correction, which decreases the energy by virtue of the variational principle (for both bosons and fermions). The coefficients A, B, and C are ~1 and > 0.

For n of the order of n_0 and more, perturbation theory is not valid, but there is no doubt that the energy per photon ϵ/n cannot have a smaller order of magnitude than the energy of the gravitational interaction of two "neighboring" photons with energy ϵ/n

$$(\epsilon/n) \gtrsim G(\epsilon/n)^2 n^{1/3},$$

i.e.,

$$\epsilon \lesssim n^{2/3} n_0^{2/3}. \qquad (2)$$

Thus, at high photon-gas densities the increase of ϵ like $n^{4/3}$ gives way to a slower growth, like $n^{2/3}$, and the derivative $d\epsilon/dn$ reaches a maximum at a certain point $n \sim n_0$, after which it decreases (the inequality (2) does not exclude likewise a decrease of the quantity ϵ itself; this question, which is of importance in cosmology, is more complicated than the question of the derivative $d\epsilon/dn$).

Neglecting photon interaction we get $n = 0.244T^3$ and the entropy density is $S = 0.874T^3$ (the temperature T is in cm^{-1}), i.e., $S = 3.58n$. This proportionality of S to n remains in force also in the presence of photon interaction, since the total number of photons is an adiabatic invariant of the compression and consequently the density of the photons and the entropy density are inversely proportional to the volume during adiabatic contraction.

According to thermodynamics, $T = \frac{\partial \epsilon}{\partial S}\Big|_V$, i.e., (for thermal radiation) $T = (d\epsilon/dn)/3.58$ and reaches a maximum T_{max} of the order of the gravitational unit T_0 when n is of the order of n_0

$$T_0 = k^{-1} c^{5/2} \hbar^{1/2} G^{-1/2} = 1.42 \times 10^{32} \text{ degrees}.$$

T_{max} of the order of T_0 must be regarded as the absolute maximum of the temperature of any substance in equilibrium with radiation.

The foregoing reasoning may, of course, turn out to be inconsistent if it becomes necessary to review the fundamental principles or the fundamental premises of physics at $n \sim n_0$.

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GALLIUM ARSENIDE LASER OPERATING AT ROOM TEMPERATURE

N. G. Basov, Yu. P. Zakharov, T. F. Nikitina, Yu. M. Popov, G. M. Strakhovskii, V. M. Tatarenkov, and A. N. Khvoshchev
P. N. Lebedev Physics Institute, USSR Academy of Sciences
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Investigations have been made of semiconductor lasers based on diffusion p-n junctions [1] operating at 300°K. The diodes were excited either with a pulse generator with strip line and controlled gas discharge (current up to 4000 A, pulse duration 20 nsec) or with a genera-

tor with discharge capacitor and mechanical discharge with current up to 1500 A and pulse duration 30 - 60 nsec. The diode emission spectrum was analyzed with a DFS-12 spectrograph.

The diode emission had at low currents a broad spectrum that narrowed down gradually from 300 to 110 Å with increasing current. At a threshold current density that varied from diode to diode between 1 x 10^5 and 5 x 10^5 A/cm^2, a single generation line is produced at a wavelength ~9000 Å, which is of longer wavelength than the maximum of the spontaneous-emission spectrum.

With subsequent increase of current, several lines appear in the emission spectrum and correspond to different oscillation modes in the resonator, concentrated in a relatively narrow region $\Delta\epsilon \approx h\Delta\nu$, with a dependence on the current I in the form [2]

$$\Delta\epsilon = A[(I - I_{thr})/I_{thr}]^{1/3},$$

(I_{thr} is the threshold current and A is a constant that depends on the properties of the diode). From the values of $\Delta\epsilon$ for different currents we calculated the coefficient A to be 1.3 x 10^{-2} eV at room temperature.

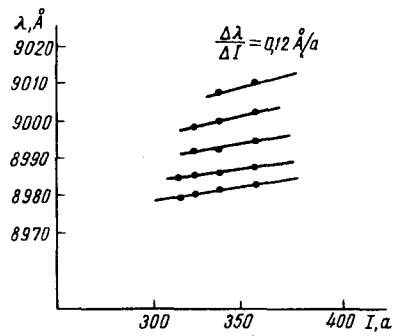

Fig. 1. Shift of the generation-line wavelength vs. current through diode. The straight lines join the generation lines that repeat in the spectrum as the current is decreased. The diagram does not show generation lines that do not repeat in the spectrum.

