Optics, Spring 2018

Exercise 8, 22.3.2018

1. Superposition of waves (Ch. 9.1)

Assuming that $\bar{E}_1(\bar{r},t) = \bar{E}_1(\bar{r})\exp[-i\omega t]$ and $\bar{E}_2(\bar{r},t) = \bar{E}_2(\bar{r})\exp[-i\omega t]$, where the wavefront shapes are not explicitly specified, show that the interference term is $I_{12} = \frac{1}{2}\left(\bar{E}_1\bar{E}_2^* + \bar{E}_2\bar{E}_1^*\right)$. Show that for plane waves the interference term reduces to $I_{12} = \bar{E}_1 \cdot \bar{E}_2 \cos\delta$.

2. Newton rings (Ch. 9.4)

If the 20th bright Newton ring has a radius of 1 cm, determine the radius of curvature of the lens (λ= 500 nm).

3. Michelson interferometer (Ch. 9.4)

Consider the interference pattern of a Michelson interferometer arising from two beams of equal flux density. Compute the half width of the fringes. What is the separation in δ between the adjacent maxima? What then is the finesse?

4. Antireflection coatings (Ch. 9.7)

Determine the refractive index and thickness of a film to be deposited on a glass surface (n = 1.54) such that no normally incident light is reflected.

Bonus. Wave plates and polarizers (Chs. 8.1, 8.7)

a) Plane wave $\bar{E} = \bar{E}_0\cos(\omega t - kx)$, $\bar{E}_0 = [0, E_{oy}, E_{0z}]$ is incident at an ideal waveplate (phase change $\Delta\phi$). The angle between the direction of polarization and the optical axis of the waveplate is α. The optical axis is parallel to the z axis. An ideal polarizer is placed after the wave plate, with the angle between the axis of polarization and z axis being β. Show that the intensity after the polarizer is:

$$I = I_0\left[(\sin\alpha\sin\beta + \cos\alpha\cos\beta)^2 - 4\sin\alpha\sin\beta\cos\alpha\cos\beta\sin^2\left(\frac{\Delta\phi}{2}\right)\right]$$

Hint: calculate the time-averages in the usual way to get I.

b) Show that in the case of a half wave plate and $\alpha = \pi/4$, the output intensity is unchanged and the state of the polarization is preserved.