Problem Set No. 2, Laser Physics, WS 10/11 **23/11/10**

Topic: retardation plates

You want to manufacture a half-wave plate for a laser operating at 1µm. If not noted otherwise it is supposed to be used such that it rotates the input polarisation by 90 degrees.

Problem 2.1

For quartz the difference of the ordinary and the extraordinary index of refraction is $\Delta n = |n_{eo} - n_o| \approx 0.01$. How thick would a quartz plate have to be to provide half-wave plate operation?

Problem 2.2

The manufacturing process does not provide perfect control over the final thickness L of the crystal.

Problem 2.2.1

Please evaluate to first order how a deviation δL from the optimal thickness affects the action of the half-wave plate. Give an intuitive interpretation of the result in an appropriate polarisation basis.

Problem 2.2.2

How much light from the non-ideal wave plate is transmitted through an ideal polarizer which is adjusted such that it would block all light from an ideal half-wave plate. How much light is transmitted through that polarizer if the wave plate has a retardance error of $\lambda/100$?

Problem 2.2.3

Determine the precision of the wave plate thickness which is necessary to ensure that only a relative fraction of 10^{-4} of the power transmitted through the wave plate is transmitted through the "crossed" polarizer.
How would you try to make / check a retardation plate with a very small retardance error ($\lambda/500$ is doable)?

Problem 2.3

Light perfectly polarized along the x-direction is injected into a quarter-wave plate, the fast axis of which is aligned under an angle of θ with respect to the x-axis. Behind the wave plate a polarizer is inserted, which is oriented such that it would transmit all the light injected into the quarter wave plate if the latter would be absent. How does the relative optical power transmitted through the polarizer (which now acts as an "analyzer") depend on the orientation θ of the wave plate? Plot the corresponding graph and explain the result.

Topic: Gaussian beams

Problem 2.4

A Nd:YAG Laser emits at the wavelength of 1.06µm in the fundamental Hermite-Gaussian mode. Its optical power is 1W with a beam divergence of $2\Theta = 1$mrad (half width @ $1/e^2$ value). Determine the focus waist and the confocal range. Calculate the peak intensity in the focal plane and the radius of curvature of the phase front at a distance of 1m from focal point. Determine the point with the smallest the radius of curvature.