Micro-optics

Winter semester 07/08

Exercise 3

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1 Birefringence (50 P)

1.1 Double image (15 P)

Birefringent crystals can be used to generate a double image of a single object. The figure shows a light beam passing through a birefringent crystal almost perpendicular to its surface. The beam is reflected at the mirror, passes back through the crystal and returns to the eye of an observer. Considering the hypothetical case of exactly perpendicular incidence for both paths, does the observer see a double image of a point on the surface Σ or not? Give plausible reasons for your answer.

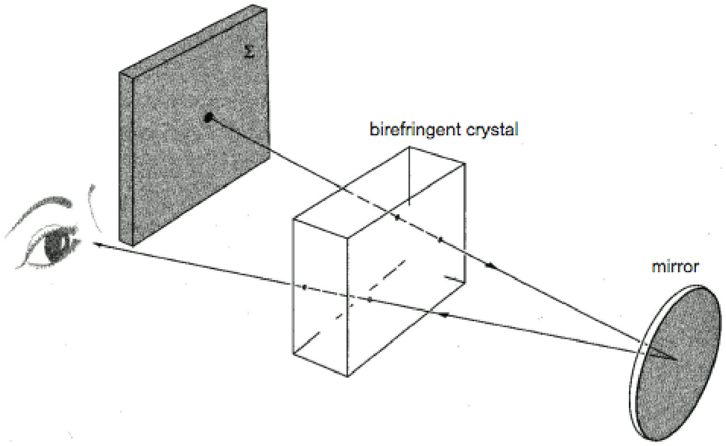

Abbildung 1: Copyright: Oldenbourg Verlag.

1.2 Change of linear into circular polarization (20 P)

Calcite is a birefringent crystal with refractive indices $n_o = 1.658$ and $n_e = 1.486$ at 590 nm. You want to convert linearly polarized light (590 nm) into circularly polarized light by means of a thinly sliced calcite plate.

a) Calculate the required thickness of the plate. (8 P)

b) What is the name of such kind of a plate and why? (2 P)

c) Are there other thicknesses which fulfill this polarization requirement? If yes, describe mathematically. (5 P)

d) What are the advantages and disadvanteges of plates of such other thicknesses? (5 P)

1.3 λ-wave plate (15 P)

The relative phase change between the ordinary and extraordinary beams for a so-called full-wave plate is 2π. We thus expect there to be no effect on the polarization of a monochromatic incident beam. However, consider two crossed linear polarizers, and put a λ-plate between them. Describe completely what happens, if white unpolarized light passes this through setup. Hint: Look carefully at the formula of the phase shift!

2 Complex quantities (50 P)

Generally, the refractive index η, the dielectric constant ϵ, and the wave number k are complex quantities. The usual convention in optics texts is:

$\eta = n - j\kappa$; $\epsilon = \epsilon_R + j\epsilon_I$; $k = k_R + jk_I$;

Here, η is the complex refractive index; n is its real part, and κ the imaginary part.

2.1 Conversion formulae (25 P)

Given η, calculate ϵ_R and ϵ_I as a function of n and κ.

2.2 Traveling wave (25 P)

Consider a planar wave traveling in a medium with a complex refractive index η. Calculate k_R and k_I. Next, consider Beer-Lambert's absorption law:

$$\frac{I(z)}{I_0} = \exp\{-\alpha \cdot z\} \tag{1}$$

This law describes the intensity of a planar wave with an initial intensity I_0 after traveling a path of the length z through a medium with an absorption coefficient α. Express α in terms of the complex refractive index η.