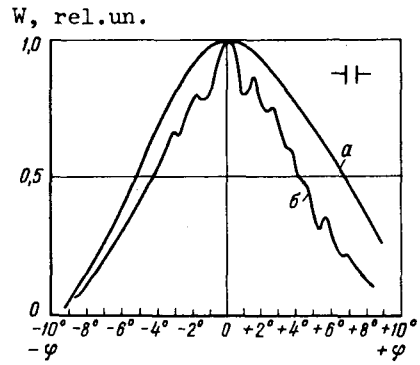

Fig. 2. Directivity patterns of diode emission.

With increasing current, the generation wavelengths become longer, with $\Delta\lambda/\Delta I = 0.1$ Å/A (Fig. 1). This shift can be attributed to the heating of the diode during the pulse [3].

The abruptness of the p-n junction, determined with the aid of a microscope (MIK-1) is $\gamma = (1/N)(dN/dx) \approx 10^{-4}$ cm^{-1}. Using an expression relating the width L_a of the active region with the abruptness of the p-n junction [4], we found that $L_a \sim 4$ μ.

We measured the width a_o of the luminescent region by determining the directivity pattern of the diode emission in a plane perpendicular to the p-n junction (Fig. 2, curve a). If we assume that the divergence is due to diffraction, we obtain $a_o = 4$ μ. The directivity pattern in a plane parallel to the p-n junction (Fig. 2, curve b) shows a clearly pronounced multilobe interference character. The half-width of the diagram, averaged over the lobes, is 8°.

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MINIMUM ELECTRIC RESISTIVITY OF AN ANTIFERROMAGNETIC METAL (Cr)

E. E. Semenenko
Physico-technical Institute, Ukrainian Academy of Sciences
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It is known that the resistivity of many impurity-containing metals has at low temperatures an anomalous behavior which is manifest in the presence of a minimum on the R(T) curve. This was observed experimentally in such weakly-magnetic metals as Ag, Au, Cu, Mg, Zn, Mo, and Al [1-6] with small amounts of definite metallic impurities added. Many authors connect this minimum with the presence of a local magnetic moment.

The resistivity minimum has recently been given a theoretical explanation from which it follows that the minimum arises in negative exchange interaction between the conduction electrons and the impurity atoms as a result of the addition of the ordinary electric resistivity, which decreases with temperature [7,8], as well as in positive exchange interaction [9].

We report here observation of a minimum in the resistivity of a metal with magnetic ordering, such as chromium, in its antiferromagnetic state.

The phenomenon was discovered and investigated in chromium samples of varying purity. A measure of the latter was the residual resistivity $R_{1.5°K}/R_{300°K}$, equal to 7.6×10^{-2}, 6.8×10^{-3}, and 8×10^{-3} respectively ($R_{1.5°K}$ - resistivity of samples at 1.5°K, $R_{300°K}$ - at 300°K).

All investigated chromium samples had minima of resistivity below 15°K.

Figure 1 shows the measurement data for three samples of differing purity. For the most contaminated sample (curve 1 - ordinate scale on right) the resistivity minimum occurs at the highest temperature (~10°K), and its depth is only ~0.07%. A minimum of like depth is observed also for the purest chromium (curve 3 - ordinate scale on left), although the temperature of the minimum is lower (~5°K).

Neither the depth of the minimum nor its temperature changed after the samples were annealed in vacuum better than 10^{-7} mm Hg at ~1300°C.

Preliminary measurements of the minimum electric resistivity of chromium with residual resistivity $\sim 8 \times 10^{-3}$ in a longitudinal magnetic field of ~30 kOe have shown that the minimum does not disappear in this field. This is unusual, for it is known, for example, that in other metals the minimum of resistivity vanishes in fields 10 - 20 kOe [4,5].

Unfortunately there are still no quantitative data on the impurity composition of the samples, but it can be noted that even the purest one contained 0.01% iron, 6×10^{-3}% nickel,