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A frequency-independent rotation of the light-polarization plane, due to the magnetic susceptibility of the ferrimagnet, was observed in a study of the Faraday effect in yttrium, erbium, and holmium iron garnets in the infrared region [1]. Calculation of the off-diagonal component of the tensor by means of the Landau-Lifshitz equation for a two-sublattice ferrimagnet leads to the following expression for the Faraday effect:

$$\alpha_F = \frac{2\pi\sqrt{\epsilon}}{c} (\gamma_1 I_1 - \gamma_2 I_2) \quad (1)$$

or

$$\alpha_F = \alpha_F^{\text{res}} + \alpha_F^{\text{exc}} = \frac{2\pi\sqrt{\epsilon}}{c} \gamma_{\text{eff}} \left[ I - \frac{I_1 I_2 (\gamma_1 - \gamma_2)^2}{\gamma_1 \gamma_2} \right], \quad (2)$$

where  $I_1$  and  $I_2$  are the sublattice magnetizations,  $\gamma_1$  and  $\gamma_2$  are the gyromagnetic ratios,

$$\gamma_{\text{eff}} = \frac{I_1 - I_2}{I_1/\gamma_1 - I_2/\gamma_2}, \quad I = |I_1 - I_2|$$

and  $\epsilon$  is the dielectric constant. The first term in (2) is the contribution of the ordinary ferrimagnetic resonance, and the second is due to the Kaplan-Kittel exchange resonance [2]. For yttrium, erbium, and niobium garnets, good agreement was obtained between  $\alpha_F^{\text{cal}}$ , calculated on the basis of formula (1) using the values of  $g_i$  for the rare-earth ions, and  $\alpha_F^{\text{exp}}$ . However, it was shown in [3] that for a quantitative reconciliation of  $\alpha_F^{\text{cal}}$  with  $\alpha_F^{\text{exp}}$  of terbium and dysprosium iron garnets at  $T \approx 100^\circ\text{K}$  it is necessary to assume that the  $g$ -factors of the ions  $\text{Dy}^{3+}$  and  $\text{Tb}^{3+}$  decrease to 0.8 - 0.9, whereas  $g_1^{\text{Dy}} = 1.33$  and  $g_1^{\text{Tb}} = 1.5$ . Later on, Johnson and Tebble [4] found by the same method that in the interval from 300 to  $80^\circ\text{K}$  the  $g$ -factor of the  $\text{Dy}^{3+}$  ions in  $\text{Dy}_3\text{Fe}_5\text{O}_{12}$  changes from 1.06 to 0.77, and Chetkin and Shalygin [5] found that the  $g$ -factor of the  $\text{Tb}^{3+}$  ions in  $\text{Tb}_3\text{Fe}_5\text{O}_{12}$  changes from 1.15 to 1.0.

Thus, the deviation of the  $g$ -factors of  $\text{Dy}^{3+}$  and of  $\text{Tb}^{3+}$ , calculated by formula (1), from the values of  $g_i$  reaches 50% in the indicated temperature interval. This contradicts the results obtained for the  $g$ -factors from the magnetic susceptibility, according to which the  $g$ -factors of rare-earth ions in a great variety of crystals differ from  $g_i$  at room temperature by less than 1% (cf., e. g., [6]). Let us consider therefore the following assumption: The  $g$ -factors of the rare-earth ions contained in the iron garnets differ little from  $g_i$  in the interval  $T \geq 80^\circ\text{K}$ , and the difference between  $\alpha_F^{\text{exp}}$  and  $\alpha_F^{\text{cal}}$  is due to the action of an additional physical mechanism, i.e., unlike (2), we have  $\alpha_F = \alpha_F^{\text{res}} + \alpha_F^{\text{exc}} + \alpha_F'$ . The figure shows plots of  $\alpha_F^{\text{res}}$ ,  $\alpha_F^{\text{exc}}$ , and  $\alpha_F'$  for  $\text{Dy}_3\text{Fe}_5\text{O}_{12}$  and  $\text{Tb}_3\text{Fe}_5\text{O}_{12}$ , obtained from the experimental  $\alpha_F$  curves [4,5] with the contributions  $\alpha_F^{\text{res}}$  and  $\alpha_F^{\text{exc}}$  calculated by using the values of  $g_i$  for rare-earth ions. It is seen from the figure that  $\alpha_F'$  has a characteristic

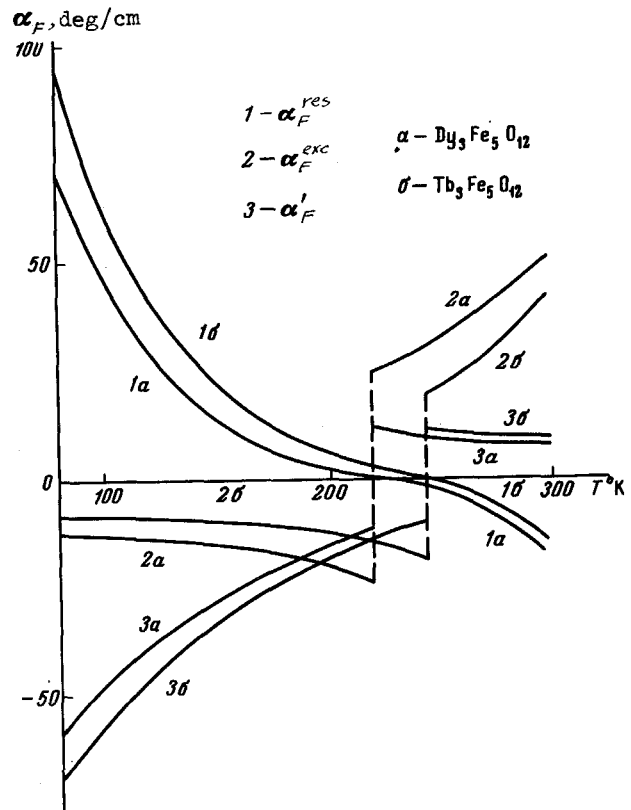
temperature dependence and is commensurate with  $\alpha_F^{\text{res}}$  and  $\alpha_F^{\text{exc}}$ . The additional physical mechanism leading to the presence of  $\alpha_F'$  can apparently be the single-ion exchange resonance observed by Tinkham in the study of resonant properties of iron garnets in the far infrared [7]. Unlike the Kaplan-Kittel exchange resonance, the single-ion exchange resonance corresponds to reorientation of the magnetic moments of the individual rare-earth ions in the exchange field of the iron sublattice. We can advance the following arguments in favor of the foregoing assumption: 1) when  $\omega \gg \omega_{\text{res}}$ ,  $\alpha_F'$  should also be independent of  $\omega$ , in analogy with the contribution made to  $\alpha_F$  by any magnetic resonance, such as ferromagnetic, antiferromagnetic, paramagnetic, nuclear resonance, etc. 2)  $\alpha_F'$  corresponds to the intensity of the single-ion exchange resonance, which is comparable in order of mag-

