Magneto-optics – Instruction Notes

Keywords: Faraday effect, Cotton-Mouton effect, Jones calculus, polarisation

I. GOALS OF THE EXPERIMENT

A magnetic field applied to an isotropic body can break the symmetry of this body resulting in the induced birefringence. In addition to the Faraday effect, which is proportional to the strength of the applied field, one also observes a second order effect, the Cotton - Mouton effect (CME). The CME is used to measure magnetic and electrical properties of molecules in transparent substances, but also for plasma diagnosis in Tokamaks. In the case of symmetrical molecules, magnetic field-induced anisotropic susceptibility is of particular interest.

The molar Cotton-Mouton constants (CM constants) determined at different particle densities provide information about the microstructure of liquids or liquid-like states.
The goal of the magneto-optics experiment is to deepen the understanding of the light propagation according to the theory of the electromagnetic field. In particular, the magnetically induced birefringence of transparent liquids will be investigated considering the classical orientation theory (1932). The de Sénarmont compensator is used as an example of novel optical measurement techniques. This requires detailed knowledge of polarization and birefringence of light and their representation by Jones vectors and Jones matrices.

II. LEARNING CONTENT

- polarisation: generation and types of polarized light, polarizers, birefringence, optical activity, optically uniaxial crystals, λ / 4 plates, Jones vectors and matrices
- magneto-optical effects: Maxwell equations, diamagnetism, paramagnetism, polarization and magnetization, Faraday effect, Coutton - Mouton effect
- CME: hertzian dipole, orientation theory according to Born (1932) for the explanation of CME, polarizability and susceptibility tensor especially for symmetric molecules, phenomenological and molar CM-constant
- measurement techniques: de Sénarmont compensator, lock-in amplifier, photodiode, resolution power of the apparatus

III. PROCEDURE

- determine the transfer equation of the apparatus using Jones matrices
- determine the strength of the magnetic field B(z) with the magnetic field probe.
- specify the modified Verdet constant V of the Farady compensator in units of rad / mA.
- determine the resolution limit of the apparatus
- measure the CME of benzene, mesithylene and carbon disulfide. The calculated profile strength applies to the maximum current through the solenoid. Make five measurements per sample in the field direction and five measurements in the opposite direction of the field,

considering also the temperature. Represent the phase differences in multiples of π.

- calculate the phenomenological CM constants in $T^{-2}\ m^{-1}$
- calculate the molar CM constants in $m^3\ T^{-2}\ mol^{-1}$
- calculate the molar susceptibility anisotropies in in $m^3 mol^{-1}$

IV. REFERENCES:

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