The Lummer-Gehrke plate delivers a bundle of fringes of successively increasing optical path difference , *Fig. 4.* As the wavelength of the components of the split lines changes, this has the same apparent effect as a change in the optical path difference, so that the fringe pattern shifts.

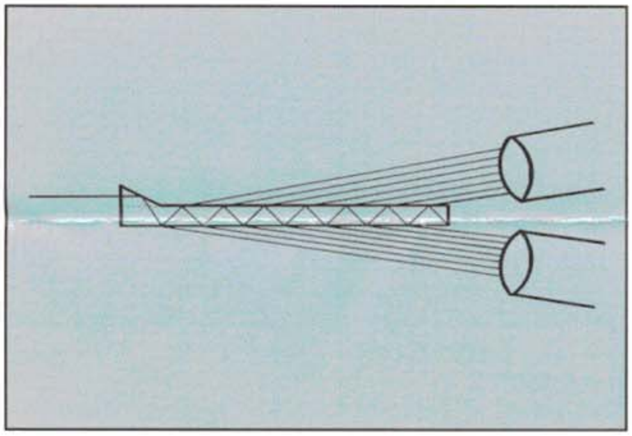

Figure 4. **The Lummer-Gehrke Interferometer**

A wavelength difference $\Delta\lambda$ can thus be expressed in terms of the separation of neighboring fringes. The starting point is the expression for $\Delta\lambda$ at the Lummer-Gehrke plate in terms of the plate thickness, d, and the refractive index of its material, n :

$$\Delta\lambda = \frac{\lambda^2}{2d} \quad \frac{\sqrt{n^2-1}}{n^2-1-n\lambda\cdot\frac{dn}{d\lambda}},$$

or $$\Delta\lambda = \frac{\lambda^2}{2d}\cdot\frac{\sqrt{n^2-1}}{n^2-1}, \qquad \text{since } \frac{dn}{d\lambda} \text{ is small.}$$

The separation of the Zeeman components of the line for a given magnetic field strength can be measured relative to the inter-fringe separation by lining up the crosshairs of the telescope on the appropriate lines and reading the corresponding positions, s, of the telescope on the dial gauge. Since all the quantities involved are small, we can use:

$$\frac{\delta\lambda}{\Delta\lambda} \quad \frac{\delta s}{\Delta s}$$

to a good approximation for the relative fringe separation (Δs) and the displacements of the split lines (δs). Applying the formula for $\Delta\lambda$ from above,

$$\delta\lambda = \frac{\delta s}{\Delta s} \quad \frac{\lambda^2}{2d} \quad \frac{\sqrt{n^2-1}}{n^2-1}$$

With $|\delta\nu| = \frac{c}{\lambda^2}\cdot\delta\lambda$, we obtain:

$$\frac{B}{4\pi}\cdot\frac{e}{m} = |\delta\nu| = \frac{c}{\lambda^2}\cdot\delta\lambda = \frac{c}{2d} \quad \frac{\sqrt{n^2-1}}{n^2-1}\cdot\frac{\delta s}{\Delta s}$$

so $$\frac{e}{m} = \frac{4\pi c}{B}\cdot\frac{\sqrt{n^2-1}}{2d(n^2-1)}\cdot\frac{\delta s}{\Delta s}$$

APPARATUS

The apparatus needed for these experiments is:

Name	Item #
Optical System for Zeeman Effect	47120
Lummer-Gehrke Plate	47121
Cadmium Lamp Unit	45112
Lamp Power Unit	45133
Electromagnet for Zeeman Effect	51450
DC Power Supply, 12V/20A, regulated	52247
Gaussmeter with 1T range,	
such as: Hall Effect Gaussmeter	78562-02
Multimeter with 10 A range,	
such as: Portable Digital Multimeter	31252
Patch cords for hookup (with banana plugs)	

To order or for more information, call:

1-800-268-4355

SETUP AND PROCEDURE

The experimental setup is as shown in *Fig.1.* The electromagnet can be rotated on the base to enable the optical viewing unit to observe either axially or transversely. The Hg-Cd lamp is fitted into its holder betwen the pole pieces, the pole piece separation adjusted to be as small as possible while still allowing the probe of a Hall effect gaussmeter to be inserted into the center of the field with the lamp removed from its holder, and the pole pieces are clamped firmly in place to ensure that they do not shift when the magnetic field is applied. The operating instructions give details of the connection of the electromagnet to a power supply. For a field of 0.75 Tesla (Wb/m^2), a current of about 20 A at 7V is required if the windings are connected in parallel.

