

110B Homework 8

1. (20 points) We have a stack of two linear half-wave retarders in series with the fast axis of one at 0 degree and the other at 45 degree. How will it affect the following incident polarization?

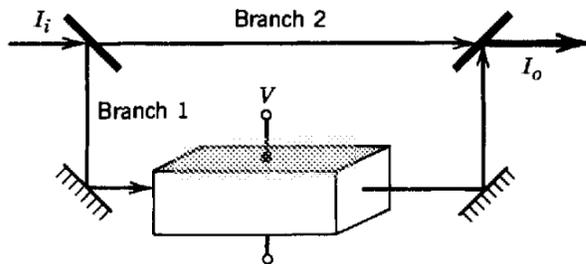
- (1) Linearly polarized at 0 degree.
- (2) Linearly polarized at 45 degree.
- (3) Right hand circularly polarized light.

2. (20 points) Assume a uniaxial crystal with $n_x=n_y=1.4$ and $n_z=1.41$, and the crystal is cut in the way that the optical axis (i.e. z-axis) is 30 degree off the normal direction.

- (1) For a normal incident light, what are the effective refractive indices for the two principle polarizations?
- (2) If we want to make a quarter waveplate for 800 nm light, what is the thickness that we should use?

3. (30 points) An electro-optical modulator can be constructed by placing a suitably cut GaAs crystal in a Mach-Zehnder interferometer (Figure 1). When an electrical field E_{bias} is applied, the effective refractive index of the GaAs crystal becomes $n_{\text{eff}}=3+10^{-12}*E_{\text{bias}}$ in MKS unit. The GaAs crystal is 1 mm high and 10 cm long.

For simplicity, let's assume that the light from the two different arms of the Mach-Zehnder interferometer to have the same amplitude and phase when $E_{\text{bias}}=0$. In this case, we observe a output light intensity $=I_0$.



- (1) In order to change the phase delay in GaAs by π , how big a bias voltage shall we apply? This is known as π -phase voltage.
- (2) Plot the output intensity as a function of applied bias voltage.
- (3) In order to have the output to be $0.5 I_0$, how big a bias voltage shall we apply?

4. (10 points) Determine the phase retardation introduced by total internal reflection for S- and P-polarized light at the boundary between glass ($n=1.5$) and air ($n=1$) for incident angle of $1.2\theta_c$. Here θ_c is the critical angle.

5. (20 points) Microwave light at 100 GHz is transmitted through a metal planar waveguide with the metal mirror separation of 5 cm.

- (1) How many guided TE modes exist in this waveguide?
- (2) What is the group velocity of each guided TE mode?

(3) For the fastest guided TE mode, write down the field distribution for both electrical field and magnetic field.