current-carrying hollow cylindrical sample. Similar conditions can be produced also in other configuration, for example on the outer surface of the same cylinder if a coaxial conductor with current -I is placed in its cavity, etc.

It can be assumed that regularly disposed inhomogeneities with dimensions on the order of the layer thickness exist in the layer. These, like the structures of intermediate state in indium [6], should move with the same velocity as the electron drift in the layer (on the order of 10^2 cm/sec).

For a further study of the properties of the mixed-state layer, we are planning to measure its surface impedance and to search for electromagnetic radiation which may be emitted by this layer.

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TURNING OF THE SUBLATTICES OF A FERRIMAGNET IN A MAGNETIC FIELD

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In ferrimagnets with two sublattices, the relative orientation of the sublattices changes from antiparallel to parallel in a certain magnetic field interval ($H_1 < H < H_2$) [1 - 3]. In rare-earth iron garnets (RIG), owing to the strong paraprocess, the turning of the sublattices has a number of peculiarities. In these garnets, a strong exchange interaction takes place inside the resultant iron sublattices, a relatively weak interaction between the iron and rare-earth sublattices, and a very weak interaction between the rare-earth ions. At sufficiently high temperatures ($T \gtrsim 10°K$) the latter interaction has no influence on the magnetic properties of the RIG, and consequently the rare-earth ions behave then like a "gas" of paramagnetic ions under the influence of the effective magnetic field produced by the resultant iron sublattice. The magnetization of the rare-earth sublattice and the critical fields H_1 and H_2 between which the turning of the sublattices takes place are therefore strongly dependent on the temperature. Thus, according to [1 - 3], $H_1 \sim 5 \times 10^5$ Oe in RIG at low temperatures, but decreases to zero in the region of the compensation temperature T_c, where the magnetizations M_1 and M_2 of the rare-earth and iron sublattices become comparable. The temperature region near T_c is of greatest experimental interest, but the results of [1 - 3] do not hold for them, since no account is taken there of the magnetic anisotropy, which plays the

principal role in this case.

In this paper we investigate the influence of magnetic anisotropy on the H-T phase diagram of RIG. We also show that the turning of the sublattices can be interpreted as a second-order phase transition. This leads to the possibility of measuring the critical fields by determining the changes of the thermodynamic quantities following the turning of the sublattices (say the specific heat, Young's modulus, magnetostriction, etc).

The free energy of an RIG can be written in the molecular-field approximation in the form

$$F = -\int M_1 dH_{eff} - M_2 H \cos\theta_2 - M_2 H_a^{(2)} \cos^2\theta_2 \tag{1}$$

$$M_1 = M_{10} B_s(\mu H_{eff}/kT), \quad H_{eff} = H\cos\theta_1 - \lambda M_2 \cos(\theta_1 - \theta_2) + H_a, \tag{2}$$

where H_a is the projection of the anisotropy field of the rare-earth sublattice on the rare-earth sublattice on the M_1 direction (it is determined in terms of the anisotropy energy by the expression $-\int M_1 dH_a = -M_1 H_a^{(1)} \cos^2\theta_1$); H_{eff} is the effective field acting on the rare-earth ions; θ_1 and θ_2 are the angles determining the orientation of the magnetizations M_1 and M_2 relative to the external field H; M_{10} is the magnetization of the rare-earth sublattice at $T = 0°K$; μ is the magnetic moment of the rare-earth ion; $H_a^{(1)}$ and $H_a^{(2)}$ are the anisotropy fields of the rare-earth and iron sublattices. For simplicity, we consider here uniaxial anisotropy. The case $H_a^{(1)} > 0$ and $H_a^{(2)} > 0$ corresponds to magnetization along the easy axis of the crystal, while the case $H_a^{(1)} < 0$ and $H_a^{(2)} < 0$ corresponds to the difficult axis. The results of minimization of the free energy are shown in Figs. 1 and 2. We can separate on the (H, T) plane four phases: three collinear phases [1) $\theta_1 = 0$, $\theta_2 = \pi$; 2) $\theta_1 = \pi$, $\theta_2 = 0$; 3) $\theta_1 = \theta_2 = 0$)], and an angular phase, where the angles θ_1 and θ_2 are given by

