If the field gradients ahead and behind the moving body are large (if the field does not have time to penetrate into the closed circuit through the body), the body is acted upon by a pressure $p_H \sim H^2/8\pi$. This pressure may be comparable with the gasdynamic pressure $p \simeq \rho_0 v^2$ at fields $H \gtrsim \sqrt{8\pi\rho_0}v \simeq 10^5$ Oe at $v \simeq 5$ km/sec. If the dimensions l of the region where the field is localized are commensurate with the range covered before the gas loses appreciable energy, then the pulse power $W_e \simeq \mathcal{E}_0^2 v/l \simeq mv^3/l$ may reach in the case of bullets [3] several dozen megawatts at $v \sim 3$ km/sec and $l \simeq 30$ cm.

If the body does not crowd out the magnetic field completely, the deceleration force is $F \sim jHV/c \simeq \sigma v H^2 V/c^2$, where $j = \sigma E_{ind} \simeq \sigma v H/c$ is the current density in the bullet, σ the conductivity of the moving section of the circuit, and V is its volume.

The described method can be used to construct compact pump systems for laboratory lasers without resorting to capacitor banks.

[1] Av. Week 82, No. 26, 85 (1965).

[2] Appl. Opt. 2, 1339, and Suppl. "Chem. Lasers" (1965).

[3] Ya. B. Zel'dovich and O. I. Leipunskii, JETP 13, 181 (1943).

[4] L. D. Landau and E. M. Lifshitz, Mekhanika sploshnykh sred (Mechanics of Continuous Media), GITTL, 1954.

TRANSVERSE HEAT TRANSFER IN A MOLECULAR-THERMAL STREAM PRODUCED IN A GAS OF NONSPHERICAL MOLECULES IN THE PRESENCE OF A MAGNETIC FIELD

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As is well known, the transport coefficients of gases are altered by a magnetic field (see [1-7]). This effect does not reverse sign when the direction of the magnetic field is reversed ("even" effect). Knaap and Beenakker, developing the theoretical method of Kagan and Maksimov [7] for the investigation of transport phenomena in a magnetic field, reached the conclusion that if a temperature gradient grad T is produced in a direction perpendicular to the magnetic field H, then heat flow will be produced in a direction perpendicular to $\vec{H}$ and to grad T [8]. The effect results from the tensor character of the heat conduction coefficient (λ) of the gas in a magnetic field. The resultant temperature difference reverses sign when the magnetic field direction is reversed ("odd" effect). A similar effect was predicted by Korving et al. in O_2, N_2, and HD [9] [1)]. Theoretical predictions of the odd effect were made also in a published paper by Kagan and Maksimov [10]. In accord with [8,10], the following formula holds:

$$\epsilon_{odd} = (\Delta\lambda_{odd}/\lambda) = -a\{[\xi/(1+\xi^2)] + 2[2\xi/(1+4\xi^2)]\}, \qquad (1)$$

where $\Delta\lambda_{odd}$ is the change of the heat capacity in the odd effect, $\xi = k\mu_{odd}H/p$, μ_{odd} is the

effective magnetic moment of the molecule, responsible for the odd effect, p is the gas pressure, and a and k are coefficients that depend on the molecular-kinetic properties of the gas and the nature of the magnetic moment. According to [10], formula (1) is valid only approximately for paramagnetic gases. We present below the results of experiments made to observe the aforementioned odd effect for thermal conduction.

