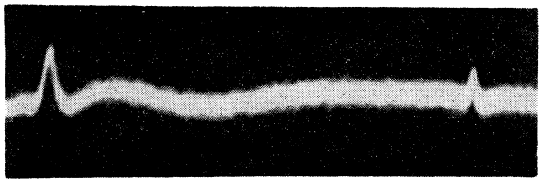
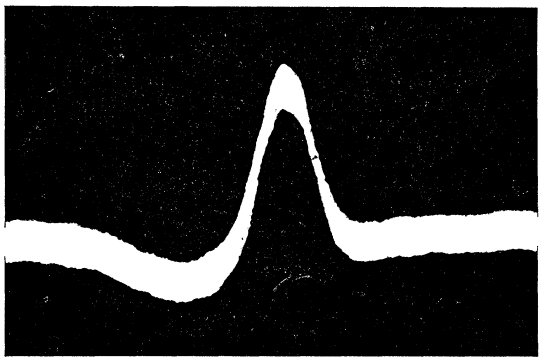


λ = 0.78 mm

FIG. 2. Cathode-ray display of two of the three hyperfine components of the $J=0 \rightarrow 1$ transition of HI at 0.778-mm wavelength. The line to the left is the $F=5/2 \rightarrow 7/2$ component, and the one to the right is the $F=5/2 \rightarrow 3/2$ component. These two components observed on the same scope trace are 163.3 Mc/sec apart. The klystron mode would not cover all three components in a single sweep.

With the klystron harmonic method, high precision and high resolution together with convenient frequency sweep and automatic display spectroscopy are, in



λ = 0.87 mm

FIG. 3. Cathode-ray display of the $J=2 \rightarrow 3$ transition of $C^{12}O^{18}$ at 0.867-mm wavelength (345 802 Mc/sec). The line width is about 1 Mc/sec.

effect, achieved as soon as usuable harmonic power can be detected. The signal-to-noise ratio obtainable in the submillimeter region with a low-power, centimeter-wave klystron as the primary source is indeed remarkable.

TABLE II. Molecular constants[a] of HI^{127}.

$eqQ(I^{127}) = 1831.0 \pm 1.0$	$C_I(I^{127}) = 0.26$ Mc/sec
$B_0 = 192\,658.6$ Mc/sec	$r_0 = 1.61970$ A
$B_e = 195\,229.1$ Mc/sec	$r_e = 1.60904$ A

[a] The infrared values of $D_0 = 0.00020$ cm^{-1} and $\alpha = 0.1715$ cm^{-1} from Boyd and Thompson[4] are used in the calculation of B and r. Atomic constants are from J. W. M. DuMond and E. R. Cohen, Revs. Modern Phys. 25, 691 (1953).

With the same klystrons six years ago we were pleased, even excited, to generate usable harmonic power in the 3- to 4-millimeter wave region.

* This research was supported by the U. S. Air Force through the Office of Scientific Research of the Air Research and Development Command.

[1] W. C. King and W. Gordy, Phys. Rev. **90**, 319 (1953); **93**, 407 (1954). C. A. Burrus and W. Gordy, Phys. Rev. **92**, 274 (1953); **92**, 1437 (1953).
[2] C. A. Burrus and W. Gordy, Phys. Rev. **93**, 897 (1954); **101**, 599 (1956).
[3] M. Czerny, Z. Physik **44**, 235 (1927).
[4] R. D. Boyd and R. J. Thompson, Spectrochim. Acta **5**, 308 (1952).
[5] Bedard, Gallagher, and Johnson, Phys. Rev. **92**, 1440 (1953).
[6] Gilliam, Johnson, and Gordy, Phys. Rev. **78**, 140 (1950).
[7] Plyler, Blaine, and Connor, J. Opt. Soc. Am. **45**, 102 (1955).

Magnetic Domains in Thin Films by the Faraday Effect*

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(Received August 30, 1956)

THE Kerr magneto-optic technique has proved well suited for photographing magnetic domains in evaporated thin films of ferromagnetic material, but the method begins to lose effectiveness for films thin enough to be transparent, principally because of the decreased intensity of the reflected light.[1] Inasmuch as the loss of reflected intensity is accompanied by an increase in the transmitted light, utilizing the magnetic rotation of the polarization in the transmitted beam (Faraday effect) naturally suggests itself. If the domains lie parallel to the film surface, no rotation will occur for the perpendicular passage of a polarized beam, but for oblique transmission a rotation proportional to the component of magnetization along the transmitted beam should develop.

