Due: Wednesday, 9/29/2004

9. Usually, $\chi^{(2)}=0$ for an isotropic medium because most isotropic media are symmetric with respect to spatial inversion. However, in general, if a medium is isotropic, it does not necessarily mean that it is centro-symmetric. Consider a gas or a liquid solution of *chiral molecules*. Such a medium is optically active – it rotates linear polarization of light propagating in the medium. The fact that the medium is isotropic means that the rotation power does not depend on the direction of light propagation and on the direction of the linear polarization.

On the basis of symmetry considerations, argue that

a). The second-order susceptibility $\chi^{(2)}$ is generally non-zero in such a medium

b). Second harmonic generation is strictly forbidden

c). Suppose a static electric field is applied along the direction of propagation of linearly polarized light. Is there optical rotation linear in the applied field? Discuss electro-optical rotation in terms of a $\chi^{(2)}$ wave-mixing process, where one of the "waves" is the dc field.

10. In a pioneering experiment of Maker and Terhune (Phys. Rev. **137**(3 A), 801 (1965)), a liquid sample was irradiated with pulsed laser light of elliptical polarization. It was observed that the principal axes of the polarization ellipse rotate upon propagation through the sample in the direction determined by the sense of the input circular polarization. This <u>self-rotation</u> is due to the intensity dependence of the effective refractive indices for the right- and left-circular polarizations, $n_{\pm}$ (a $\chi^{(3)}$ process). Assuming that the interaction length is 1 cm, and that the rotation angle is $\varphi=1$ rad, calculate the magnitude of $\Delta n=(n_{+}- n_{-})$.

11. Show that the intensity-dependent refractive index as measured with a single strong beam is two times smaller than that measured using an additional weak probe beam. Here we are assuming that all interactions are non-resonant, the medium is isotropic, the waves are infinite plane waves, and whatever else you wish to assume. The probe field could be collinear with the strong pump and can be distinguished from the pump wave by frequency. Alternatively, both waves could be of the same frequency, but propagating at a small angle. This is the so-called weak-wave retardation effect first described by R. Y. Chiao et al [Phys. Rev. Lett. **17**(22), 1158 (1966)]. If possible, please provide a physical picture of why this difference arises. Discuss what would happen if one smoothly removes the distinction between the waves.