$$\begin{aligned} &H^2 + [2(H_a^{(1)}\cos\theta_1 + H_a^{(2)}\cos\theta_2) - \lambda(M_1\cos\theta_1 + M_2\cos\theta_2)]H + \\ &+ 4H_a^{(1)}H_a^{(2)}\cos\theta_1\cos\theta_2 - 2\lambda(M_1 H_a^{(1)}\cos^2\theta_1 + M_2 H_a^{(2)}\cos^2\theta_2) = 0, \\ &M_1\sin\theta_1(H + 2H_a^{(1)}\cos\theta_1) = -M_2\sin\theta_2(H + 2H_a^{(2)}\cos\theta_2). \end{aligned} \tag{3}$$

The limits of the collinear and angular phases are determined by the equations

$$\begin{aligned} &H^2 - [\lambda(M_2 - M_1) + 2(H_a^{(1)} - H_a^{(2)})]H - 2\lambda(M_1 H_a^{(1)} + M_2 H_a^{(2)} - 4H_a^{(1)}H_a^{(2)} = 0, \\ &H^2 - [\lambda(M_1 - M_2) - 2(H_a^{(1)} - H_a^{(2)})]H - 2\lambda(M_1 H_a^{(1)} + M_2 H_a^{(2)}) - 4H_a^{(1)}H_a^{(2)} = 0, \\ &H^2 - [\lambda(M_1 + M_2) - 2(H_a^{(1)} + H_a^{(2)})]H - 2\lambda(M_1 H_a^{(1)} + M_2 M_a^{(2)}) + 4H_a^{(1)}H_a^{(2)} = 0. \end{aligned} \tag{4}$$

We note the following characteristic features of the phase diagram: When $H > 0$ and $H > 0$ (Fig. 1), the turning of the sublattices starts with the minimum field corresponding to the compensation temperature. Its order of magnitude is $H_{cr} \geq (2K\lambda)^{1/2}$, where K is the anisotropy constant. When $T > T_*$, the transition from the antiparallel to the parallel orientation of the sublattice magnetizations occurs without turning. Figure 1 shows also the regions of existance of metastable phases. The limits of these regions yield in essence the plot of the

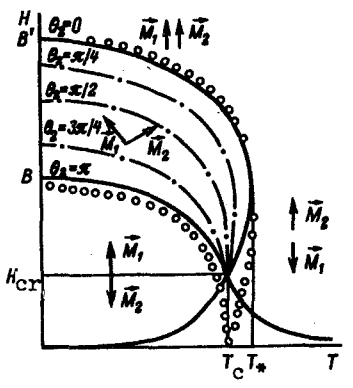

Fig.1

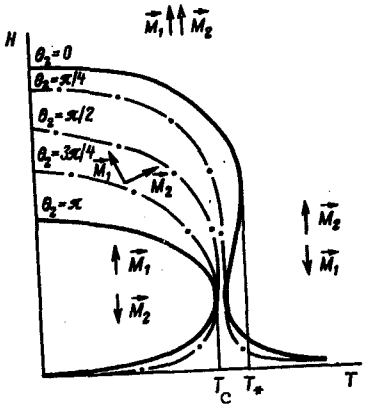

Fig. 2

Fig. 1. (H,T) phase diagram of ferrimagnet with H parallel to the easy axis of the crystal. ——, oooo - boundary of angular and collinear phases with and without allowance for the anisotropy energy, respectively; ——— boundary of region of existence of metastable states (phases 1 and 2 coexist); dashed lines - curves of equal angles $\theta_2(H, T)$

Fig. 2. Phase diagram of ferrimagnet with H parallel to the difficult axis.

temperature dependence of the coercive force $H_c^{(2)}$ for the magnetization of the iron sublattice M_2. This coercive force appears, for example, in experiments on the Faraday effect, in the visible region, where the rotation of the plane of polarization of the light is determined by the iron sublattice. The point A, where the curves of equal angles θ_2 converge, is of interest. On passing through this point, the angles θ_1 and θ_2 can change jumpwise. When $H_a^{(1)} < 0$ and $H_a^{(2)} < 0$ (Fig. 2), the turning of the sublattices begins with zero field. The latter is connected with the "nonsynchronous" rotation of the magnetic moments of the sublattices from the easy axis to the magnetic field.

