

Problem Set 7 – Phys 4510 Optics – Fall 2014

Due date: Th, November 13, in class

Reading: Hecht 8.1 - 8.11

1. Suppose you have two unlabeled optical components, of which one is a linear polarizer and the other is a quarter wave plate. How could you determine which is which, using only a source of unpolarized light.
2. Show that the transmitted intensity of incident linearly polarized light through a polarizer is given by $I(\theta) = I_0 \cos^2 \theta$ (Malus's law) where θ is the angle of incident polarization with respect to the transmission axis of the polarizer.

Now assume you take two crossed polarizers (like the sheets we handed out at the beginning of the class) and insert a third one with its transmission axis at 30° with respect to the first one. What fraction of unpolarized incident light will transmit through that stack of three polarizers?

3. Fig. 1 shows two common types of polarizers, the Wollaston prism, and the Glan-Foucault prisms, both made out of calcite.

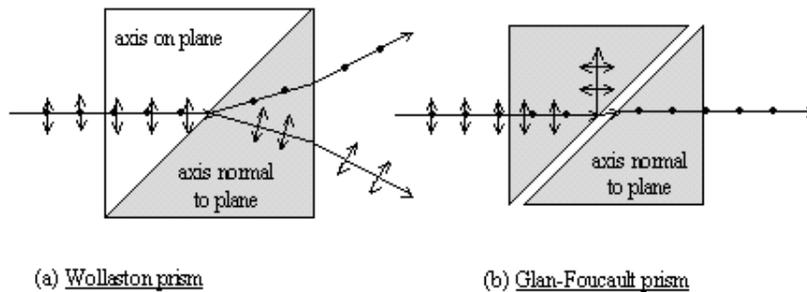


Figure 1: Two common types of polarizers.

- a) The Wollaston prism consists of two calcite prisms, one with optic axis in plane and parallel to the entrance face (left), and one with optic axis perpendicular out of plane (right), cemented together with a thin layer of a resin (Canada balsam). Explain the depicted ray behavior, in particular indicate which beam is the eo- and which the o-ray, why eo- and o-rays in the first prism are parallel, but diverge in the second. And why the eo-ray of the first prism turns into the o-ray in the second.
 - b) The Glan-Foucault polarizer is also made of two calcite prisms, but both with the optic axis parallel to each other and perpendicular out of plane. Again, identify the eo- and o-ray, and explain the observed behavior as indicated for the different rays. Show that the condition for the o-ray to be totally internally reflected, but not the eo-ray is given by $n_{eo} < 1/\sin\theta < n_o$.
 - c) Consider again the case of an e- and eo-ray hitting the calcite-resin interface with $n_e = 1.4864$, $n_{eo} = 1.6584$ and $n_{resin} = 1.55$ (i.e., in between the two e- and so-values). What is the critical angle for total internal reflection for the o-beam? Why does the eo-beam not get reflected.
4. Fig. 2 shows the optics in the read-head of a CD player.
 - a) Explain why the circularly polarized light, after back-reflection and passing the same quarter-wave plate again, is polarized perpendicular to the original beam.

- b) Consider the polarizing prisms made out of calcite. Indicate the necessary choices for the optic axis.

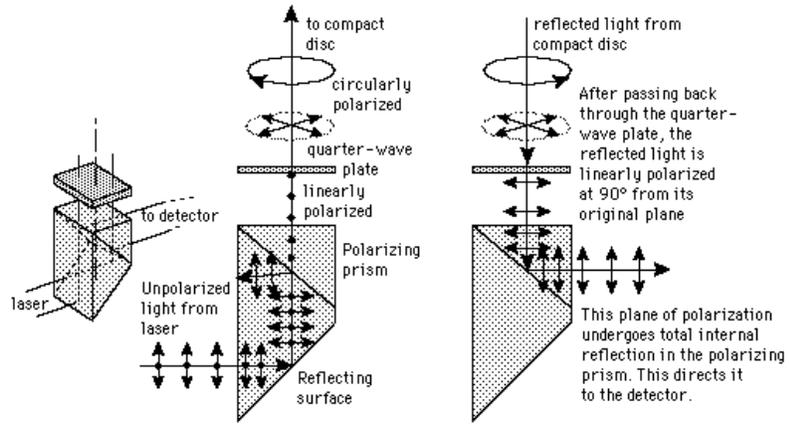


Figure 2: Polarizing optics inside a CD read-head.

The light does not change its polarization state when reflected from the CD.