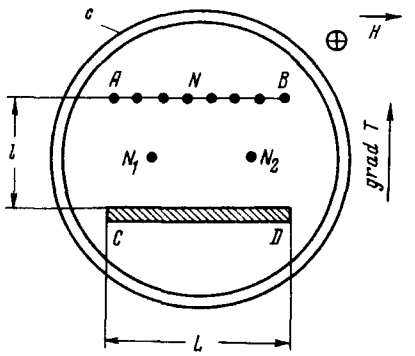

Fig. 1

The cross section of the measuring chamber is shown schematically in Fig. 1. It comprises a cylindrical brass cup (c) placed in a solenoid and containing electrically heated (to 180 - 200°C) wires N that produce the temperature gradient ("gradient" wires), a brass plate CD for heat removal (it is in thermal contact with the cup), and two platinum wires N_1 and N_2 of 50 μ diameter, heated with current to 90 - 100°C and used to record the transverse heat transport ("measuring" wires). The gradient wires are stretched along the cylinder in section AB; they are made of platinum wire of 50 μ diameter. The measuring wires are located at a distance $l/2$ from AB and $L/4$ from the cup axis. (In our equipment $L = l = 20$ mm.) They serve as two arms of a Wheatstone bridge fed with 1000 cps current, and have a common contact. A selective amplifier is connected in the diagonal of the bridge. If heat flow is produced in the direction N_1N_2, the temperature difference between wires N_1 and N_2 unbalances the bridge. The value of ϵ_{odd} is best deduced from the change in the bridge unbalance when the field direction is reversed. The pickup was placed in a magnetic screen. The experiments were made at room temperature, 1 - 15 mm Hg pressure, and fields up to 650 Oe. To prevent an extraneous effect due to bending of the gradient wires, the latter were stretched with the aid of springs and fed with 3 kcs current. The absence of the extraneous effect was confirmed, in particular, by the fact that in Ar the effect turned out to be practically equal to zero. In order to eliminate completely the aforementioned extraneous effect, a new pickup was recently constructed, in which the gradient wires are made of bifilarly wound enamelled copper wires of 50 μ diameter.

The preliminary experiments, made at different oxygen pressures (1 - 15 mm Hg), have shown that ϵ_{odd}, in accord with the theoretical data, is a function of H/p. Figure 2 shows the relative variation of ϵ_{odd} with H/p for oxygen, starting with 5 mm Hg. At large values of H/p we have $\epsilon_{odd} \to 0$, in agreement with formula (1). The $\epsilon_{odd}(H/p)$ curve has two maxima, at $H/p \sim 3$ and 50 Oe/mm Hg. The presence of the first maximum agrees with the odd effect theoretically predicted in [10], brought about by the inelastic oxygen-molecule collisions accompanied by a change in the projection σ of the electron spin on the angular momentum (i.e., transitions from $\sigma = \pm 1$ to $\sigma = 0$ and vice versa). The second maximum agrees with the odd effect predicted in [8] and brought about by the elastic collisions of the oxygen molecules with electron spin component $\sigma = 0$. The agreement between the theoretical results and the experimental data is evidenced, in particular, by the fact that the ratio of the values

of H/p for the second and first maxima (~15) is approximately equal to the ratio of the effective magnetic moment of the oxygen molecule in states $\sigma = \pm 1$ and $\sigma = 0$ [8]. According to preliminary estimates, the maximum value of ϵ_{odd} is of the order of 10^{-4}.

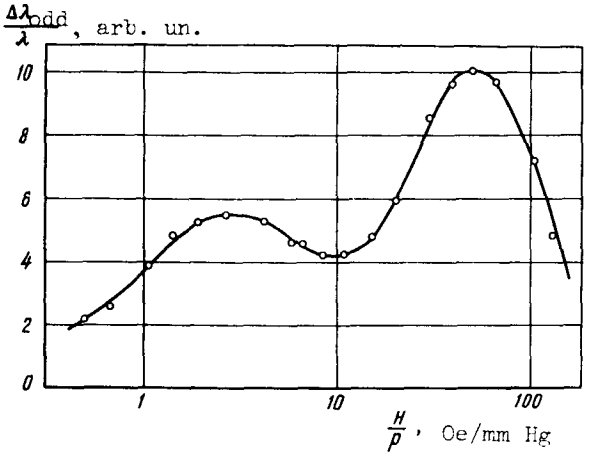

Fig. 2

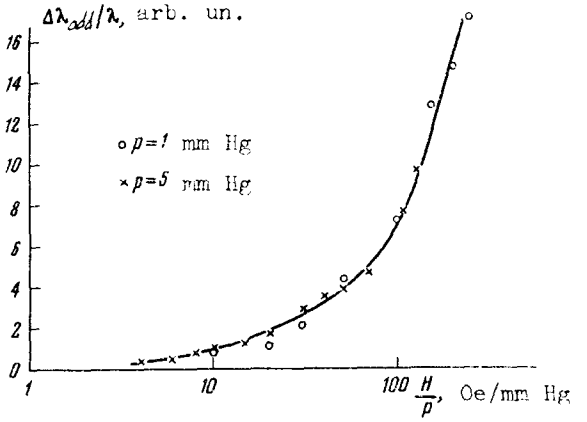

Fig. 3

The odd effect was observed also in nitrogen. Figure 3 shows a plot of $\epsilon_{odd}(H/p)$ obtained in N_2 at pressures 1 and 5 mm Hg and in fields up to 650 Oe. Relative estimates show that at $H/p \sim 130$ Oe/mm Hg ϵ_{odd} for N_2 is approximately equal to the maximum value of ϵ_{odd} for O_2. The sign of the effect turned out to be the same for these gases. We are planning more thorough investigations in O_2, N_2, and other gases.

