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INFLUENCE OF MAGNETIC FIELD GRADIENT ON THE THERMAL CONDUCTIVITY OF OXYGEN

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It is known that the gas transport coefficients depend on the magnitude and direction of the magnetic field (see [1-7]). Until recently, however, there were no data of any kind pointing to a dependence of these coefficients on the magnetic-field gradient. We have recently observed that it is possible to obtain in a magnetic field a large odd effect of variation of the thermal conductivity of oxygen by producing a definite gradient of this field. The existence of an odd effect for the thermal conductivity in a homogeneous field was previously demonstrated theoretically in [6,7] and experimentally in [5]. The gist of the effect is that if we produce in the gas a gradient of the temperature (T) in a direction perpendicular to the magnetic field (H), then a heat flux is produced in a direction perpendicular to $\vec{H}$ and to grad T. The effect is the result of the tensor character of the thermal conductivity of the gas (λ) in the magnetic field. The resultant transverse temperature difference reverses sign when the direction of the magnetic field is reversed ("odd" effect). The relative change of the thermal conductivity in the odd effect will henceforth be denoted $\epsilon_{odd} = \Delta\lambda_{odd}/\lambda$. We present below brief information on the experiments we performed to observe in oxygen the odd effect due to the presence of a magnetic field gradient.

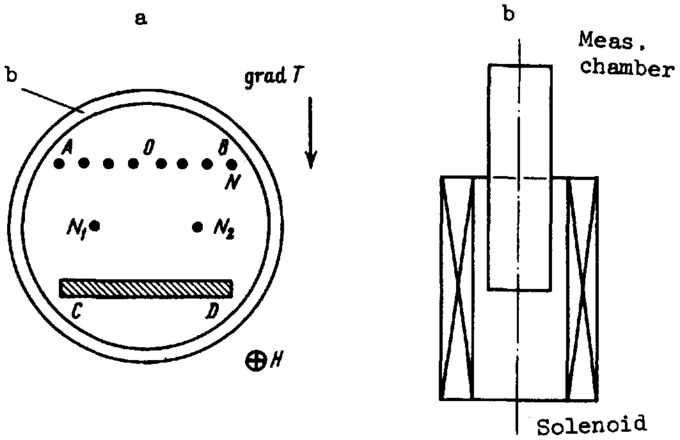

Fig. 1

The measuring chamber used for the investigation was similar to that described in [3]. Figure 1a shows its cross section. The shell of the chamber is a brass beaker (b) placed in a solenoid. When the chamber is outside the solenoid, the field in it is practically uniform. To obtain a relatively large field inhomogeneity in the region of the chamber, its central part is placed on the edge of the solenoid (Fig. 1b). Wires N are stretched along the beaker, in section AB, platinum wires N_1 and N_2 are stretched along the diametral section, and a brass plate to carry the heat away is mounted in section CD. The wires N are heated electrically to produce a temperature gradient ("gradient" wires). The direction of the temperature gradient producing the odd effect in region AB is determined by the closeness of the gradient wires to the surface of the beaker (Fig. 1a shows the direction of the effective temperature gradient). The gradient wires are connected in a Wheatstone bridge in such a way that two equal halves of the total number of the wires, AO and OB, constitute two arms of the bridge and have a common terminal. If heat flow is produced in the AB direction, then the resultant temperature difference between the wire groups AO and OB causes the bridge to become unbalanced. The value of ϵ_{odd} is easiest to assess from the unbalance produced in the bridge when the field direction is reversed.

