ABOUT THE NECESSITY OF ACCOUNTING MAGNETIC RESONANT FORCES IN THE EXPERIMENTAL STUDY OF NONLINEAR FERROMAGNETIC RESONANCE IN UNFIXED SAMPLES A. I. FILATOV, V. G. SHIRONOSOV

Brief messages and letters to the editor.

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Numerous experimental studies carried out in the field of NFMR have revealed the fine structure of magnetoacoustic oscillations and hysteresis phenomena in the magnetizing field and pump power [1-3]. Some features of this structure have already received a completely satisfactory physical explanation. The reasons for the appearance of others (slow quasiperiodic variations of the NFMR signal, spontaneous jumps from one acoustic mode to another, etc.) have not yet been fully clarified. [3, 4].

It is possible that some of the NFMR "anomalies" mentioned here are due to trivial technical reasons (inhomogeneity of magnetic fields, parasitic DM and FM of the pump signal, overheating of the central part of the sample above the Curie point, etc.), which are not taken into account in the existing NFMR theories.

Such anomalies, as we found out, include slow (frequency ~ 1 ÷ 20 Hz) variations of the magnetoacoustic resonance (MAP) signal in spherical unattached samples from a single crystal of yttrium iron garnet (YIG) with continuous transverse pumping at a frequency of 9420 MHz. It turned out that when approaching the NFMR, the magnetic resonance force (MRS) begins to act on the YIG sample. It pushes the YIG from the bottom of the ampoule onto its side wall, where the resonance conditions are violated either due to the inhomogeneity of the magnetizing field, or due to the rotation of the sample during rolling. Leaving the FMR region leads to the disappearance of the MRS. Under the action of gravity, the YIG sphere rolls back to the bottom of the ampoule, where it enters the resonance region and is again pushed out onto the side wall. In the future, all processes are repeated.

This rather unexpected explanation of the slow variations in the NFMR signal is confirmed by estimates of the MRS value and a series of control experiments[1]). Assuming the possibility of changing the magnetic moment **μ** during spatial displacement and rotation of the sample (due to the inhomogeneity of the external field ***H*** and crystallographic anisotropy of YIG), we obtain the following formula for the force ***F*** acting on the sample:

$$F_i = \mu_k(\partial H_\kappa/\partial x_i) + H_\kappa(\partial \mu_k/\partial x_i) = F_i^{(1)} + F_i^{(2)}. \qquad (1)$$

Calculations show that for YIG in (1) the second term dominates. This is exactly the MRS that is responsible for the above-mentioned variations in the NFMR signal.

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[1]) *The intricate "dance" of the sample on the inner surface of a small ampoule, with the help of which the YIG was fixed in the center of the microwave resonator, we observed through protective limiting attenuators installed at the places where the ampoule was inserted into the resonator. The magnitude of the MRS was estimated from the rupture of two spherical YIG samples at the moment of resonance passage.*

It has a resonance character and at moderate saturation (the pump field is equal to the width ***2 ΔH*** of the ***FMR*** line) is of the order of magnitude equal to:

$$\boldsymbol{F}^{(2)} \approx H_0 V \boldsymbol{M_s} / l \qquad \textbf{(2)}$$

where H_0 - bias field at the sample location, V - sample volume, $\boldsymbol{M_s}$ — saturation magnetization, l - the characteristic size of the spatial region, at the boundaries of which the bias field changes by an amount of the order of $2\Delta H$.

Substitution in (2) of the corresponding numerical values for YIG ($4\pi M_s$= 1750 Gs, $2\Delta H$=0,5 Э, at gradient 0,5 Э/ cm this gives $l \approx 1$ cm) in field H_0=3300 Eh leads to the following estimate of the MPC value: $F(2)=90\ F_{\text{т}}$, where $F_{\text{г}} = \rho V g$ — sample gravity (for YIG the density $\rho \approx 5{,}2$ g/cm^3). It is clear that such a significant MRS cannot be ignored when interpreting the results of an experimental study of instabilities and hysteresis phenomena in NFMR.

More accurate estimates of the MRS and the nature of its dependence on spatial coordinates, as well as the details of the experiment, will be published elsewhere. Here we only note that a large MRS arises not only due to the inhomogeneity of the magnetizing field. It turns out to be significant even in a uniform field, in this case, the MRS appears either due to the gradient of the pumping field, or due to the influence of fictitious mirror reflections in the pole pieces of the magnet.

It has also been found that traditional methods of rigidly holding the specimen are not reliable. When the sample is heated, the adhesive film breaks, and a cavity is formed in the polystyrene and fluoroplastic fasteners, in which the sample is "free".

In conclusion, we are grateful to A.G. Gurevich for the kind presentation of YIG samples.

LITERATURE

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