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MAGNETOELECTRIC RESONANCE IN MAGNETIC SEMICONDUCTORS

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The appearance of a dc electromotive force (emf) was observed in magnetic semiconductors at ferromagnetic resonance (FMR). This emf exceeds by several time the emf previously observed in metallic magnetic films at FMR [1 - 3]. The emf previously observed in $HgCr_2Se_4$ [4] had a non-reproducible and complicated character, and at the author's own admission could not be uniquely interpreted.

The present investigations were made on disks of lithium spinel single crystals with resistivity $\rho \approx 10^3$ Ω-cm at 300°K, and on single-crystal $CdCr_2Se_4$ plates doped with silver ($\rho \approx 10^3$ Ω-cm at 77°K) with gold electrodes (Fig. 1). The current-voltage characteristic of the contacts was linear.

The samples were measured in a resonator and in a waveguide, using pulses of 9400 MHz frequency and 1 - 10 μsec duration, at a repetition frequency 40 Hz and a maximum pulse power 10 W. The sample was not heated under these conditions.

The emf of the lithium ferrospinel was measured at room temperature, and that of the $CdCr_2Se_4$ single crystals at 77°K.

Figure 1 shows plots of the resonant absorption (χ'') and of the emf (V) on the contacts as functions of the external magnetic field for a transversely magnetized disk of Li-ferrospinel. The sample was in a waveguide in the region of linear polarization of the microwave field. It is evident that the character of the variation of the emf with the external magnetic field is similar to the character of the variation of χ''.

A dc emf is produced not only in the case of homogeneous precession (H = 7400 Oe), but also for magnetostatic modes (H = 6900 Oe). The sign and magnitude of the emf remained the same when the direction of the external field was reversed (always positive at the center of the disk. Figure 2 shows a plot of the resonant emf against the microwave power. The transversely

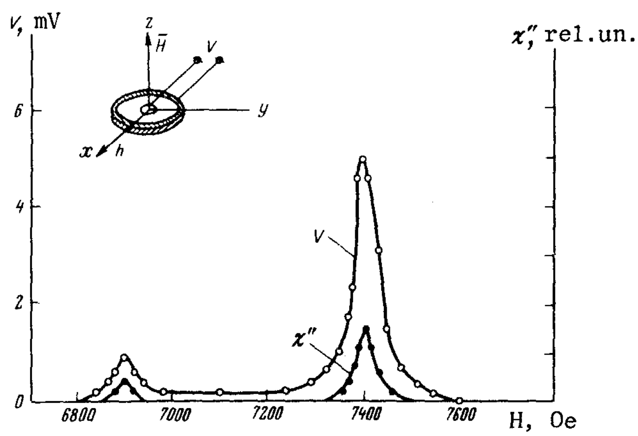

Fig. 1

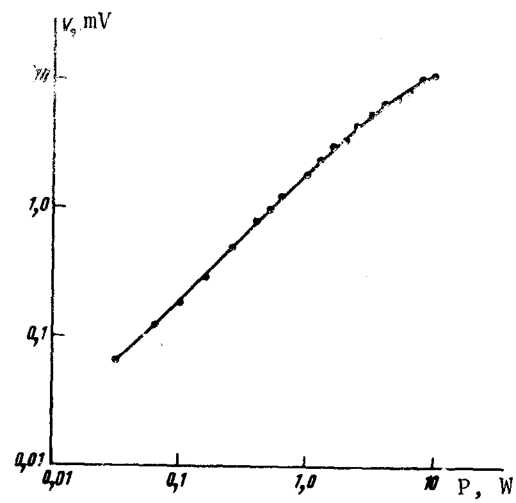

Fig. 2

Fig. 1. Resonant absorption (χ'') and dc emf (V) in waveguide vs the external magnetic field for transversely magnetized disk with [111] axis perpendicular to the plane of the disk. The construction of the sample with the electrodes is shown in the upper right.

Fig. 2. Resonant value of dc emf vs microwave signal power in short-circuited waveguide. The sample was in the antinode of the microwave magnetic field.

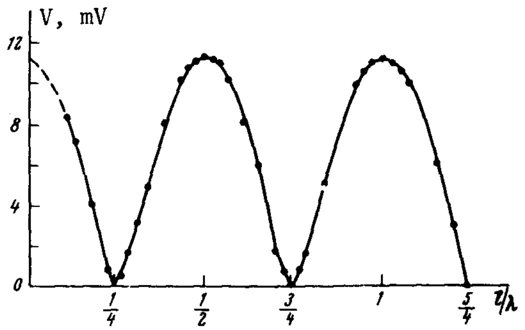

Fig. 3. Resonant value of dc emf vs the distance between the sample and the short-circuited waveguide wall.

magnetized disk was placed in the antinode of the magnetic field of the short-circuited waveguide. At a power less than 1 W, the emf was linear in the power.

As a check on the fact that the emf is caused by the microwave magnetic field, Fig. 3 shows the dependence of the resonant value of the dc emf on the distance between the transversely-magnetized disk and the short-circuited waveguide wall. The absence of a signal in the antinode of the microwave electric field indicates that the induced emf is of magnetic origin and there is no contribution from the possible small nonlinearity of the contacts.

Similar results were obtained with single crystals of other compounds, viz., Mg-Mn ferrospinels and $CdCr_2Se_4$ doped with silver.

The measured emf exceeds by three orders of magnitude the emf obtained from an estimate of the model of the anomalous microwave Hall effect [1 - 3]. The influence of the anomalous Hall effect can therefore be neglected.

Several causes of this emf can be suggested: (a) Scattering of the homogeneous precession by magnetic inhomogeneities (0-k process) excites spin waves. The emf is then the result of dragging of the carriers by the propagating spin waves. This dragging mechanism was considered theoretically in [5] for magnetic semiconductors. (b) The presence of a gradient of the amplitude of the alternating magnetization in the sample, due to the s-d exchange interaction, leads to inhomogeneous heating of the electrons, and the dc emf results from the redistribution of the electron density.

Magnetoelectric resonance can serve as a new method of investigating the properties of magnetic semiconductors, can possibly be used to detect microwave signals (filter-detector), for selective measurement of pulsed power or frequency, etc.

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STIMULATED LINE NARROWING AND THE MOSSBAUER EFFECT ON LONG-LIVED ISOMERS

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The possibility is considered of suppressing the inhomogeneous shift of the Mossbauer line of a long-lived nuclear isomer by placing the crystal in an external periodically-varying electromagnetic field with a specially chosen temporal waveform of the signal.

In real crystals there are a number of mechanisms that lead to broadening and inhomogeneous shift of the Mossbauer lines (ML) of long-lived nuclear isomers with lifetimes $\tau \gg 10^{-6}$ sec [1 - 4]; these mechanism limit the accuracy of Mossbauer measurements. It is reported in [1], for example, that the inhomogeneous Mossbauer-line shift due to random electric and magnetic fields produced by defects and impurities is much larger than the natural line widths of long-lived isomers.

The purpose of the present paper is to show that it is possible in principle to suppress[1)] the inhomogeneous Mossbauer-level shift by placing the crystal in a periodically varying electromagnetic field with a signal of special waveform.