Light Diffraction – Instruction Notes

Keywords: interference, diffraction, Fourier transform, Fourier optics, spatial filter

I. GOALS OF THE EXPERIMENT

Diffraction of X-ray, electron and neutron beams on molecules in gases, liquids and solids provides important information about the structure of the objects. The interpretation of the diffraction patterns becomes more difficult if the arrangement of the object components deviates from a strict periodicity. Semi-empirical analogy experiments performed with visible light on correspondingly enlarged models of the presumed structure can be applied. In this way, the correspondence between theoretical approach and experiment can be revised. This experiment offers insights into the mathematical methods for the analysis of diffraction patterns of simple geometric objects. Additionally, the students will learn to conduct material test and verify the validity of specific hypotheses used in structural analysis.

II. LEARNING CONTENT

- Fourier and inverse transforms
- transforms of several functions: gaussian, rectangular, cylindrical, delta functions
- definition of the convolution integral of two functions
- convolution theorem of Fourier transforms
- theory of geometric diffraction
- principle of Huygens, Fresnel zones
- Kirchhoff, Fresnel, Fraunhofer diffraction
- lattice defects
- calculation of the diffraction intensity in single slit, circular aperture, wire, doubleslit, grating with N rulings, circular grating
- blackening curves of films
- film analysis

III. PROCEDURE

Wear laser googles!

- experimental setup
- expand of the laser beam with spatial filtering, diffraction arrangement according to Fraunhofer
- measure the intensity distribution of one-dimensional diffraction objects
- collect the diffraction images of the n two-dimensional diffraction objects with plan films
- analysis of the diffraction figures and comparison with calculated patterns
- qualitative analysis of the structure of an unknown diffraction object.

IV. REFERENCES:

(1) Max Born, Emil Wolf, *Principles of Optics: Electromagnetic Theory of Propagation, Interference and Diffraction of Light*, Cambridge (1999).

(2) Joseph W. Goodman, *Introduction to Fourier Optics*, 3rd Ed., Roberts (2016).

(3) E. Hecht, *Optics*, 4th Ed., Peason (2008).

(4) Klein, Furtak, *Optics*, 2nd Ed., Wiley (1986).

(5) Champeney, *Fouriertransforms and their physical applications*, Academic Press, (1973).