To test the idea, we have accordingly made the obvious modifications in our Kerr reflection arrangement[2] in order to make observation by direct transmission possible, i.e., aligned on a single optical bench the source, collimator lens, polarizer, specimen, analyzer, and camera. The specimen was a NiFe film (80% nickel) of 500 angstrom thickness whose domain behavior we had previously investigated by the reflection technique. This film prefers to exist as a single domain, but it will occasionally develop multiple domain structure if carefully disturbed with a coercing field.

With the film surface normal to the incident beam, magnetization reversals caused no measurable rotation of the polarization plane as observed with the photocell monitor, but with oblique passage of the light a Faraday rotation associated with the magnetization reversal appeared, its magnitude increasing with the obliquity. Inasmuch as the difficulty of satisfactorily photographing the entire surface also increases with obliqueness, we set the angle at 45°. For this angle the Faraday rotation accompanying a reversal of magnetization amounted to about 9 minutes, a value sufficiently large to reveal adjacent domains photographically.

Figure 1 shows two photographs of the 500-angstrom specimen in the same partially magnetized state, the upper picture taken in reflection by the Kerr method, the lower photograph obtained in transmission by the Faraday effect. The improvement in sharpness, in

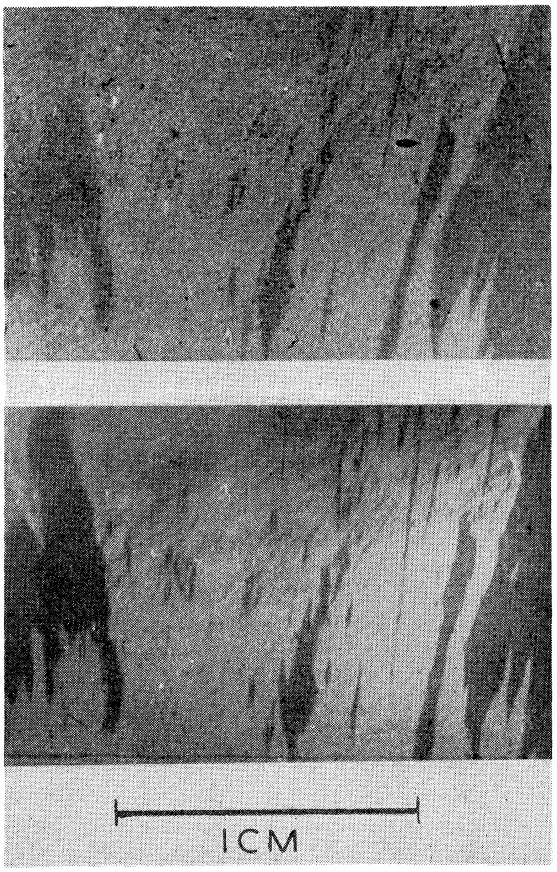

FIG. 1. Photographs of the domain structure of a transparent NiFe film in the same magnetic state, taken (upper) with the Kerr magneto-optic reflection technique and (lower) with the transmission method utilizing the Faraday effect.

contrast, and in decreased surface imperfections is apparent in the transmission case, whose photographic exposure time was only one quarter that required for the reflection picture. We would conclude that the method is a practicable one for observing domains in transparent ferromagnetic films, and are proceeding with an investigation of much thinner specimens.

* Supported by the Office of Naval Research.

[1] Fowler, Fryer, and Stevens, Phys. Rev. **104**, 645 (1956).
[2] C. A. Fowler and E. M. Fryer, Phys. Rev. **94**, 52 (1954).

Hyperfine Structure of K^{39} in the $4P$ State and of Cs^{133} in the $6P$ State*

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THE atomic-beam resonance method has been used to investigate the hyperfine structure of the $4P$ excited state of K^{39} and the $6P$ excited state of Cs^{133}. For cesium, the apparatus and method of observation were the same as those used in a previous experiment on the $5P$ state of rubidium.[1] For potassium, certain important modifications were necessary.

TABLE I. Results of ten runs on the $6P_{\frac{3}{2}}$ spectrum of Cs^{133}.

