Phys 531 Assignment 11 Due November 14

1. It is possible to obtain group velocities v larger than c_0 for light passing through a dilute atomic vapor. Recall (S&T, equation 5.5-18) that near a resonance, the electric susceptability of a medium is given by

$$\chi(\nu) = \chi_0 \frac{\nu_0/2}{(\nu_0 - \nu) + i\Delta\nu/2}$$

where ν_0 is the resonant frequency and $\Delta\nu$ is the width of the resonance. Assume χ_0 is small enough that $|\chi(\nu_0)| \ll 1$.

(a) Calculate the group velocity at frequency ν_0. Show that it can have arbitarily large or negative values, even under the restriction $|\chi(\nu_0)| \ll 1$.

(b) Suppose a pulse of duration Δt propagates a distance L through such a medium where $v > c_0$. The pulse will exit the medium a time

$$\tau = L\left(\frac{1}{c_0} - \frac{1}{v}\right)$$

earlier than a pulse with speed c_0 would have. However, this requires that the absorption αL be no larger than 1, so that the pulse is not strongly attenuated. Also, the bandwidth of the pulse (i.e., the range of frequencies present) must be much smaller than $\Delta\nu$, to avoid strong dispersion effects. By imposing these requirements, show that $\tau \ll \Delta t$.

2. Saleh and Teich, problem 6.1-1, page 235.

3. Saleh and Teich, problem 6.1-3, page 235.

4. Saleh and Teich, problem 6.1-4, page 235. Note, I don't get the $\pi/2$ phase shift referred to in the problem.

5. Consider light linearly polarized along the x axis, which incident on a polarizer with transmission axis at angle θ to the x axis, followed by a polarizer with transmission axis along the y axis. Calculate the fraction of the incident power transmitted through the system. What is the maximum value of the transmission, and what angle θ achieves this?