5.3 Zeeman Effect

The explanation of the discrete emission spectra at the beginning of this century considerably aided the development of modern nuclear and quantum physics. Based on the success of Maxwell's electromagnetic theory of light, early experiments were made on the influence of electric and magnetic fields on the emission of light.

In the simplest case of the so-called "normal" Zeeman effect some spectral lines show a splitting into triplets when observed perpendicular to the magnetic field. Because of the magnetic moment of the electron with charge $e$ and mass $m$ the frequency shift $\delta$ of the equidistant components at a magnetic field strength $B$ can be described by:

$$\delta n = n \left( \frac{e}{2m} \right) B$$

In order to observe the Zeeman splitting in the experiment arrangement of this topic set, one of the spectral lines of cadmium light is filtered out. The virtually monochromatic light is passed to an interference spectrometer (resolution 0.01 nm) represented by a Lummer-Gehrcke plate. The interference pattern created by the plate can be viewed at different angles with the telescope. This contains cross hairs, and its adjustment can be read off from a micrometer dial gauge. Polarizers inserted between the plate and the telescope allow the determination of the sense of polarization of the Zeeman components. When plotting the measured amount of splitting (frequency shift) as a function of magnetic field strength, the proportionality as demanded by theory is verified. From the slope of the straight line the specific charge of the electron can be calculated.
Interference fringes issued in grazing beams from a Lummer-Gehrcke-plate

Splitting-up while observing the triplet, $ds = \frac{1}{3} \Delta s$

a) before switching on the magnetic field
b) after switching on the magnetic field

Measuring the Zeeman splitting

Polarization of the triplet $a$ and the doublet $b$
451 12 Cadmium lamp
Special design for observing the Zeeman effect. With a rotatable, height-adjustable screwed socket on a holding plate for attachment to the electromagnet for the Zeeman effect (514.50).
- Operating current: 1.0 A
- Connection: cable with multiple plug
- Diameter: 8 mm
- Dimensions: 15 cm x 15 cm x 8 cm

Additionally required:
Universal choke 230 V, 50 Hz. ………... 451 30

451 30 Universal choke in housing
For operating the spectral lamps (450.011–111), the high-pressure mercury lamp (451 15) and the cadmium lamp (451 12).

For further information, see catalogue section 3.2.2, page 151

471 20 Optical system for observing the Zeeman effect
Consisting of holder for Lummer-Gehrcke plate (471 21), observation telescope and basic plate with rotatable platform for the electromagnet (514.50). Without Lummer-Gehrcke plate and electromagnet.
Specifications:
- Base plate dimensions: 41 cm x 26 cm
- Height of the unit with assembled electromagnet, pole pieces and lamp socket 68 cm
- Weight without magnet: 4 kg

514 50 Electromagnet for Zeeman effect
Including pole pieces and clamp. Recommended current: 20 A approx.
- Flux for a pole-piece spacing of 1 cm: 0.7 T max.
- Pole pieces:
  - Cross section: 8 cm x 8 cm
  - Diameter of the pointed end: 22 mm
- Base:
  - Diameter: 8 mm
- Magnet:
  - Dimensions: 26 cm x 35 cm x 15 cm
- Weight: 42 kg
- Connection: via two pairs of 4-mm sockets

471 21 Lummer-Gehrcke plate
For observing the Zeeman effect with the optical system (471 50).
- Resolution for λ = 434.8 nm ≥ 50 000
- Dimensions: 190 mm x 19 mm x 4 mm