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[1] H. Senftleben and J. Pietzner, Ann. Physik 16, 907 (1933); 27, 108 and 117 (1936); 30, 541 (1937).

[2] H. Senftleben and H. Gladisch, ibid. 30, 713 (1937); 33, 471 (1938).

[3] J. J. Beenakker, G. Scoles, H. F. P. Knaap, and R. M. Jonkman, Phys. Lett. 2, 5 (1962).

[4] L. L. Gorelik and V. V. Sinitsyn, JETP 46, 401 (1964), Soviet Phys. JETP 19, 272 (1964).

[5] L. L. Gorelik, Yu. N. Kredkoborodyi, and V. V. Sinitsyn, JETP 48, 761 (1965), Soviet Phys. JETP 21, 503 (1965).

[6] J. J. M. Beenakker, H. Hulsman, H. F. P. Knaap, J. Korving, and G. Scoles, Advances in Thermophysical Properties of Extreme Temperatures, ASME, N.Y. 1965, p. 261.

[7] Yu. M. Kagan and L. A. Maksimov, JETP 41, 842 (1961), Soviet Phys. JETP 14, 604 (1962).

[8] H. F. P. Knaap and J. J. M. Beenakker, Heat Conductivity and Viscosity of a Gas of Nonspherical Molecules in a Magnetic Field, Suppl. No. 124 to the Communications Kamerlingh Onnes Laboratorium, Leiden, Netherlands.

[9] J. J. Korving, H. Hulsman, H. F. P. Knaap, and J. J. M. Beenakker, Phys. Lett. 21, 5

(1966).

[10] Yu. M. Kagan and L. A. Maksimov, JETP 51, No. 12 (1966), in press.

[1)] It is indicated in [9] that preliminary measurements of the odd effect for the thermal conduction were also made, and their results will be published.

PHASE BOUNDARY IN FERROELECTRIC SbSI AS THE ANALOG OF AN ELECTRIC DOMAIN IN A SEMICONDUCTOR

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In an earlier paper [1] we reported a new optical method of observing the phase transition of single-crystal SbSI. This method is based on the fact that an anomalous shift of the intrinsic absorption edge of SbSI toward longer wavelengths occurs in the region of the first-order phase transition near 20°C [2].

The crystal was placed in a glass vacuum cryostat and observed and photographed with the aid of a microscope in transmitted monochromatic light of wavelength corresponding to the intrinsic absorption edge near the phase transition. Owing to the difference in the absorption, the paraelectric phase regions should appear to be dark and the ferroelectric regions light. Both phases coexist in a first-order phase transition within a finite temperature interval. Accordingly, we observed in [1] a structure of alternating strips, similar to that shown in the figure. Analogous results were obtained independently by Japanese workers [3,4]. The phase boundaries correspond to the (101) planes. The results described below were obtained by the optical method of [1] for SbSI crystals grown from the gas phase in the form of needles and with dimensions on the order of 1 x 0.1 x 7 mm. The axis of the needle (c axis of the crystal) coincides with the direction of the spontaneous polarization. The observation of the crystal in transmitted light was carried out through parallel pinacoid (100) faces in a direction perpendicular to the c axis of the crystal.

Motion of the boundary between phases in SbSI under the influence of a constant electric field (cathode on top, anode on bottom). a - With field, b - without field. Distance between electrodes 2.5 mm, applied voltage 75 V. The boundary moved 180 μ toward the cathode in 15 seconds.

1. A constant electric field applied to the crystal causes the interphase boundary to move toward the cathode. In sufficiently weak fields this motion is not accompanied by, and cannot be connected with, a shift of the Curie temperature, since the ratio of the areas corresponding to the two phases remains constant. This is also evidenced by the fact that the shift of the Curie temperature does not depend on the field direction. The rate of boundary displace-