SPLITTING OF THE ANGULAR MAXIMA OF ΔH IN AN YTTRIUM GARNET WITH Pr ADDITIVE UNDER THE INFLUENCE OF PRESSURE

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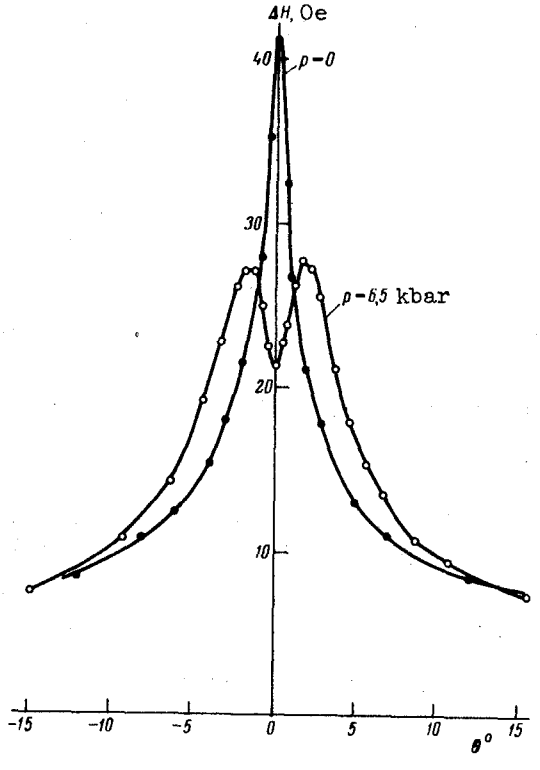
The dependence of the width of the resonance curve in yttrium-iron garnet (YIG) with Pr additive on the angles between the magnetization and the crystal axes is characterized by the presence of sharp maxima in the directions of <100> [1], due to the coming together of the energy levels of the Pr^{3+} ion on approaching these directions. Unlike yttrium-iron garnet with Tb and Ho additives, no splitting of the angular maxima of ΔH was observed.

The splitting of the angular maxima of ΔH in YIG with Tb^{3+} and Ho^{3+} ions indicates that a predominant contribution to ΔH is made by the mechanism of the so-called slow (or longitudinal) relaxation [2]. A characteristic feature of this mechanism is the presence of a minimum of ΔH at the point at which the distance between the ion levels is minimal.

The absence of splitting of the angular maxima of ΔH in YIG with Pr^{3+} ions is due to the fact [1] that the energy levels of Pr^{3+} come closer together in the directions <100> to such an extent that the value of hω becomes comparable with the minimum distance between the levels, and the mechanism of resonant (transverse) relaxation begins to make a major if not predominant contribution [2]. This mechanism calls for ΔH to have a maximum rather than a minimum at the point where the distance between the levels is the smallest. The lower energy levels of the rare-earth ions in YIG are produced as a result of splitting of the main multiplet ($^2H_4$ in the case of Pr^{3+} ions) in the crystal and exchange fields. One of the methods of acting on these fields, and consequently on the energy levels of the ion, is pressure. It is therefore of interest to ascertain the influence of pressure on the angular dependence of ΔH caused by rare-earth ions in YIG.



Angular dependence of the width of resonance curve in YIG with 0.03 mol.% Pr^{3+}. θ is the angle between the constant magnetic field and the <100> axis in the {110} plane.

We have investigated the influence of high hydrostatic pressure on the ferromagnetic resonance in YIG to which 0.03 mol.% Pr^{3+} has been added. The measurements were performed on spheres of ∿0.5 mm diameter in the 3-cm wavelength band at liquid-helium temperatures. We used a constant-pressure bomb [3] and a dielectric resonator [4].

The measurement results are shown in Fig. 1. Under the influence of the pressure, the angle peak of ΔH splits and acquires a form similar to that observed (in the absence of pressure) for the additives Tb^{3+} and Ho^{3+} [1].

The observed change in the angular dependence of ΔH under the action of pressure can be explained by assuming

that the pressure leads to an increase of the minimal distance between the lower levels of Pr^{3+} in the directions of <100>. This decreases the contribution of the mechanism of transverse relaxation and increases the contribution of the slow-relaxation mechanism. The result is the minimum of ΔH in the direction <100>, which is characteristic of the slow-relaxation mechanism.

A more exact answer to the question of the nature of relaxation in YIG with Pr^{3+} ions can apparently be made by measurement of the angular and temperature dependences of ΔH at different pressures.

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OBSERVATION OF RADIATIVE RECOMBINATION ON THE SURFACE OF A SEMICONDUCTOR (GaAs)

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1. The influence of the surface of a semiconductor on the luminescence was established in a number of investigations, and in all the studied cases the surface served as a quenching factor caused by the intense nonradiative channel of surface recombination (see, e.g., [1 - 3]). So far no one has succeeded in observing the radiation produced by luminescence from surface centers. Yet experiments in this direction are of fundamental importance for several reasons. In view of the lowering of the crystal symmetry, the eased conditions for "cooling" of the free carriers on the surface [4, 5], etc., the question is raised whether radiative processes can exist at all on the surface of the semiconductor. For exciton radiation, this reduces to the question whether surface excitons can exist in principle. We are thus dealing with fundamental properties of the surface of semiconducting crystals.

On the other hand, the creation of a surface on which radiative processes predominate is important for the establishment of the nature of local centers, for the investigation of surface-phonon spectra, and also for laser physics.

2. Experiments aimed at observing surface radiation were performed on a high-emissivity material (GaAs) using a pulsed ($t_p \approx 3 \times 10^{-8}$ sec) ruby laser exciting a narrow (~ 1 μ) surface region. The maximum laser intensity (L) was 10^{24} kV/cm^{2}sec. In addition to a sharp increase in the investigated signal, the use of the laser techniques is important when it comes to reducing the relative influence of nonradiative channels (particularly, because of the shift of the Fermi quasilevels towards the edges of the forbidden band and the ensuing inclusion of shallow centers [6]). As is well known, shallow centers are more capable of resonant energy exchange with release of phonons than are the deep and as a rule nonradiative centers. For the same reason, the surface mainly employed was the one obtained by cleavage along the (110) direction at low temperature in a neutral medium (liquid hydrogen). In this case a sufficiently large number ($\sim 10^{14}$ cm^{-2}) of shallow centers is produced on the surface [7]; on the other hand, the production of deep centers connected with structure or chemical-structure complexes is made difficult.

We investigated single-crystal samples of GaAs of two types: (I) n-type with $n_0 = 3 \times 10^{15}$ cm^{-3} and $\mu_n \approx 1.3 \times 10^3$ cm^2/V-sec and (II) semiinsulating