Determination of the refractive index of a waveplate using a Mach–Zehnder interferometer

A Mach–Zehnder interferometer splits a beam of light into two paths. If the optical path length in one of the arms is altered, a phase shift occurs between the two beams, which then overlap at the second beam splitter. This phase shift is visible as a change in the interference pattern.

Task

Determine the refractive index n of the waveplate

Show that the following applies: $$n = 1 + \frac{z \cdot \lambda}{\Delta d}$$

Background knowledge

The optical path length L_{opt} through a medium with refractive index n and thickness d is

$$L_{\mathrm{opt}} = n \cdot d$$

If the thickness of the plate changes by Δd, the optical path length ΔL_{opt} changes by compared to air:

$$\Delta L_{\mathrm{opt}} = (n-1) \cdot \Delta d$$

Procedure

- Align the interferometer by adjusting the thickness of the waveplate in one of the arms until an interference pattern with a central maximum becomes visible.
- Change the thickness continuously and as frequently as possible until the central maxima appear again.
- Count the number z of passing interference maxima.
- Determine the corresponding change in mechanical thickness Δd of the waveplate.

Experimental Settings

Wavelength of red light: $\lambda_{red} = 650 nm$

Wavelength of green light: $\lambda_{green} = 510 nm$

Wavelength of blue light: $\lambda_{blue} = 440 nm$