perature independent at higher temperatures), but the effect of the vacancies at low concentrations seems to be qualitatively predictable. We consider an individual vacancy as a region considerably smaller than the ion it replaces since the lattice is known to relax inward on a vacancy. The region, being deficient one positive ion, can be treated as a unit negative charge which will attract positrons. However, because the potential well is not deep, it is unlikely that it can restrain a positron within the small volume available and form a bound state. Instead, it merely increases the probability that the positron will annihilate with electrons in vacancy sites and thereby decreases the chance of annihilation with the competing core electrons and normal valence electrons. Since electron density in vacancy sites should be lower than elsewhere in the lattice, we can expect a general lowering of the annihilation rate as the vacancy density increases.

Quantitative correlation of our results with the activation energy of vacancies in the various metals[5] will certainly require a sophisticated model, but a compelling qualitative correlation is evident. It is a little surprising that we observe an effect in aluminum which has a vacancy activation energy of 0.76 eV, and this may imply that the positron itself collaborates in vacancy formation.

The data indicate that the positron may be a useful tool for studying metallic defects. In addition there is a clear warning that if lifetime measurements are to be used as a check on theory, they should be carried out on annealed samples at temperatures such that vacancy density is negligible.

We would like to thank the National Research Council of Canada for aid in the form of studentships (B.T.A.M. and A.B.M.) and for partial aid in the research and the External Aid Office for a Colombo Plan Scholarship (T.L.K.).

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MAGNETO-OPTICAL PROPERTIES OF TRANSPARENT $RbFeF_3$

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In this Letter we wish to report on some unusual magneto-optic effects in perovskite crystals of $RbFeF_3$. We believe that this is the first example of a ferromagnetic[1] crystal which (1) is transparent in the bulk to visible light, (2) has a very low saturation magnetization (≈ 250 G), (3) has a large magnetic rotation in the uv, visible, and near infrared at a temperature below 85°K, and (4) has good optical quality. To the best of our knowledge, no one of the previously reported[2-5] ferromagnets that are transparent in the visible has all four of these properties. Therefore, this material looks very interesting from the point of view of studies such as visual observations of domain structures[6] and some possible applications of these magneto-optic effects.[7-9] The work described in this Letter includes measurements on magnetic rotation, Cotton-Mouton effect, and optical absorption of $RbFeF_3$ at 82°K.

It has been established only recently[1,10] that $RbFeF_3$ remains paramagnetic from room temperature down to 102°K, becomes antiferromagnetic between 102 and 87°K, and then undergoes a transition to a state having a magnetization in zero field below 87°K. Testardi, Levinstein, and Guggenheim[11] have shown that the transition at 102°K is accompanied by a distortion to tetragonal symmetry. A distortion to an orthorhombic symmetry occurs at 86°K, and a further decrease in symmetry to a monoclinic-structure class occurs at 45°K.

All of our measurements were made on x-ray oriented single crystals of $RbFeF_3$ that were grown by a method described elsewhere.[1]

Crystals about 4 mm×3 mm in cross section and varying from 3.5 to 0.5 mm in thickness were used. Optical absorption at 300 and 82°K was measured between 3000 Å and 1.1 μ using a high resolution $\frac{1}{2}$-m Jarrell-Ash spectrometer and between 1.1 and 10 μ on a Beckman IR-7 spectrophotometer. Figure 1 shows the transmission behavior of $RbFeF_3$ at 300°K between 3000 and 9000 Å. For these measurements the direction of light propagation was along a [100] direction and no magnetic field was applied to the sample. The Fe^{2+} spectrum is quite weak except for an intense absorption near 9400 cm^{-1} with an absorption coefficient $\alpha = 31$ cm^{-1}. This strong absorption band is ascribed to the transition $^5T_{2g} \rightarrow {}^5E_g$, whereas the weak absorption peaks observed from 18 000 cm^{-1} upwards are believed to be the transitions $^5T_{2g} \rightarrow {}^3T_{1g}$, $\cdots$. Absorption data taken at 82°K were found to be essentially the same as those at 300°K.

The index of refraction at room temperature was obtained using the minimum deviation method on a small prism with [100] direction in the plane of its wedge. The index of refraction thus measured for the visible range of the spectrum is shown in Fig. 1.

Magnetic-rotation measurements were made on those samples that were used in the optical-absorption experiments. The direction of light propagation and the magnetic field was along [100]. The sample was cooled to 82°K in a cold-finger Dewar flask and the light source was a Bausch & Lomb monochromator in conjunction with a xenon high-pressure lamp. The proper magnitude of magnetic rotation was ascertained by making the observations with different crystal thicknesses and reversing the direction of the magnetic field with respect to the direction of light propagation.

