SC Optical activity and saccharimetry

1. Motivation

Some crystals and many liquids affect the polarization direction of light. This characteristic is called optical activity and has important applications, e.g. in determination of the concentration in chemistry. In this experiment the characteristics of the optical activity of sugar solutions are examined by means of saccharimetry.

2. Bases/Theory

- Licht als elektomagnetische Welle
  (Staudt Skript II, Kap. 8.1 oder E. Hecht, Optik, Kap. 3.2, 3.4)
- Unterschied geometrische Optik/Wellenoptik
  (Staudt Skript II, Kap. 8.1 oder E. Hecht, Optik, Kap. 4.2.3, 5.1)
- Polarisation von Licht
  (Staudt Skript II, Kap. 8.3.1 oder E. Hecht, Optik, Kap. 8.1)
- Doppelbrechung
  (Staudt Skript II, Kap. 8.3.1 oder E. Hecht, Optik, Kap. 8.4)
- Zirkular polarisiertes Licht
  (Staudt Skript II, Kap. 8.3.2 oder E. Hecht, Optik, Kap. 8.1, 8.8)
- Optische Aktivität
  (Staudt Skript II, Kap. 8.3.3 oder E. Hecht, Optik, Kap. 8.10)

Questions:

- When are the optical phenomena described by geometrical optics? When is the wave property of light needed for the explanation? How is a light wave described? How is light produced?
- What is linearly polarized light? How is natural light polarized and how can linearly polarized light be produced from it? How can polarized light be evidenced?
- What is circularly polarized light? How can circularly polarized light be produced? How can circularly polarized light be evidenced?
- What does one understand by refraction? How is the refractive index defined? What is dispersion?
- What is birefringence?
- What is the optical activity? How does the equation for the rotation angle read? What is the rotation dispersion?
- How can the optical activity be explained microscopically?

3. Description of the experiment

In the experiment the optical activity of different solutions (glucose, fructose) is investigated with a *Halbschattenpolarimeter (Polarimeter nach Loppich).*

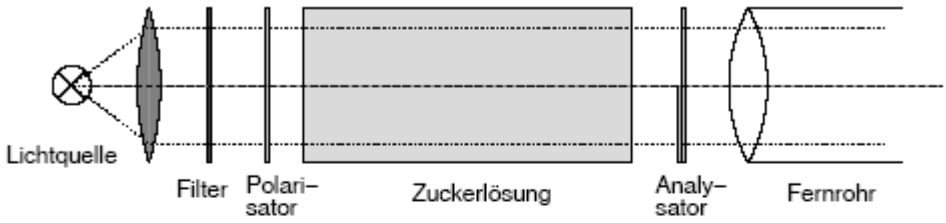

Abbildung SC.1: Halbschattenpolarimeter

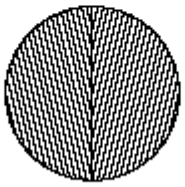

Abbildung SC.2: Geteilter Analysator

With the *Halbschattenpolarimeter* the analyzer is divided into two parts with slightly different polarization angles. For the determination of the rotation angles the position is adjusted, such that both halfs are equivalently dark or equivalently bright, respectivelly. This way a higher accuracy can be achieved than when the position of a minimum (relatively spread) is adjusted.

Firstly the rotation dispersion is experimentally examined with different wavelengths for sugar solutions of a certain concentration. Moreover the specific rotatoy power *(drehvermögen)* of different kinds of sugar are to be determined for given wavelengths. Finally the concentration of some unknown sugar solutions is measured. The length which puts back the light in the sugar solution is $l = 20$ cm in each case.

4. Measurements

1. Determination of the two zero-points of the saccharimeters without inserted filters:
   Measure without sugar solution as exactly as possible the four angles, with which the two halfs of the analyzer are equivalently bright or equivalently dark, respectivelly (measure several times!).
2. Measurement of the rotation dispersion:
   Measure the rotation angle of one fructose and glucose solution of high concentration, with 4 different wavelengths in each case.
   Determine in each case the angles with which both halfs are equally bright, and the angles with which both halfs are equivalently dark. Try to estimate for each angle an error.
3. Determination of the zero point of the saccharimeters with fix inserted interference filter ($\lambda = 589$ nm):
   Measure without sugar solution as exactly as possible, the angle with which the two halfs of the analyzer are equivalently dark (may be measure several times!).
4. Measurement of the rotatpry power:
   Measure the angle of rotation of 4 fructose and 4 glucose solutions with well-known concentrations at one wavelength (saccharimeter from 3.). Estimate an error in each case.

5. Determination of the concentration of 4 different solutions:
   Measure the rotation angle of four unknown samples two to three times each; estimate also here an error in each case.

5. Evaluation

1. Represent the measurements to the rotation dispersion for fructose and glucose in $\Phi_{(\lambda)}$ diagrams. Draw the error margins to the measured values. Is the dependence of the rotation dispersion from the wavelength consistent with the dependence of the refractive index *n* with materials such as glass?
2. Using the results from the samples with known concentration draw one diagram for each kind of sugar, in which you represent the rotation angle (with error margins) as function of the concentration. Determine from the slope of the graphic (fit) the specific rotatory power Φ_0 for glucose and fructose.
   Try to estimate from the diagram an error for Φ_0.
3. Identify with the specific rotatory power determined above the kind of sugar and concentration of the unknown samples.