When the chamber was placed coaxial with the solenoid, we sometimes used a different measurement procedure. Inasmuch as in this case there was no component of grad H in the direction of grad T in the plane formed by the filaments N_1 and N_2, the presence of grad H, as will be made clear in what follows, produces practically no odd effect in the N_1N_2 direction. It is then possible to detect the relative change in the temperature difference between the wire groups AO and OB indirectly, from the change in the temperature difference between wires N_1 and N_2 ("auxiliary" wires). To this end, the latter are connected in the Wheatstone bridge as individual arms having a common terminal. Such a procedure allows us to increase the measurement accuracy, since the auxiliary wires, unlike the gradient wires, have relatively good thermal symmetry. We note here that the plate CD contributes to the creation of an acceptable temperature regime for the auxiliary wires.

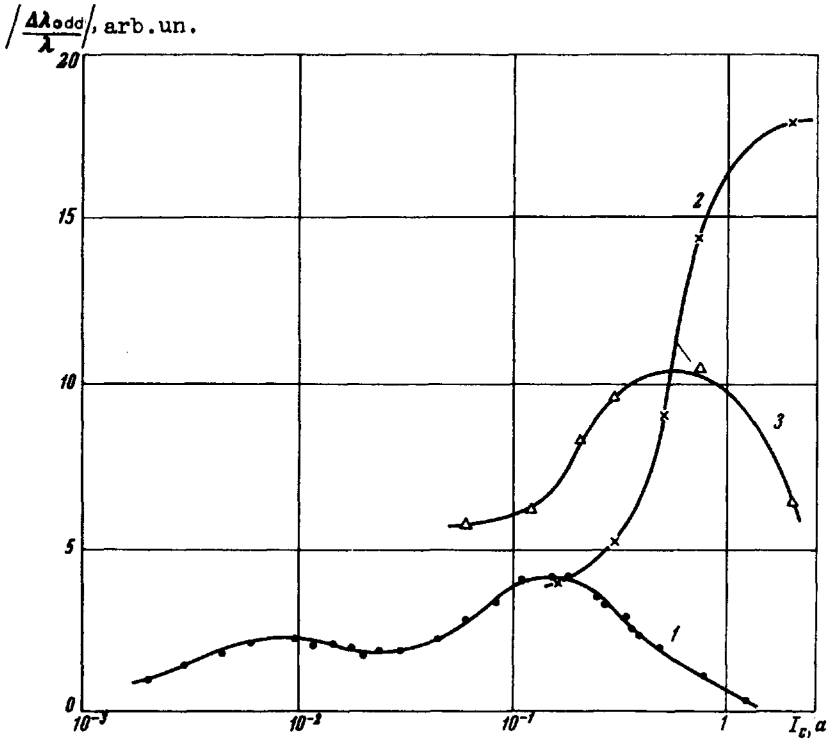

Fig. 2. At I_s = 1 A, H_{max} = 300 Oe, $(\text{grad } H)_{max}$ = 50 Oe/cm.

The investigations described below were made at room temperature, at an oxygen pressure ~1 mm Hg, and in magnetic fields up to 650 Oe. Qualitative experiments made at different distances from the chamber axis to the solenoid axis, and also experiments with the aid of an electromagnet with special pole pieces, have shown that an appreciable dependence of ϵ_{odd} on grad H takes place only when $\vec{H}$ is perpendicular to grad T and grad H is in the plane containing the vectors $\vec{H}$ and grad T, making an angle markedly different from zero with the vector $\vec{H}$. Figure 2 shows the dependence of ϵ_{odd} on the current through the solenoid (I_s) in homogeneous and inhomogeneous fields (plots 1, 2, and 3, respectively), obtained with the measuring chamber and the solenoid coaxial. The $\epsilon_{\mathrm{odd}}(I_s)$ curves are drawn to the same scale, with allowance for the temperature jump between the heated elements and the gas in the chamber. Comparison of curves 1 and 2, obtained at a pressure 1 mm Hg, shows that the maximum value of ϵ_{odd} attainable in an inhomogeneous field (at grad H $\approx$ 100 Oe/cm) is approximately five times larger than the maximum value of ϵ_{odd} attainable in a homogeneous field. We see also that the maximum value of the effect in an inhomogeneous field is attained at a value of H_{max}(600 Oe) when the effect in the homogeneous field approaches zero. Comparison of curve 1 with curve 3, obtained at a pressure 0.4 mm Hg, also leads to the conclusion that ϵ_{odd} depends strongly on grad H. The presence of a maximum on curve 3 points to the existence of a certain analogy in the curves describing the behavior of ϵ_{odd} in homogeneous and inhomogeneous fields.