The magnetic rotation in degrees per cm versus applied magnetic field H at the light wavelength 6330 Å is shown in Fig. 2. In this case the sample thickness was 1 mm. Poor extinction due to light scattering from the unsaturated magnetic domains was observed below $H = 150$ Oe. The magnetic rotation almost reaches its saturation value at $H = 300$ Oe. The wavelength dependence of rotation is shown in Fig. 1. The input light wavelength was varied at increments of 50 Å. No anomalous dispersion in the rotation was found between 3000 and 9000 Å. Furthermore, it was noticed that the measured rotation was independent of the direction of the input light polarization which was varied over a range of 90°. We were thus assured that our data were free from the effects of any structural birefringence. Probably the c axis of the orthorhombic structure that the sample assumes at this temperature lies in a [100] direction of the room-temperature cubic structure, but the deviation from tetragonality at 82°K is small.[11] We found no magnetic rotation with a sample having its [110] direction parallel to the direction of the applied

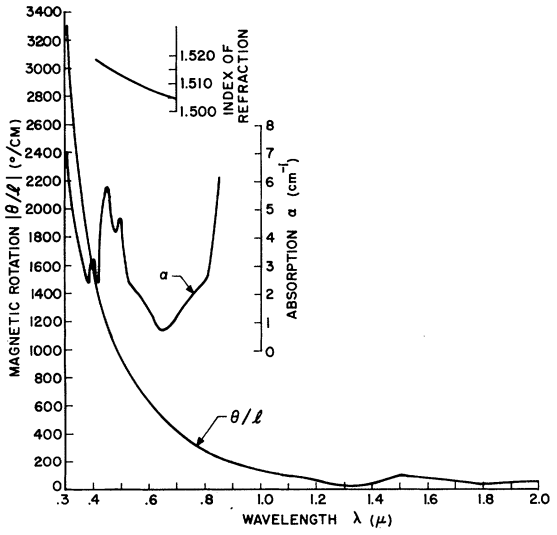

FIG. 1. Magnetic rotation in deg/cm (at 82°K) and the absorption in cm^{-1} (at 300°K) versus wavelength. The magnetic field was held at 3000 Oe during the rotation measurements. The index of refraction at room temperature is also shown.

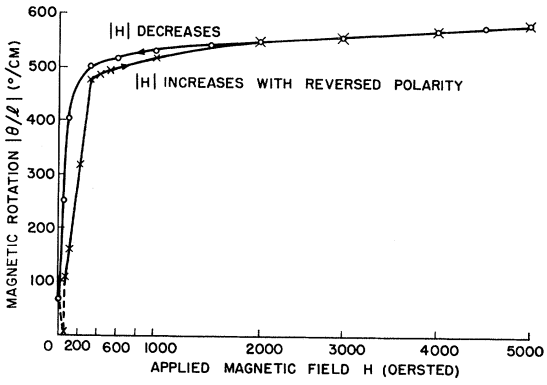

FIG. 2. Magnetic rotation in deg/cm versus applied magnetic field H in Oe. The wavelength is 0.633 μ and the temperature is 82°K.

magnetic field (up to 5000 Oe) at 82°K. The magnetic rotation was also measured as a function of temperature for a (100) plate at 6330 Å. It decreased from 570°/cm to 400°/cm as the temperature was raised from 80 to 85°K. The transmitted light then becomes elliptically polarized from 85 to 100°K and linearly polarized again at 100°K, but the rotation above 100°K was small.

Finally, the Cotton-Mouton effect (magnetic birefringence) at 82°K was measured by applying the magnetic field perpendicular to the direction of propagation of light, which was along the [100] direction of the sample. For this purpose a Babinet-Soleil compensator was used between the crossed polarizers. The difference of the indices of refraction $\Delta n = n_{\parallel} - n_{\perp}$, where $n_{\parallel}$ and $n_{\perp}$ are the indices parallel and perpendicular to the applied magnetic field, varies with magnetization. Δn was found to be negative and remained unchanged upon reversal of the magnetic field. The difference of Δn measured at $H = 5$ kOe and $H = 0$ was found to vary linearly with wavelength. It is 9×10^{-5} at 4000 Å and 1.6×10^{-4} at 8000 Å.

We wish to thank J. E. Geusic for his helpful discussions and R. P. Morris and D. W. Tipping for their technical assistance.

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CHARACTERISTIC EXTREME uv EMISSION FROM CHANNELED POSITIVE IONS*

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The phenomenon known as "channeling" has been studied by many.[1,2] Although different methods have been used, basically they all have as a common ground the observation of a reaction that takes place at the lattice points of the crystal under investigation. To enumerate, one would mention the study of the emission of x-ray characteristic lines from a single crystal,[3] the scattering of protons from the nuclei of a single crystal,[4] the emission of beta particles from radioactive nuclei embedded in the crystal,[5] etc.

In the present work, experiments have been conducted to measure the photon yield resulting from neutralizing the incident charged particles. The intensity of such emission is observed as a function of the orientation of the planes of a single crystal with respect to the direction of incidence of the impinging collimated beam.

A single crystal of copper was cut, cleaned, and mounted in a crystal holder,[6] and then exposed to a monoenergetic (±0.5%) beam of protons. The incident beam was collimated to about ±0.2°. The intensity of the Cu L radiation was measured by means of a proportion-