measurement of the critical temperatures in the ternary system V-Si-In and the x-ray data on V-Al system favor this assumption.

It is quite probable that the superconductivity of the V samples subjected to diffusion annealing in In vapor in [1] is also the consequence of the formation of the ternary compound $V_3Si_xIn_{1-x}$ and is not connected with the superconductivity of the compound V_3In, the existence of which is still doubtful.

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ANOMALIES OF THE MAGNETOSTRICTION OF SAMARIUM AND THULIUM IRON GARNETS AT LOW TEMPERATURES

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Submitted 6 June 1967
ZhETF Pis'ma 6, No. 4, 586-589 (15 August 1967)

We have already reported on the unusual magnetostriction properties of iron-garnets and gallium-garnets of the rare earths terbium, dysprosium, holmium, and erbium at low temperatures [1,2]. A characteristic feature of these garnets is their tremendous magnetostriction near 4.2°K, which has been attributed to the anisotropy of the electron cloud of the ions Tb^{3+}, Dy^{3+}, Ho^{3+}, and Er^{3+} and its interaction with the intracrystalline field of the lattice.

We report here an anomalous behavior of the magnetostriction, which we observed at low temperatures in samarium and thulium iron garnets. The measurements were made on polycrystalline samples of $Sm_xY_{3-x}Fe_5O_{12}$ ($x = 0, 0.5, 1, 2, 3$) and $Tu_3Fe_5O_{12}$ by a capacitance method [3] in the temperature interval 4.2 - 100°K and in magnetic fields up to 25 kOe.

Figure 1 shows the temperature dependences of the magnetostriction (λ) and the saturation magnetization (σ_s) of iron garnets of the Y-Sm system. We see that whereas the $\sigma_s(T)$ curves for different compositions differ very little from one another, the magnetostriction curves have a very complicated character and depend significantly on the Sm^{3+} concentration in the garnet,

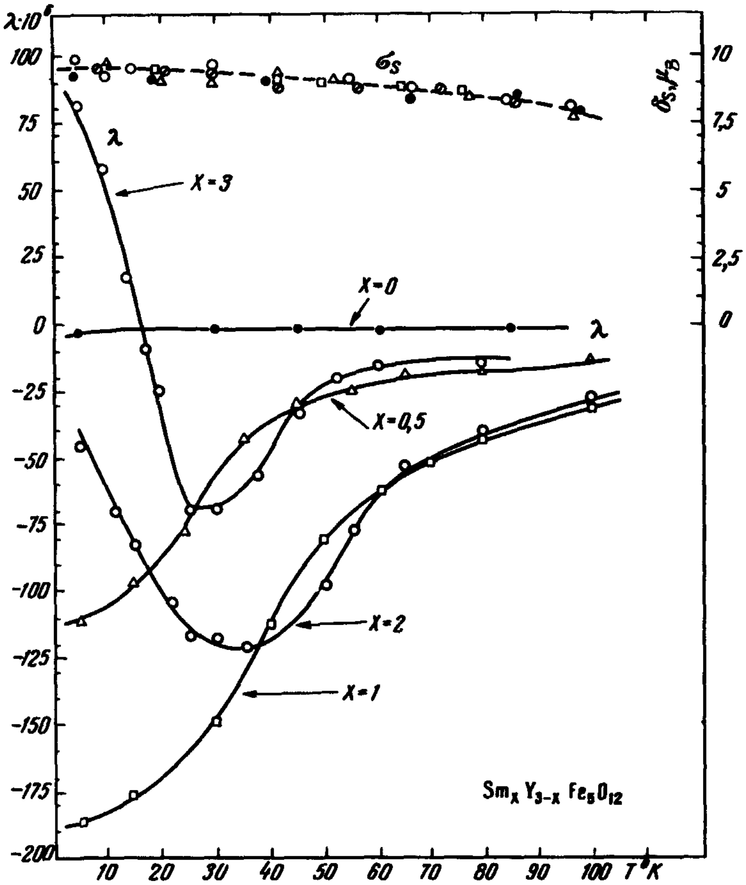

Fig. 1. Magnetostriction (λ) and saturation magnetization (σ_s) of Y-Sm garnets vs. temperature.

especially in the region of liquid-helium temperature (in the case of the $Sm_3Fe_5O_3$, λ even reverses sign at 15°K), i.e., there is no visible correlation at all between the magnetostriction and the magnetization. It is obvious that the magnetostriction of iron garnets containing Sm^{3+} is brought about at low temperatures by the ordering of the magnetic moments of the samarium ions, since the magnetostriction contribution of the iron sublattices is very small ($\lambda_s \approx 2\times10^{-6}$ for $Y_3Fe_5O_{12}$ at 4.2°K). However, since the total magnetic moment of the Sm^{3+} ion differs little from zero (for the free ion, $M = gJ = 0.71\mu_B$), this does not affect strongly the saturation magnetization of the ferrites.

