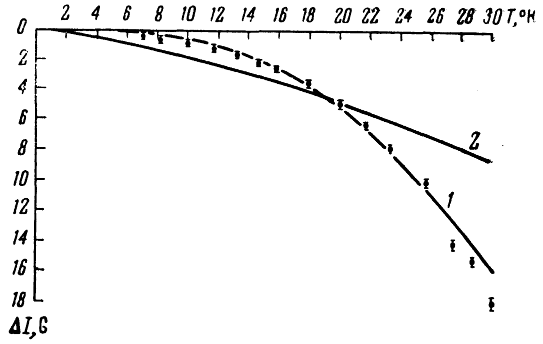

FIG. 2

tempt to interpret our results according to Niira[3], who showed that, in the case of a ferromagnet with the hexagonal close-packed structure, the following temperature dependence of the magnetization obtains:

$$I = I_0 - AT^{3/2}\exp(-\Delta/T). \qquad (1)$$

Figure 2 shows that the experimental points fit well the theoretical curve of type 1 with the parameters A = 0.25 G/deg$^{3/2}$, Δ = 30 deg K, selected to obtain the best fit with the experimental data.

For comparison, Fig. 2 includes curve 2, which is described by Bloch's law.

The results obtained indicate, according to Niira[3], the presence of a gap Δ = 30 deg K in the energy spectrum of spin waves in Gd.

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OPTICAL EXCITATION OF SEMICONDUCTORS

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At present semiconductor lasers are excited either by injection of current carriers across a p-n junction[1] or by a beam of fast electrons[2]. The optical method of excitation for producing population inversion in semiconductors has been considered in a number of papers[3-5]. An experimental investigation of the recombination radiation excited by a powerful ruby laser has been carried out previously[6].

We consider here the excitation of semiconductors by monochromatic radiation at a frequency which slightly exceeds the frequency of the intrinsic-absorption band edge. At high radiation intensities the sum of the quasi-Fermi levels of the electrons and holes $\mu_e + \mu_p$ is approximately equal to the energy of the incident quanta $\hbar\omega_1$ (the so-called saturation effect, cf. [7]). In this situation there will be a certain band of frequencies $\Delta\omega$, satisfying the relation $\hbar\omega < \mu_e + \mu_p$, for which there will be population inversion and at which laser action is possible. Since semiconductors have broad, continuous absorption bands the frequency of the exciting light may be made close to the lasing frequency $\hbar\omega_0$, resulting in high efficiency laser action.

A large number of independent and hence incoherent semiconductor p-n junction lasers can be used as the source of monochromatic excitation. In this case the whole system may be treated as a converter of incoherent monochromatic radiation into coherent radiation, with high transformation efficiency.

In the case of direct transitions the gain coefficient can be written in the form[1]

$$k(\omega) = B(\omega)(\hbar\omega - \Delta)^{1/2}[f_e(\varepsilon_e) + f_p(\varepsilon_p) - 1], \qquad (1)$$

where f_e and f_p are the distribution functions for electrons and holes whose energies ϵ_e and ϵ_p are determined by the laws of conservation of energy and quasi-momentum, and where Δ is the width of the forbidden band. If the dimensions of the system are considerably larger than the wavelength of the radiation, the condition for self-excitation of the laser has the form

$$k(\omega_0) = L^{-1}\ln R^{-1} + \varkappa, \qquad (2)$$

where L is the separation between the mirrors of the cavity, R is the reflectivity, κ is the absorption coefficient due to free carriers, impurities, etc, and ω_0 is the frequency at which $k(\omega)$ is a maximum. Equation (2) and the condition $\partial k/\partial\omega = 0$ for $\omega = \omega_0$ determine the value of the sum of the electron and hole quasi-Fermi levels which corresponds to the oscillation threshold.

It has been shown[7] that when semiconductors are excited by intense monochromatic light the sum of the quasi-Fermi levels is given by the expression

$$\mu_e + \mu_p = \hbar\omega_1 - R_0/[A - B(\hbar\omega_1 - \Delta)^{1/2} J\partial f_e/\partial \varepsilon_e], \quad (3)$$

where J is the flux of quanta at frequency ω_1, and R_0 is the recombination rate. Then

$$\mu_e + \mu_p = \hbar\omega_1, \quad A = \left(\frac{\partial R_0}{\partial n} + \frac{\partial R_0}{\partial p}\right)\left[\left(\frac{\partial n}{\partial \mu_e}\right)^{-1} + \left(\frac{\partial p}{\partial \mu_p}\right)^{-1}\right]^{-1}.$$

From (3) we can determine the minimum intensity which will give rise to the threshold value of $\mu_e + \mu_p$;

$$J_{min} = R_0/k(\omega_1) \approx R_0/B(\hbar\omega_1 - \Delta)^{1/2} \times (\hbar\omega_1 - \mu_e - \mu_p)(\partial f_e/\partial \varepsilon_e), \quad (4)$$

where $k(\omega_1)$ is the absorption coefficient.

If the intensity of the external radiation J exceeds the threshold intensity given by (4) laser action will occur in the semiconductor, so that, independent of the excitation, (2) is always satisfied. This has the result that the quantity $\mu_e + \mu_p$ remains constant and equal to its value at threshold even up to extremely large intensities, at which point significant heating of the electron-hole gas begins. In this case the thickness of the active region is given by

$$l = [k(\omega_1) + \varkappa]^{-1} \ln (J/J_{min}) \quad (5)$$

and the efficiency η is given by

$$\eta = \{J - J_{min}(J/J_{min})\varkappa/(k + \varkappa) - R_0 \ln (J/J_{min})/(k + \varkappa)\}/(J\omega_1/\omega_0).$$

If the conditions $J \gg J_{min}$ and $k \gg \kappa$ are satisfied, the value of η will be approximately unity, indicating the possibility of efficient transformation of incoherent monochromatic radiation into coherent radiation.

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SUPERFLUIDITY OF He^3

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THE question of whether He^3 can be superfluid was raised immediately after studies of its properties were started. However, no superfluidity could be observed down to the lowest attainable temperatures. After the formulation of the theory of superconductivity, it appeared quite probable[1-3] that He^3 would become superfluid at sufficiently low temperatures, since its atoms, in analogy with the electrons in superconductors, have a tendency towards noticeable pair interaction, owing to the presence of nuclear spins. These considerations have served as an impetus for complicated experimental investigations, brief results of which are presented here.

To attain the very lowest temperatures in He^3, an instrument was developed with three-stage demagnetization of paramagnetic salts. The first stage constituted iron-ammonium alum, the second consisted of large crystals of cerium-magnesium nitrate (CMN), while the third is shown in Fig. 1. The bath with He^3 was connected by means of a superconducting tin heat switch to a pellet of iron-ammonium alum, while the third was connected by the tin switch to the second stage, the method of connecting the second stage to the first being shown in Fig. 1. For more rapid cooling, 640 copper wires 2 cm long and 50 microns in diameter, silver-soldered to a copper frame, were placed in the third capsule. The capsule was pressed in the form of a sphere made of CMN powder with average grain dimension $\sim 10\,\mu$ in such a way that the total volume of the pores was ~ 1 cm^3, with a sphere volume 8 cm^3. The sphere was coated with epoxy resin mixed with crushed quartz (the composition was prepared at the Institute of Physics