In addition to the foregoing experiments, we performed also qualitative experiments which revealed a dependence of ϵ_{odd} on H at a given value of grad H. Thus, for example, for $p \approx 1$ mm Hg and $(\text{grad } H)_{\mathrm{max}} = 100$ Oe/cm, variation of H_{max} from 900 to 300 Oe leads to an increase of ϵ_{odd} by a factor of five, with ϵ_{odd} turning out to be 3 - 4 times larger than the maximum value indicated in Fig. 2.

It is interesting to note that a considerable dependence of ϵ_{odd} on grad H is attained at values of grad H such that the change of the frequency of the molecule precession, even at a distance equal to the mean free path, is of the same order as the precession frequency in the case when a noticeable odd effect appears in a homogeneous field. This circumstance makes it apparently possible to relate the observed phenomenon with the fact that the given gradient complicates the character of the motion of molecules possessing a magnetic moment over distances on the order of the mean free path. Preliminary theoretical calculations, performed by L. A. Maksimov and Yu. V. Mikhailova in connection with the obtained experimental results, confirm these conclusions qualitatively. We are planning more thorough investigations of the observed phenomenon in different gases.

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SEPARATION OF ONE MODE IN A LASER

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Much attention is being paid nowadays to modifications of optical resonators and laser operating conditions which would make it possible to generate at one mode in resonators of large length, when only several modes of high Q fit the active-medium gain line width. Whereas the selection of transverse modes is a relatively simple matter, say by using a diaphragm or choosing the mirror curvature radii, the elimination of undesirable fundamental TEM_{00q} modes entails great difficulties. We describe in this note a method of separating one TEM_{00q} mode with the aid of a thin absorbing film.

The proposed configuration is shown in Fig. 1, and is extremely simple. Here 1 and 2 are the mirrors making up the optical standing-wave resonator, 3 the active medium, and 4 is a plate of transparent material. One face (A) of this material is left clear, and the other (B) is covered with a thin absorbing layer of optical thickness much smaller (say by a factor of several times 10) than the wavelength. The surface of the film should coincide with the equal-phase surface for the mode that is to be separated. The plate can be displaced slightly along the axis. When the film is located in a node of the standing wave, where the electric field is zero, the loss introduced by the film is very small. At that instant, the film produces a large attenuation of other modes (longitudinal and transverse) whose node surfaces do not coincide with the surface of the absorbing film. If the absorption is sufficiently large, then the laser generates only the mode in whose node the film is located.

A successful application of this method depends on the possibility of producing very thin films with appreciable attenuation, and its experimental verification is therefore of interest. In the experiment we used a helium-neon laser operating at 6328 Å, and the experimental setup was as in Fig. 1. A discharge tube 3 with a discharge length 55 mm and an inside diameter 2.3 mm was filled with a mixture of neon and He^3. The tube was sealed with Brewster windows, and a dc discharge was excited in it. Mirrors 1 and 2 were located 101.6 cm apart and had curvature radii 106 and 136 cm.

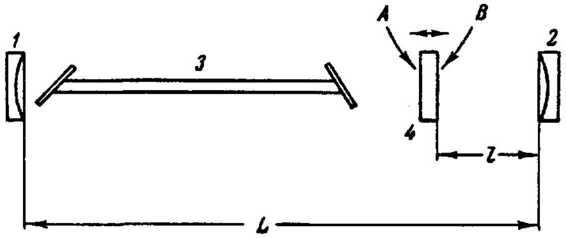

Fig. 1