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ANOMALOUS DISPERSION OF THE FARADAY EFFECT IN FERRIMAGNETIC $RbNiF_3$

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We investigated the Faraday effect in $RbNiF_3$ in the wavelength interval from 0.35 to 1.1 μ and observed a strong spectral dependence of the rotation of the plane of polarization of light. Hexagonal $RbNiF_3$ goes over into the ferrimagnetic state below 145°K [1]. The crystallographic symmetry is described by the space group D_{6h}^4 [2]. The investigated sample was a plate 0.6 mm thick perpendicular to the hexagonal axis. The measurements were made in magnetic fields up to 16.5 kOe using a single-beam installation with linear dispersion 32 Å/mm at 77 and 295°K.

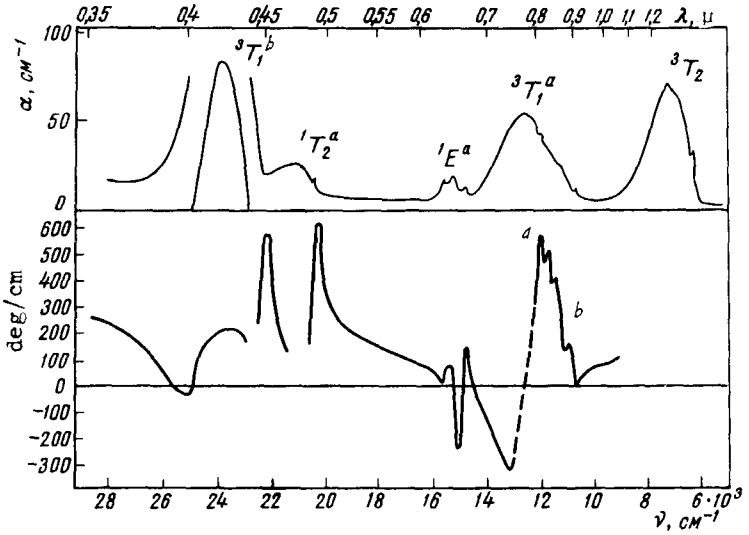

Fig. 1. Faraday effect in $RbNiF_3$ at T ≈ 77°K in a 16.5 kOe magnetic field (section ab was measured in a 13.25 kOe field). The upper part of the figure shows the absorption spectrum of the crystal at the same temperature.

The obtained spectral dependence of the specific rotation α_F at 77°K and in a 16.5 kOe field is shown in Fig. 1, which shows also the optical absorption of $RbNiF_3$ along the optical axis [3]. The Faraday rotation reverses sign several times and its magnitude changes greatly in the investigated spectral interval. This complicated behavior can be explained by examining the connection between the rotation and the absorption. When the absorption lines are approached from the sode of the long-wave edge, the rotation of the plane of polarization of

the light reaches large values compared with the region in which there is no influence by the electron transitions. In individual spectral regions where the absorption lines exhibit a complicated structure, this relation is more complicated, for example in the region of the transitions $^3T_1^a$ and $^1E^a$. We attach importance to the circumstance that the Faraday effect exhibits strong "sensitivity" to the absorption lines. It increases noticeably far from the absorption lines and reaches a maximum value even in that region of the spectrum where the absorption of the line itself is small. In addition, the Faraday effect is sensitive to the absorption-line fine structure brought about by the spin-orbit interaction and by the distortions of the crystalline field (for example, near the $^3T_1^a$ and $^1E^a$ lines). In individual cases, this sensitivity of the Faraday rotation can yield important additional information on the electronic structure of paramagnetic ions in crystals. It is important to note that the investigated crystal, unlike $Y_3Fe_5O_{12}$ or $CrBr_3$, has a broad forbidden band ($\Delta E \approx 5$ - 6 eV). Therefore the Faraday effect in $RbNiF_3$ is not masked by an intense influence of the conduction electrons.

