Experiments “Faraday Rotation” and “Charge-Mass Ratio of Electrons”

Verdet Constant	**Axial Magnetic Field**	**Different LED**
Charge-Mass Ratio	**Malus Law**	**Polarization Modulation**
Effective Mass	**Birefringence**	**Free Space Data Transfer**
Density of Dispersion Electrons	**Zeeman Effect**	**Faraday Rotation**

Experiment “Faraday Rotation“ for atomic physics lab courses to measure *Verdet-Constants*, C*harge-Mass Ratio*, *Effective Mass*, and *Density of Dispersion Electrons*

Complete set up of the “Faraday Rotation lab experiment” realized with our supplementary kit

You see from left to right on the optical bench: LED, convex lens, polariser, iris aperture, magnetic coil with glass cuboid, analyser, convex lens, detector. You need also one multimeter to measure the ac-current through the coil, a multimeter for the dc-detector signal occurring at the 45° analyser position and an oscilloscope for the ac-detector signal due to magnetic field modulation generated by the yellow controller box.

By this experiment it is proved that electrons are responsible for optical properties of a medium (here glass). You learn only some of the weakly bound outer electrons interact with light. These are called dispersion electrons.

Educational objectives:

- dielectric function of a transparent, dielectric, and nonmagnetic medium
- dispersion theory, oscillator model, Sellmeier equation
- gradient of an axial magnetic field in a short coil
- Zeeman Effect in an axial field, linear and circular polarized light, Malus Law
- magnetic field induced birefringence, contrast, polarisation degree
- experience with multimeter, oscilloscope and low-pass filter
- modulation technique to measure small values exactly
- spectra of different light emitting diodes
- density of dispersion electrons, charge-mass ratio of electrons

Abstract / Background:

Using an oscillator model for the UV-absorption, the dielectric function and so the spectral behavior of the refractive index can be obtained. Within a magnetic field the dispersion electrons are subject to the Lorentz Force. The Zeeman Splitting of the resonance in an axial magnetic field produces different refractive indices for left and right circular polarized light – even in the transparent region far from the resonance. Thus, linear polarized light experiences double refraction when it is transmitted through a dielectric and nonmagnetic medium. This so-called "magnetic field induced birefringence" leads to a rotation of the polarization plane which is known as Faraday Rotation.

In our experiment "Faraday Rotation", the rotation angles are measured in dependence on the axial magnetic field strength at different wavelengths using LEDs as light sources. The medium is a simple N-BK7 (crown) or SF 10 (dense flint) glass cuboid in a magnetic coil. A modulation technique is used to measure the small rotation angles exactly. So that, the Verdet Constants at different wavelengths can be calculated and the effective mass of the dispersion electrons as well as their density are obtained. The setup can also be used to demonstrate Free Space Information Transfer, e.g. music, via light beam (LED or laser) by polarization modulation.

Kit content:

- five LED light sources with different wavelengths in the visible spectral region (optionally with five single housings or with one common base LED-holder for easier change and adjustment) and power supply
- magnetic coil with holder, diaphragm and rectangular opening for glass cuboids
- two cuboids made of crown and of dense flint glass
- generator with two selectable frequencies and 20 W amplifier
  (and with 3.5 mm-AUX input to demonstrate e.g. Free Space Music Transfer via light by polarization modulation)
- detector (photodiode with OPV, single supply), optional with integrated switch and battery
- tutorial / theory and measuring tasks / best practice – standard solution
- extras (only in the **extended kit** FP-A-2020-E):
  one-mode semiconductor laser, loudspeaker with amplifier, connection cables (phone jacks, BNC/phone jack)

Basic Kit "Faraday Rotation"

Extended Kit "Faraday Rotation including additional lecture hall demo: Free Space Information Transfer"

Idea and Concept of the Supplementary Kits:

The supplementary kits contain only specific elements for this experiment. To realize the Faraday Rotation Experiment experiment, you need beside these specific elements of the "Supplementary Faraday Rotation Kit" (1 or 2) some standard optical elements from your own basic equipment:

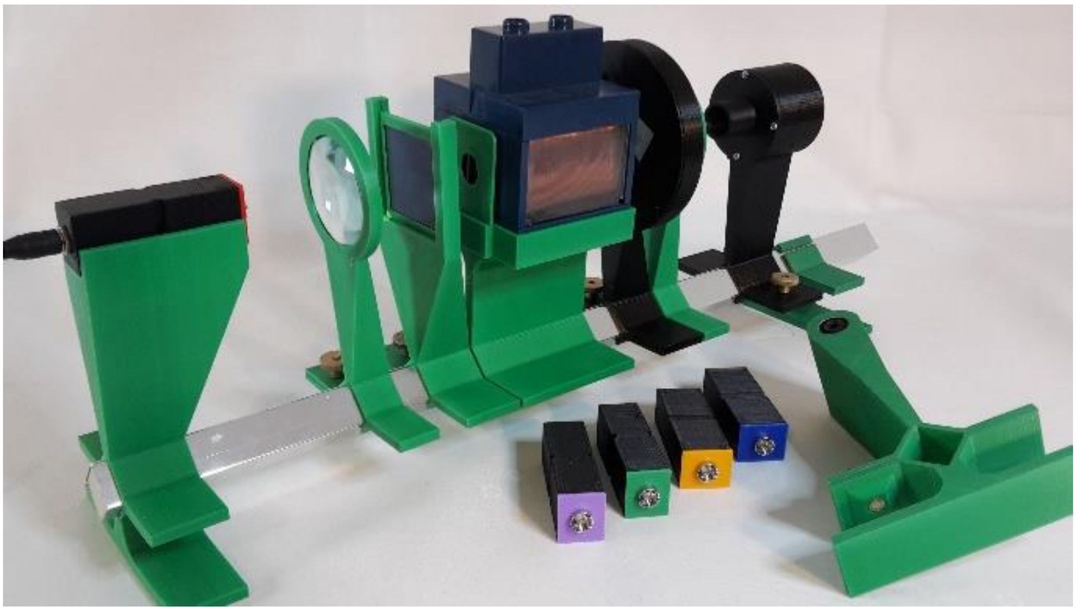
- optical bench with six standard holders
- two focus lenses (in the range from 50 to 100 mm focal length)
- polarizer and analyser
- two multimeters and a standard oscilloscope

Supplementary Kit Versions:

(1) basic supplementary kit "Faraday Rotation" for pupils' and students' laboratory courses
(2) extended supplementary kit "Faraday Rotation + Demo" containing an additional lecture hall demo experiment „Free Space Music Transfer via Laser Beam by Magnetic Field Induced Polarisation Modulation in Glass"

All-Round Complete Experiment for Schools to measure Charge-Mass Ratio of Electrons optically:

(3) **school version "Electron charge-mass-ratio"** contains **all optical components** economically priced and the controller (generator with amplifier). Optional with a second bench for the "Free Space Music Transfer".



Complete School Experiment „Measurement of the electron charge-mass ratio" via magnetic field induced birefringence (Faraday Rotation) with all optical parts and generator/amplifier (not shown in the picture)