Besides the ordering of the spin magnetic moments (under the influence of the exchange forces), the strong spin-orbit interaction produces also ordering of the orbital magnetic moments of Sm^{3+}. This alters radically the position of the anisotropic electron cloud relative to the symmetry of the lattice electrostatic field, giving rise to a large magnetostriction. At that, unlike the other rare-earth iron garnets [1], this interaction is more complicated in the samarium garnet. It is possible that at low temperatures the peculiarities of the Sm^{3+} electron cloud lead to a reversal of the sign of the magnetostriction, and also to a change of the magnetic anisotropy constant (K_1) [4]. One cannot exclude the possibility that the very change of the sign of the magnetostriction causes the change of the sign of K_1 in the samarium iron garnet.

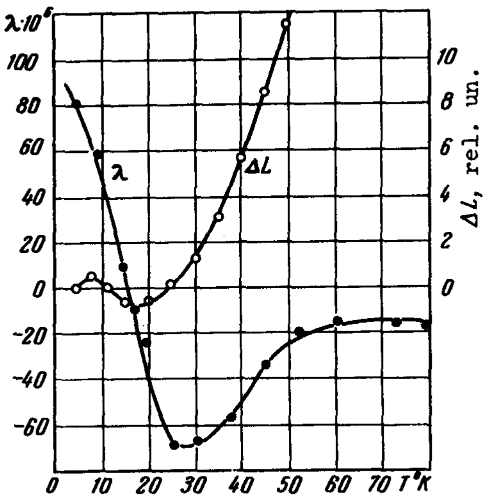

Fig. 2. Magnetostriction (λ) and thermal expansion (ΔL) of $Sm_3Fe_5O_{12}$ vs. temperature.

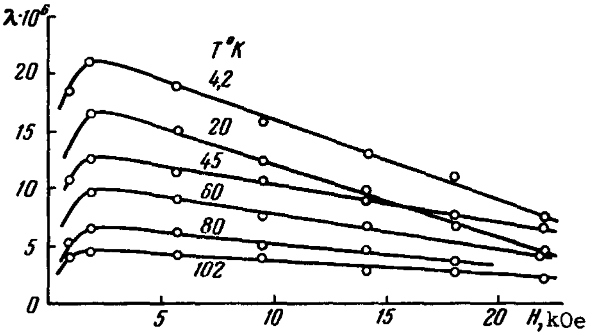

Fig. 3. Isotherms of magnetostriction of thulium iron garnet.

Figure 2 shows the measured temperature dependence of the expansion of $Sm_3Fe_5O_{12}$. Near 15°K, where the magnetostriction of this garnet reverses sign, there is an anomaly on the $\Delta L(T)$ curve, due in accord with the foregoing to the spontaneous deformation of the crystal lattice upon ordering of the orbital moments of Sm^{3+}.

Geller and his co-workers found, in an investigation of the magnetic properties of the thulium iron garnet [5], that the magnetic moment of $Tu_3Fe_5O_{12}$ increases linearly at 4.2°K up to a field of 80 kOe, without reaching saturation. Our measurements have shown that the magnetostriction isotherms of this ferrite have an unusual character (Fig. 3): the magnetostriction first increases rapidly with the field, and then decreases, without exhibiting saturation.

The magnetic and magnetostriction properties of thulium iron garnet can be explained by assuming that a noncollinear structure of the magnetic moments of Tu^{3+} takes place in it at low temperatures. With this, the magnetostriction due to the change in the angular configurations of Tu^{3+} with the magnetic field has a sign opposite to that of ordinary (anisotropic) magnetostriction. Owing to the smallness of the anisotropic magnetostriction in the thulium iron garnet, the magnetostriction due to the destruction of the noncollinear structure in it is more clearly pronounced than in the holmium irong garnet, which likewise has a noncollinear magnetic structure [6].

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INFRARED LASER WITH MAGNETIC PUMPING

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Submitted 13 June 1967
ZhETF Pis'ma 6, No. 4, 589-591 (15 August 1967).

We shall discuss here several possibilities of obtaining stimulated coherent emission in the submillimeter band.

1. The working media usually employed in quantum generators and amplifiers are ionic crystals activated with paramagnetic atoms. If pulsed magnetic fields are used to obtain splittings on the order of $\Delta \approx 10 - 100$ cm^{-1}, then it is advantageous to use concentrated paramagnetic salts as the working media. At a temperature T = 4.2°K and in strong magnetic fields we have $\Delta/KT \gg 1$, so that total ordering of the magnetic moments sets in and eliminates the main source of broadening - the magnetic dipole-dipole interactions of the paramagnetic atoms. One can expect the lines, whose width is usually $\Delta\nu \sim 10^9 - 10^{10}$ Hz, to be narrowed down by two orders of magnitude [1,2]. In paramagnets with weak spin-phonon coupling, the principal role is played in line broadening by hyperfine interactions or, in the absence of the latter, by imperfections in the crystal.

2. In strong magnetic field and at not too high temperatures, the spin-lattice relaxation is produced principally by single-phonon processes. The probability per second of the transition from the upper magnetic level to the lower one is

$$A = K \frac{\Delta^3}{\rho v^5} \frac{\exp(\Delta/KT)}{\exp(\Delta/KT) - 1}, \qquad (1)$$

where ρ is the crystal density, v the average speed of sound, and K depends on the nature of the relaxation mechanism and the structure of the paramagnetic ion. Whereas under ordinary conditions, for ions with relatively weak spin-phonon interaction, the most effective relaxation mechanism is somehow connected with the spin-spin interactions between the paramagnetic