nitude with the intensity of the Kaplan-Kittel exchange resonance [7]. 3)  $\alpha_F'$  increases sharply with increasing magnetization of the rare-earth sublattice as a result of a decrease in the temperature (see the figure).

We note also the following circumstance. In measurements of  $\alpha_F$  in  $\text{Tb}_3\text{Fe}_5\text{O}_{12}$  ( $T = 300^\circ\text{K}$ ,  $\lambda = 4 \mu$ ), Tyutneva [8] observed an anisotropy of the Faraday effect, viz.:  $\alpha_F^{\text{H}\parallel[111]} = 28 \text{ deg/cm}$ ,  $\alpha_F^{\text{H}\parallel[110]} = 33 \text{ deg/cm}$ , and  $\alpha_F^{\text{H}\parallel[100]} = 36 \text{ deg/cm}$ . The absolute values of the gyromagnetic Faraday effects measured along the principal crystallographic axes need to be revised, since at  $\lambda = 4 \mu$  there is still a small contribution of the gyroelectric effect in  $\alpha_F$  [8], but it is significant that the difference is  $\alpha_F^{\text{H}\parallel[100]} - \alpha_F^{\text{H}\parallel[111]} = 8 \text{ deg/cm}$ , i.e., of the same order of magnitude as  $\alpha_F'$ .

Tinkham [7] proposes that the intensity of single-ion exchange resonance is determined by the difference of the transverse  $\gamma$ -factors of the neighboring rare-earth ions, owing to the non-equivalence of the places in the garnet lattice, this non-equivalence being connected with the orientation of the magnetization vector relative to the crystallographic axes.

Thus, the single-ion exchange resonance can have a much larger anisotropy than the Kaplan-Kittel exchange resonance, the intensity of which is connected with the difference of the longitudinal  $\gamma$ -factors (see (2)), which determine the natural precession frequencies and the magnetic susceptibility. Measurement of the anisotropy of the gyromagnetic Faraday effect at low temperatures, where the contribution of  $\alpha_F^{\text{exc}}$  decreases sharply (see the figure),



and the value of  $\alpha_F^{res}$  can be determined from independent measurements of the ferromagnetic-resonance frequency, is therefore a method for directly verifying experimentally the existence of the exchange Faraday effect of the second kind  $\alpha_F^1$ .

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#### INFLUENCE OF THE ELECTRIC FIELD ON THE RADIATION-INDUCED FLUORESCENCE OF AROMATIC HYDROCARBONS IN CYCLOHEXANE <sup>1)</sup>

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Irradiation of dilute solutions of aromatic hydrocarbons leads to the formation of electron-excited molecules of the dissolved substance [1-3]; this reaction has a high yield. The results of experiments in which charge capture was investigated [2,3] indicate that the most probable process of formation of electron-excited molecules of substance dissolved in cyclohexane is charge transfer from the solvent, accompanied by charge recombination. We investigated the influence of an electric field on the yield of electron-excited singlet molecules of anthracene (A) and pyrene (P), by studying the fluorescence of solutions of A and P in cyclohexane.

The investigated solution flowed continuously through a quartz ("Spectrosil") cell containing two parallel platinum electrodes, separated by a 4 mm gap. The volume between the electrodes was irradiated by a continuous beam of 3-MeV electrons accelerated by a Van de Graaff accelerator. The irradiation caused fluorescence, which was observed in a direction perpendicular to the electron beam, by means of a system containing a set of mirrors, a monochromator, and a photomultiplier. The fluorescence intensity was measured at the maxima of the spectra at wavelengths 395 and 470 nm for the normal and excimer fluorescence of pyrene and at 400 nm for normal fluorescence of anthracene. The bandwidth was 10 nm.

Application of a constant electric field  $10^3 - 1.5 \times 10^4$  V/cm decreased the fluorescence intensity in the solutions of both substances. The percentage change of the fluorescence intensity (i.e.,  $(\Delta L/L)100$ , where  $L$  is the intensity corrected for the Cerenkov radiation) is shown in the figure as a function of the dose intensity for the pyrene solution. The electric field intensity was  $1.25 \times 10^4$  V/cm. At dose intensities much higher than indicated in the figure ( $\sim 10^9$  rad/sec), obtained by periodic pulsed illumination, the electric field did not influence the fluorescence. Results similar to those shown in the figure were ob-

<sup>1)</sup> Work performed at the Center of Radiation Research in Leeds, England, during the exchange visit of E. L. Frankevich (Institute of Chemical Physics, USSR Academy of Sciences).