Nonlinear Optics
Homework 2
due Wednesday, 9 Feb 2011

- **Problem 1:**
  Boyd problem 2.1. For this problem, assume that "optimum focusing" means that the length of the crystal equals the confocal parameter (2 x the Rayleigh range) of the lowest frequency beam. You don't need to account for focusing phase mismatch (we'll treat this later). Section 2.6 treats the case of upconversion.

- **Problem 2: practice with polarization**

- **a. Consider 3 polarizers in sequence. Polarizers 1 and 3 are crossed, passing light polarized in the x and y directions, respectively. Calculate the transmission through the third polarizer as a function of the rotation angle of polarizer number 2, which is in between the other two.**

- **b. Find the eigenvectors and eigenvalues of the 2x2 rotation matrix. Relate the eigenvectors to polarization states and give a physical interpretation.**

- **c. A real waveplate that is made of a single piece of quartz ($n_o - n_e = 0.009$) can be thick enough that the designer must aim for the desired phase retardation plus m*(2 π), where m is an integer. A zero-order waveplate is where $m = 0$.**
  - if the design wavelength is 800nm, how thick should a zero-order half-wave plate be?
  - what order would the waveplate be if the thickness is approximately 1mm.
  - another way to make the waveplate zero-order is to combine two waveplates with the optic axis of the second plate rotated 90^o to the first. If each half of the waveplate is approximately 1mm, calculate the exact thicknesses of the two halves of a zero order half waveplate.

- **Problem 2:**
  The nonlinear crystal used for doubling the 3000nm output of an optical parametric amplifier (OPA) is $LiIO_3$ (lithium iodate).

- **a. Using the Phase_match_KDP.nb notebook as a template, code the dispersion equations for $LiIO_3$ and calculate the variation of n_e with angle θ to the z-axis. The Sellmeier equations for $LiIO_3$ are given in the datasheet posted online.**

- **b. Calculate the optimum phase matching angle for doubling 3000nm light with Type I and Type II. If we changed the input wavelength to something shorter, what is the shortest input wavelength that can be phasematched?**

- **c. For both types of phase matching, plot the harmonic yield (intensity) as a function of incident angle for a few thicknesses. This shows the angular acceptance.**

- **d. For both types of phase matching, plot the harmonic yield as a function of input wavelength for three thicknesses. This shows the phase matching bandwidth.**