In regions where there are no absorption bands, the magnitude of the rotation is connected essentially with the ferrimagnetic moment of the crystal and therefore depends little on the wavelength. Figure 2 shows the dependence of the relative rotation on the intensity of the external magnetic field for the transmission region of the crystal ($\lambda = 0.55$ μ). This dependence agrees in its main outlines with the dependence of the magnetization on the field in $RbNiF_3$ along the c axis, which shows a bend at fields 10 - 14 kOe, and may be connected with the influence of the electronic transitions. Such a bend may be due in part to the residual birefringence as a result of inaccurate crystal orientation. The maximum rotation can be attained in a saturating field (25 kOe [1]), and at low temperatures (4.2°K) it may amount to 250 - 300°/cm at this wavelength.

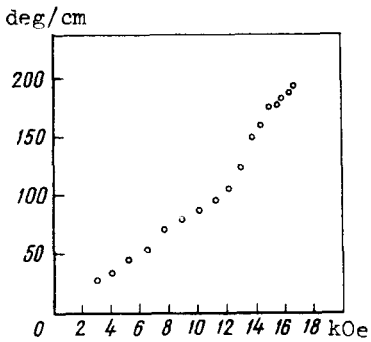

Fig. 2. Relative rotation of the plane of polarization in $RbNiF_3$ vs. the intensity of the external magnetic field at T = 77°K for $\lambda = 0.55$ μ ($\nu = 18020$ cm^{-1}).

At 295°K the parametric rotation of the plane of light polarization was 0.06 - 0.08 min/cm-Oe (Verdet constant) and depended little on the wavelength.

A large relative rotation was previously observed in $Y_3Fe_5O_{12}$ [4] and in $CrBr_3$ [5]. In these crystals, however, the strong rotation is accompanied by intense absorption, and they can be effectively used to modulate light only in the infrared region. At the same time, the crystal investigated by us has definite advantages. Thus, it is transparent at the wavelengths of the argon and neodymium lasers and absorbs light weakly at the wavelengths of the helium-neon and ruby lasers. In addition, $RbNiF_3$ is transparent in the infrared up to 11 μ, where it can also be effectively used.

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INVESTIGATION OF Kx-γ DIRECTION CORRELATION IN THE DECAY OF Mn^{54}

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Electron capture by an excited level in nuclear decay can be used to study the relative angular distribution of the emitted x-rays and γ quanta. In practice this differs little from the γ-γ correlation investigations, but the nature of the phenomenon is different. Theory [1] denies the existence of Kx-γ correlation of the directions. On the other hand, the theory predicts Lx-γ correlation. There are no published papers on this question. A special setup was constructed to investigate Lx-γ correlation, and also correlations with Auger or conversion electrons, but it was found the measurement of Lx-γ correlation is hindered by the background from the Kx rays, which has an anisotropic angular distribution relative to the γ-quantum direction. This was followed by investigations of the coincidence between the Kx and γ rays. It was assumed initially that the apparatus gives rise to errors, and much time was lost in ascertaining their cause. Various experiments, however, not only failed to disclose an error but, conversely, gave compatible results, thus demonstrating the existence of Kx-γ correlations.

The apparatus consists of a proportional counter, a movable scintillation counter, and analyzing and recording equipment. The construction of the proportional counter is somewhat similar to that described earlier [2], except that the fiducial volume absorbs quanta in the required solid angle. The body of the fiducial volume is made of thin aluminum foil, so that the counting rate from the movable γ detector is the same for all angles, even $\nu = 0$, when the γ rays pass through the Kx-ray detector. Only pulses from the peak of the Kx rays of the proportional counter and from the photopeak of the γ rays of the scintillation counter are selected for the coincidences, so that corrections for distance are small.

We measured the number of coincidences simultaneously with the counting rate in the channels at four angles: 0, $\pi/2$, $2\pi/3$, and π. From the experimental data we calculated the expansion coefficients of the correlation function

$$W(\nu) = \sum_g A_g P_g(\cos \nu).$$

The experimental data reduction and the calculations of the coefficients A_g were by the same procedure as described by Rose [3].

The isotope Mn^{54} has a "convenient" decay scheme: one 0.835-MeV line, sufficiently short intermediate-state lifetime 1.2×10^{-11} sec, and allowed transition. We obtained