Transition	Center frequency of observed resonance in Mc/sec	Average in Mc/sec
$F=3$ to $F=2$	152.2, 151.2, 152.2, 152.5	152.0±0.8
$F=4$ to $F=3$	202.9, 204.0, 201.5, 203.5	203.0±1.1
$F=4$ to $F=5$	252.6, 252.4	252.5±1.0

In Cs^{133}, three resonances were observed in the $6P_{\frac{3}{2}}$ state at near-zero static magnetic field. The results of ten runs are given in Table I.

With this arrangement, we were able to observe a partially resolved resonance at a frequency of 20.1±0.4 Mc/sec. Four runs were taken on this resonance and the results are shown in Table II.

In the $6P_{\frac{3}{2}}$ state of Cs^{133}, the three hyperfine level separations are given by

$$5a+(5/7)b \quad \text{for} \quad F=5 \quad \text{to} \quad F=4,$$
$$4a-(2/7)b \quad \text{for} \quad F=4 \quad \text{to} \quad F=3,$$
$$3a-(5/7)b \quad \text{for} \quad F=3 \quad \text{to} \quad F=2.$$

The assignment of individual resonances to a particular transition can be made uniquely as follows:

$$252.5 \text{ Mc/sec}: \quad F=5 \text{ to } F=4,$$
$$203.0 \text{ Mc/sec}: \quad F=4 \text{ to } F=3,$$
$$152.0 \text{ Mc/sec}: \quad F=3 \text{ to } F=2.$$

The interaction constants a and b are then

$$a=50.67\pm0.11 \text{ Mc/sec}, \quad b=-0.46\pm0.53 \text{ Mc/sec}.$$

The corresponding value of Q is

$$Q=(-0.0033\pm0.0039)\times10^{-24} \text{ cm}^2.$$

For potassium it was impossible to find the $4P_{\frac{3}{2}}$ resonances with the apparatus as previously described,[2] because the ground state rf effect,[2] due to the transition $F=2$, $m_F=-2$ to $F=2$, $m_F=-1$ in the region of interest (20 Mc/sec) gave signals on the recorder twenty to fifty times as large as the expected excited-state rf effect. It was not possible to read the excited-state rf effect on top of this ground-state effect and its associated fluctuations directly. The following scheme sufficed to avoid the problem.

In addition to the high-power square-wave modulated rf current used to study the excited-state rf effect, an unmodulated rf current of 50 ma at a frequency of 1.5 Mc/sec was put into the hairpin. This served to

TABLE II. Center frequency of $F=3$ to $F=2$ transition in $4P_{\frac{3}{2}}$ state of K^{39}.

Run	Observed frequency in Mc/sec	Average in Mc/sec
1, 2, 3, 4	20.2, 20.5, 19.8, 20.0	20.1±0.4

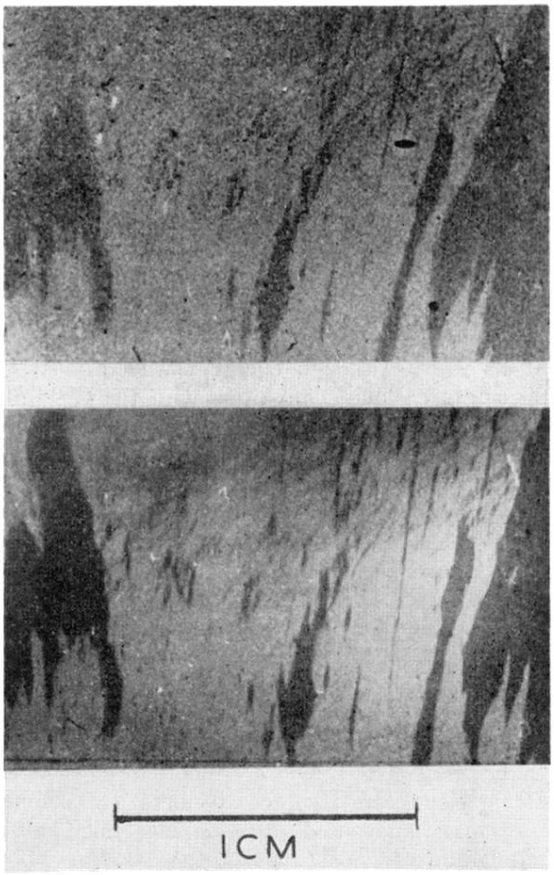

FIG. 1. Photographs of the domain structure of a transparent NiFe film in the same magnetic state, taken (upper) with the Kerr magneto-optic reflection technique and (lower) with the transmission method utilizing the Faraday effect.