Laserphysik

WS 2017/2018 **1. Exercise sheet** **18.10.2017**

Lecture: Prof. Dr. Alejandro Saenz, Prof. Dr. Oliver Benson

Prepare your answers for the exercise on 25.10.2017.

Problem 1: Polarization

a) Consider a plane wave

$$\mathbf{E}(x) = \hat{e}E_0 exp(-ikx + i\omega t) \quad (1)$$

where $\hat{e}$ describes the polarization of the wave. What are the possible states of polarization for the wave? Elements to control the polarization state are optical wave plates. (i) How does such a waveplate work? (ii) Describe the general transformation of the linear polarization of a plane wave after passing through a quarter wave plate!

b) Another process to modify the polarization is Faraday rotation. Explain how Faraday rotation can be utilized to construct an optical diode, i.e. an optical device that allows propagation only in one direction!

c) An elegant formalism to describe the modification of the polarization of light beams by optical devices is the "Jones calculus". In this formalism, the polarization state is represented by a two-dimensional vector (Jones vector) and the modification of the state is described by 2x2 matrices (Jones matrices). Consider a beam of linearly polarized light passing subsequently through two ideal linear polarizers. A polarizer is an optical filter that passes light with a component along its transmission axis. The angle between the polarizers is 30°. The Jones matrix of a linear polarizer with an angle of α with respect to the x axis is

$$M_{\mathrm{LP}}^{(\mathrm{J})} = \begin{pmatrix} \cos^2\alpha & \sin\alpha\cos\alpha \\ \sin\alpha\cos\alpha & \sin^2\alpha \end{pmatrix}.$$

The angle between the light polarization and the transmission axis of the first polarizer is 15°. Calculate the Jones vector after passing both polarizers.

Problem 2: Wave Optics

Derive Poynting's theorem. Use the Maxwell-Equations starting with Ampère's circuital law. You may use the hint:

$$\frac{\partial u}{\partial t} = \mathbf{E}\frac{\partial \mathbf{D}}{\partial t} + \mathbf{H}\frac{\partial \mathbf{B}}{\partial t}. \tag{2}$$

where u is the electromagnetic energy density.

Problem 3: Optical Coherence

Show explicitly that the visibility v in a double slit experiment as shown in the figure is given by

$$v = \frac{I_{max} - I_{min}}{I_{max} + I_{min}} = |g^{(1)}(x_1, x_2)| \cdot \frac{2\sqrt{(I_1 I_2)}}{I_1 + I_2}. \tag{3}$$

Here $g^{(1)}$ is the normalized first order correlation function which determines the degree of possible interference between two fields.