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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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

ions, as is manifest by the presence of a concentration dependence, in strong magnetic fields the decisive role should be played by the Van Vleck mechanism. It is known from experiments [3,4] that make it possible to separate the Van Vleck relaxation that $K = 3\times10^{48}$ $g^{-2}cm^{-4}$ for Cr^{3+} in Al_2O_3, whence, according to (1), $A \approx 10^5$ sec^{-1} for a field 2×10^5 Oe. Calculations [5] have shown that for ions in the S-state K should be smaller. Therefore the most suitable for our purpose are probably salts of divalent manganese and trivalent iron.

We note that in fields producing a splitting $\Delta > \hbar\omega_D$, where ω_D is the limiting Debye frequency, the relaxation times beginst to lengthen, since single-phonon processes become impossible.

3. It can be concluded from experiments on acoustic paramagnetic resonance [6] and on EPR under pressure [7] that in the case of ions with an odd number of electrons (the lower Stark level is a Kramers doublet) the Van Vleck mechanism makes a very small contribution to the spin-lattice relaxation under ordinary conditions. Since it can be expected that the Van Vleck mechanism predominates in strong field, the possibility of using rare-earth ions is not excluded.

Distinct among the rare-earth ions with even number of electrons are those for which the lower pair of Stark levels constitutes two randomly closely-located singlets. An example is Tb^{3+} in ethyl sulfate and in $CaWO_4$.

Measurements have shown [8] that the relaxation times of these ions do not differ in order of magnitude from those of ions with Kramers doublets. The use of Tb^{3+} ions and some other rare-earth ions is quite promising for the following reason: In many crystals these ions have a very large effective g-factor (close to 20), so that splittings $\Delta \approx 20$ cm^{-1} can be obtained in fields of approximately 2×10^4 Oe.

4. Let us consider the possibility of inverting the populations of the magnetic sublevels by reversing the direction of the magnetic field. In the case of strong magnetic fields the use of this method is facilitated by the narrowing of the resonance and its shift as a result of the reversal of the magnetization of the paramagnetic material. In addition, the requirements imposed on the rate of magnetic-field inversion can be relaxed by choosing substances with $g > 2$ and $S > 1/2$. Estimates have shown that this inversion method is perfectly realizable technically.

5. Strong magnetic fields can be used to generate hypersound of frequency $\sim10^{12}$ Hz. Estimates [9] show that the paramagnetic salts considered by us are suitable also for obtaining the acoustic laser effect. We note, however, that intense incoherent sound pulses can be excited without inverting the magnetic sublevel populations. If the magnetic field is turned on after a time interval $t << T_1 = 1/A$, then the magnetic sublevels will be identically populated; the subsequent establishment of an equilibrium distributions under conditions when single-phonon processes predominate will lead to the appearance of a sound pulse of an intensity that depends on the relation between the times t, T_1, and T_{ph} (T_{ph} is the "diffusion" time of the resonating phonons). Detection of the hypersound is possible by means of light diffraction or by Mandel'shtam-Brillouin scattering. It is of undisputed interest to determine the influence of sound oscillations at such high frequencies on chemical and biological processes.

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RELATION BETWEEN THE VOLUME JUMP DURING MELTING AND THE VOLUME OF A SOLID AT THE MELTING POINT

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Kraut and Kennedy [1] have recently proposed an empirical formula relating the change in the melting point of a substance with the relative contraction of its solid phase. This formula is

$$\frac{T}{T_0} = 1 + m\frac{\Delta V}{V_0}, \qquad (1)$$

where $\Delta V/V_0 = (V_0 - V)/V_0$ is the relative contraction, T_0 the melting temperature when the volume of the solid phase is V_0, T the melting temperature when the volume of the solid phase is V, and m a constant of the particular substance. To illustrate the correctness of formula (1), the authors use most frequently for the parameter $\Delta V/V_0$ the value of the compression along the 25-degree isotherm. This can hardly have any physical meaning, but since the compressibility does not depend strongly on the temperature and the derivative dT/dp is not large for the melting curves, it is possible to assume with equal justification that the term $\Delta V/V_0$ in Eq. (1) represents compression along the melting curve.

The results of [1] are presently under extensive discussion [3-7], and most authors attempt to find a connection between formula (1) and the hitherto known empirical and semiempirical laws for the melting process. The results of these papers show that expression (1) does not contradict the hitherto known data, but nevertheless it cannot be derived, say, from the Lindeman equation [8] in rigorous fashion without introducing some assumptions.

We are thus forced to conclude that Eq. (1), discovered by Kraut and Kennedy, is of independent significance. Let us rewrite (1) in differential form

$$\frac{dV_s^m}{dT_m} = \text{const}, \qquad (2)$$

where V_s^m is the volume of the solid phase at the melting point and T_m is the melting temperature.

We recall further the very interesting experimental fact, observed by M. K. Zhokhovskii [9], which can be written in the form

$$\frac{d \ln \Delta V^m}{dT_m} = \text{const}, \qquad (3)$$