGET

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1. When a laser pulse acts on a condensed target containing D and DT atoms, a temperature $T \simeq 10$ keV and accordingly a large neutron yield $N_n \simeq 10^{16} - 10^{17}$ can be obtained if the total pulse energy is $W \simeq 10^5$ J [1]. The influence of light-element impurities was investigated in [2]. In the present paper we point out the possibility of obtaining a large neutron yield $N_n \simeq 10^{15}$ by applying a short laser pulse of duration $\tau \simeq 10^{-10}$ sec and energy $W \lesssim 10^4$ J on a condensed target consisting of a DT mixture with admixture ($\sim$10%) of a heavy element with atomic number $A \sim 250$.

Let us consider qualitatively the process of heating a compound target by electronic thermal conductivity. The time of inertial containment of a plasma with ionization multiplicity z, temperature T^z, and heavy-ion and DT-ion concentrations N^z and N^{DT}, respectively, is

$$\tau_u^z \simeq \frac{A^*}{z^3}\tau_u^{DT}(T^{DT})\frac{N^{DT}}{N^z}\left(\frac{T^z}{T^{DT}}\right)^{3/2}, \tag{1}$$

where $\tau_u^{DT}(T^{DT})$ is the analogous time in a pure DT plasma with temperature T^{DT}, and $A^* = A/2.5$. Assuming the radiation pulse duration to be $\tau \simeq \tau_u^z$, let us find an expression for the depth of penetration of the thermal wave into the target

$$x_{fr}^z \simeq x_{fr}^{DT}\frac{N^{DT}}{N^z}\left(\frac{T^z}{T^{DT}}\right)^2\frac{A^{*1/2}}{z^2}, \tag{2}$$

where x_{fr}^{DT} is the depth of heating in a pure DT plasma under the condition $\tau \simeq \tau_u^{DT}(T^{DT})$. Further, we have for the ratio of the energies E^z and E^{DT} per unit target surface area in both cases

$$\frac{E^z}{E^{DT}} = \frac{N^z z x_{fr}^z T^z}{N^{DT} x_{fr}^{DT} T^{DT}} = \left(\frac{T^z}{T^{DT}}\right)^3\frac{A^{*1/2}}{z}. \tag{3}$$

Assuming the diameter of the focusing spot to be $d \simeq 2x_{fr}$, we obtain the ratio of the total energies

$$\frac{W^z}{W^{DT}} = \frac{E^z}{E^{DT}}\left(\frac{x_{fr}^z}{x_{fr}^{DT}}\right) = \frac{A^{*3/2}}{z^5}\left(\frac{T^z}{T^{DT}}\right)^7\left(\frac{N^{DT}}{N^z}\right)^2. \tag{4}$$

The ratio of the neutron yields is then