Due October 27, 2004

HOMEWORK PROBLEM SET VI

NOTE: Whenever you make sketches involving linear or circular polarized light, mark properly the propagation direction and polarization direction of light, show for the retarder the orientation of the slow and fast-axes, and for polarizers or analyzers their transmission direction.

1. (A) Find the thickness of a particular birefringent crystal \( n_1 = 1.4737 \) and \( n_2 = 1.4714 \) needed to produce \( \lambda/4 \), \( \lambda/2 \), and \( \lambda \) retardation plates, respectively, for the argon laser line \( (\lambda = 488 \text{ nm}) \).

(B) Explain, including a sketch of the polarized states, how you can use these retarders (in combination with a linear polarizer) to produce:
   1. right circular polarized light
   2. left circular polarized light
   3. 90° rotation of plane-polarized light

(C) How do you produce with the help of the above mentioned optical elements elliptically polarized light? (Explain and make a sketch.)

2. You want to distinguish experimentally unpolarized from circularly polarized light of the same wavelength \( \lambda \). Describe the procedures in words and sketches.

   (A) What physical tools will you need to do this and how will you arrange and use them?

   (B) How will you determine if a circularly polarized light is left- or right-circular?

3. An organic material in solution has a refractive index of \( n_r = 1.7297 \) for right circularly polarized light and \( n_1 = 1.7295 \) for left circularly polarized light

   (A) What does this tell you qualitatively about the molecular structure and symmetry properties of the material (which way will linearly polarized light rotate, and is the molecular structure right or left handed)?

   (B) What path length does linearly polarized light of \( \lambda = 7500 \text{Å} \) travel through the solution such that the plane of polarization rotates by 360°? What is the rotation direction of the polarized light?

4. Two narrow parallel slits illuminated by light from a He-Ne laser \( (\lambda = 6328\text{Å}) \) produce interference fringes with a separation of 0.5 mm on a
screen 3 meters away. What is the center to center **distance** of the two slits? What would change (and by how much?) if the same experiment were performed **under water** ($n = 1.33$)? What would change in the fringe-pattern if you use, instead of the HE-NE laser, an Ar laser operating at $\lambda = 4880 \text{ Å}$ in air and under water?

5. Imagine that in a double-slit (center to center separation = $a$) interference experiment (in which you can neglect the slit-width), one of the slits becomes covered by a very thin slab of transparent material of refractive index $n$ and thickness $D$. Discuss qualitatively (with a sketch) the **difference** between interference patterns before and after inserting the slab. Derive the expression for the change in the **angular position of the zeroth** order interference maximum, as a function $a$, $D$, and $n$, caused by inserting the transparent slab?