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Letter to the Editor

# NOTE ON THE FMR LINE SHAPE OF YIG POWDER SAMPLE

## К ВОПРОСУ О ФОРМЕ КРИВОЙ ФЕРРОМАГНИТНОГО РЕЗОНАНСА В YIG ПОРОШКОВОМ ОБРАЗЦЕ

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It happens very often in practice that single crystals of materials to be investigated are not available for various technological reasons. Powder samples usually remain the only samples in such cases.

The FMR absorption curve represents a complex phenomenon in which the factor $g$, the spontaneous magnetization $M$, and the crystaline anisotropy field $H_a$ play a fundamental role. Being interested in powder samples, we intended to check whether the model of independent powder particles is applicable in FMR experiments for the evaluation of the quantities mentioned above. We chose a well known yttrium iron garnet in powder form as the material testing this model. The validity of the relations $M \gg H_a \gg \Delta H$ for YIG practically means that the explanation of both measured and calculated curves could be facilitated considerably.

The model of independent particles and our programme take the following assumptions into account:

1. The powder sample consists of a great number of noninteracting particles embedded in a diamagnetic matrix.
2. The particles have the shape of general ellipsoids which differ both in form and size.
3. All particles are single crystals magnetized homogeneously to saturation. The magnetization has the same value in all particles.
4. The particles are immobile and randomly oriented both as to the shape and as to the anisotropy.
5. There is no relation between the shape and the position of the anisotropy axes in any particle.
6. The line width $\Delta H$ has the same value for all particles. It is assumed that this is an isotropic quantity independent on the shape of particles.

The whole of the powder sample may be considered as a magnetically isotropic material. The main task of our computation consists in the evaluation of the distribution function $w(H)$ of resonance field strengths for the ellipsoidal particles of cubic symmetry. Schlömann [1] has found the resonance field in polycrystalline ferrites with large anisotropy. His solution of the problem of independent grains in polycrystalline materials is equivalent from our point of view to the case of noninteracting spherical particles. This case is included in our computer programme as a special case of ellipsoidal particles.

The structure of the computational procedure comprises basic parts as follows:

1. The choice of the shape and of the orientations of one particle by means of the Monte Carlo

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method. The choice is made in accordance with optical measurements of the mean three-dimensional form of particles.

2. The minimization of the total energy

$$E = -\mu_0 \vec{M}\vec{H} + K_1[\alpha_1^2\alpha_2^2 + \alpha_2^2\alpha_3^2 + \alpha_3^2\alpha_1^2] + \frac{\mu_0}{2}[M_a^2N_a + M_b^2N_b + M_c^2N_c]$$

of this particle so that the equilibrium position of vector $\vec{M}$ will be determined. In this expression $K_1$ is the first order cubic anisotropy constant, $\alpha_1$, $\alpha_2$, $\alpha_3$ are the directional cosines of $\vec{M}$, $N_a$, $N_b$, $N_c$ are the demagnetizing factors in the coordinate system associated with the main axes of the ellipsoid.

3. The evaluation of the precession frequency $\omega_r$ of vector $\vec{M}$ in its equilibrium position. This was performed by using the known formula

$$\omega_r = \frac{\gamma}{M \sin \vartheta}\left[\frac{\partial^2 E}{\partial \vartheta^2} \cdot \frac{\partial^2 E}{\partial \varphi^2} - \left(\frac{\partial^2 E}{\partial \vartheta \partial \varphi}\right)^2\right]^{\frac{1}{2}}.$$

4. The repetition of the procedures sub 2 and 3 in order that the precession frequency will be equal to the measurement frequency.

The result of the computation represents the first derivative of the calculated absorption curve which is plotted in Fig. 1 together with the measured spectrum. The coincidence of the zero points of both curves is obvious, which is very important fact for the evaluation of the factor $g$. This quantity can be determined with the accuracy of 1 % by measurements at two frequencies. The saturation magnetization cannot be determined from these FMR experiments. It must be said that the magnetically oriented powder samples are necessary for this purpose.

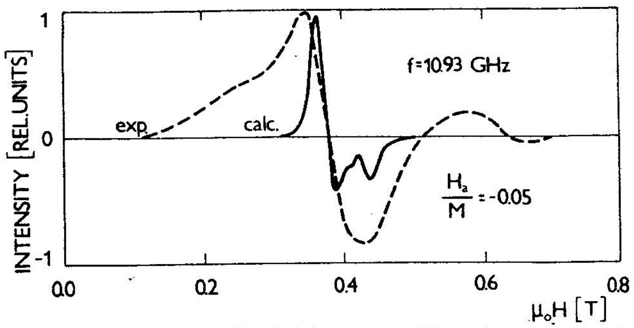


Fig. 1. The shapes of the calculated and of the measured lines of a powder sample of YIG.

The large broadening of the experimental line is apparently connected with the violation of the assumption 2 of our model. This influence could be qualitatively explained by means of the inhomogeneity of demagnetizing fields which were analysed by Geschwind and Clogston [2]. Finally, let us remark that the experimental and theoretical curves will have approximately the same shape after putting the value $\mu_0 \Delta H = 0.06$ T into the programme.

## REFERENCES


[1] Schlömann, E.: J. Phys. Chem. Solids *6* (1958), 257.

[2] Geschwind, S., Clogston, A. M.: Phys. Rev. *108* (1957), 49.



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