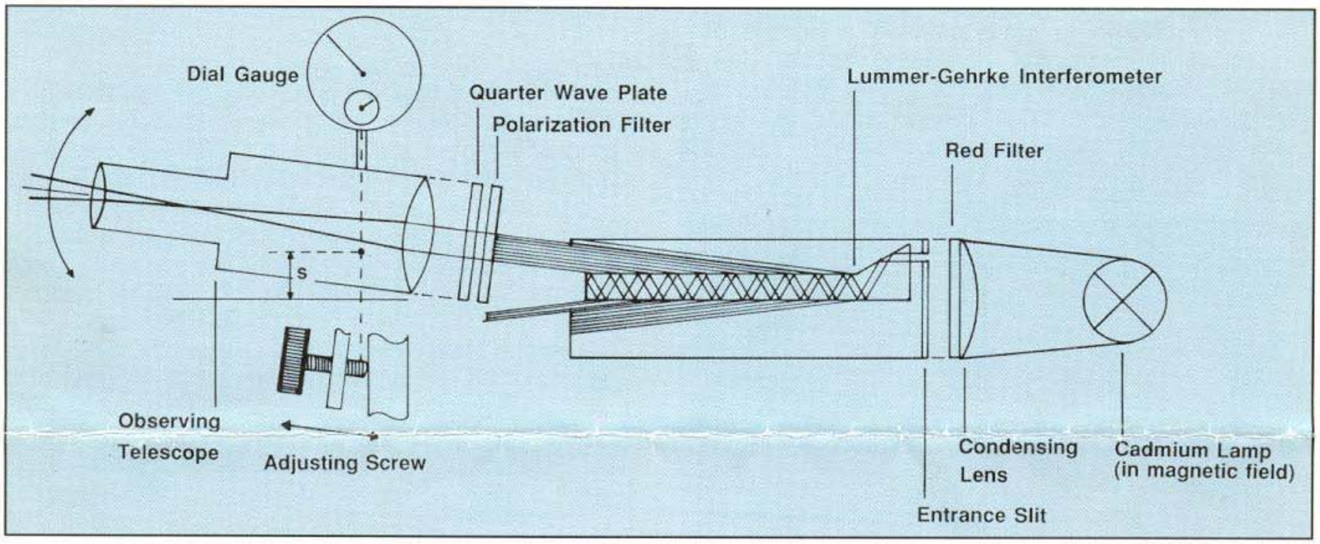

Figure 5. Block diagram of the optical arrangement.

Terminals for serial connection are provided, to accommodate power supplies with different characteristics. Before making optical measurements, the field/current characteristic of the electromagnet for the position of the pole pieces as set up is measured using a Hall effect gaussmeter.

A schematic diagram of the optical arrangement of the viewing unit is given in *Fig.5.* Great care is used in placing the Lummer-Gehrke plate into its holder, to avoid damaging its surface, which has been polished to be flat to within 0.01μm. The telescope is arranged and focused to view the fringe pattern at grazing incidence, close to the edge of the pattern closest to the axis of the plate. It is important to make all measurements on the same line pair, since the spacing of the lines is not uniform. A fine adjustment screw allows the crosshair in the telescope eyepiece to be centered on a line, and the dial gauge then gives a position reading. The separation of two neighboring lines at zero field is measured, and a field of known value is applied, observing in a transverse direction. The polarization filter is rotated until the unshifted central line of the triplet is in extinction. The separation of the outer two components is then measured. The Zeeman shift is then one-half this value. This procedure is then repeated for several different values of the magnetic field.

The results demonstrate the linearity of the Zeeman split with field strength, and enable e/m to be estimated from the slope of the line. A typical set of values obtained is:

$I = 20$ A, $B = 0.77$ T, $\Delta s = 0.15$ mm (line separation), $\delta s = 0.04$ mm (Zeeman displacement)

For the Lummer-Gehrke plate : $d = 4.04$ mm, $n = 1.4567$.
This yields a value of 1.48×10^{11} C/kg for e/m. (Accepted value: 1.76×10^{11} C/kg)

Rotating the polarization filter alone when observing the triplet shows that all components are linearly polarized, but the plane of polarization for the unshifted line is perpendicular to that of the two outer components. If the electromagnet is rotated by 90° and the telescope refocused on the interference pattern generated from the axially transmitted light, a doublet is seen. There is no extinction position found for these lines on rotating the polarization filter, but rotation of the quarter wave plate produces alternate extinctions of the two components, in accordance with their circular polarization state.

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