# PHYS 408 2010/11 term 2

Homework problem set #10 problem 1
Assigned: 01/04/2011
Written Solution due 07/04/2011 3 PM at beginning of class
If you collaborated with anyone, please write their name at the top of your HW

Problem 1 (100 marks)

In this problem you will use a number of topics (interference, polarization, resonators) we have covered over the past term to read and understand a scientific paper. It will serve as an excellent start for reviewing for the final exam.

Background: In real life, the wavelength of a laser is not fixed. Rather it fluctuates due to various perturbations. For example, in one configuration a HeNe laser produces light at 632.8 nm (on average). But in reality, the output is $632.8 \pm \Delta\lambda$ nm, where $\Delta\lambda$ is the deviation of the output from 632.8 nm. In many optical experiments (precision measurement, etc…see http://www.winterseo.com) , it is very desirable to make the uncertainty $\Delta\lambda$ to be as small as possible. As you will recall from the resonator lectures, the width of a Fabry-Perot resonator modes is inversely proportional to the finesse and with a high finesse it can easily be made a factor of $10^{-4}$ then typical values of $\Delta\lambda$. So if we can get the laser's wavelength to track the resonator's transmission peak, then we can reduce $\Delta\lambda$. The problem is how to "lock" the laser wavelength to the resonator (aka cavity) to minimize $\Delta\lambda$. The first step is to generate an error signal so that when the laser wavelength drifts outside the transmission peak of the resonator, the proper correction can be applied to the laser to correct its wavelength. In other words an electronic signal needs to be generated that is linear with respect to the wavelength drift of the laser and has a zero crossing at the center wavelength. This is the topic of this problem.

Problem: A scheme for generating this error signal (i.e. a voltage from a photodetector at is proportional to the intensity) is described in the attached scientific manuscript: ( http://dx.doi.org/10.1016/0030-4018(80)90069-3) from Optics Communications 35-3, 441 (1980) . For your solution you are required to:

a) (15 marks) Explain in your **own words** how this scheme works

b) (75 marks) Derive equations (2), (4), and (6) shown in the manuscript.

c) (10 marks) List the assumptions/approximations in generating these three equations

.

This polarization scheme was invented by Ted Haensch in 1980. It is now widely used in laboratories across the world (including mine). In 2005, Haensch was awarded a portion of the Nobel Prize for Physics for his life long work on optics and spectroscopy and his work on the femtosecond frequency comb.