Let us examine the behavior of the free energy in the transition between the collinear and angular phases. Expanding the free energy near the transition point in powers of the parameter $\eta = \pi - \theta_2$ or $\eta = \theta_2$ (for transitions through curves AB and AB' of Fig. 1, respectively), we obtain

$$F = a(T, H)\eta^2 + b(T, H)\eta^4 + \cdots\cdots, \qquad (5)$$

where the function a(T, H) vanishes on the boundary between the phases, and b(T, H) is larger than zero on the boundary (with the exception of the point A, where b = 0). This form of the free energy is characteristic of second order phase transitions [4].

The parameter η can be regarded as an ordering parameter. When $\eta = 0$, the ferrimagnet is invariant against arbitrary rotations around the magnetic field. When $\eta \neq 0$ (in the phase with the turning of the sublattices), this invariance is eliminated. The transition occurs in accordance with the Landau theory of second-order phase transitions, with a lowering of the symmetry. The jump of the specific heat on the boundary of the transition is $\Delta C_p = T_c(da/dT)^2/2b \approx 10^{-2} - 10^{-3}$ cal/g-deg; ΔC_p increases when the transition point approaches the point T_*. Similar changes occur also in other thermodynamic quantities (such as Young's modulus). We note that measurement of the critical field by determining "sharp" changes of thermodynamic quantities may turn out to be more convenient than measurements based on the total magnetization M(H), which changes smoothly during the turning of the sublattices.

We have calculated the phase diagram also for the case of cubic anisotropy. If the magnetic field is directed along preferred directions of the cubic lattice, then the phase diagram is similar to those given above. For example, the phase diagram is similar to diagram I (Fig. 1) if H is parallel to the light axis [111], and similar to diagram II (Fig. 2) if H is parallel to [110 or [100].

We note also that the case of uniaxial anisotropy in iron garnets is of interest in itself. It is convenient to study the behavior of the sublattice magnetizations in a magnetic field with the aid of the Faraday effect, using thin plates. It is known [5] that strong uniaxial anisotropy frequently appears when such plates are processed.

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FEASIBILITY OF SUPERRADIANCE IN THE REGION OF THE VACUUM ULTRAVIOLET IN BREAKDOWN OF DIATOMIC MOLECULAR GASES BY ULTRAVIOLET LIGHT PULSES

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Pulsed excitation of inversion in a gas discharge is one of the few promising methods of obtaining lasing in the vacuum-ultraviolet region [1, 2]. The presently used excitation of diatomic molecular gases [2] by powerful short ($T \sim 10^{-9}$ sec) current pulses has a number of shortcomings (difficulty of producing "traveling-wave" inversion in the gas, low pressures of the working gas, impossibility of obtaining an excited-particle density higher than $N^* \sim 10^{13} - 10^{14}$ cm^{-3}). We consider below the possibility of obtaining vacuum-ultraviolet lasing by breaking down gases N_2 or H_2 with a powerful ultraviolet laser pulse. The inversion is then produced in the following manner: As shown in [3], at light fluxes $Q \sim 13$ W/cm^2, the breakdown region propagates with the velocity of the laser pulse, forming a long spark (plasma with low degree of ionization), with characteristic dimensions $l \sim 10^2$ cm, $s \sim 10^{-3}$ cm, $v = sl = 10^{-1}$ cm^3. The average electron energy $\langle \mathcal{E} \rangle$ in the plasma produced by the breakdown is of the order of (10 - 15)I, where I is a characteristic energy close to the ionization potential. We note that inasmuch as the excited states produced in the presence of the laser-pulse field decay as a result of multiphoton ionization [4], the neutral molecules are in the ground state in the breakdown region. The laser pulse is followed by an inverse-wave propagating at the speed of light. This wave is connected with the excitation of the neutral molecules by the hot electrons.

The deformation of the electron distribution function $f(\mathcal{E}, t)$ following the passage of the laser pulse can be approximately described, in the energy region $\mathcal{E} > I$, by the equation

$$(df/dt) - I(d/d\mathcal{E})[\nu_i(\mathcal{E})f] = 0, \quad (1)$$