Due: Wednesday, 10/27/2004

16. In class, we have recalled the following results pertaining to plane-wave light propagation in transparent anisotropic medium such as a uniaxial or biaxial crystal:

- For a given direction of the wave vector, there are two polarization eigenmodes, where the polarization is characterized by the direction of the electric-inductance vector **D**. An eigenmode is a wave that propagates in the crystal maintaining its polarization.
- The two eigenmodes are linearly-polarized light with mutually orthogonal directions of **D**.

Now to the questions:

a. Why are the eigenmodes characterized by **D** rather than **E**?
b. Why are there two eigenmodes?
c. Why do the two eigenmodes correspond to mutually orthogonal directions of **D**?
d. Why are the eigenmodes linearly polarized?
e. Comment on the analogies between this problem and quantum mechanics.

17. If, as it is commonly the case, the gain spectral profile of a laser's medium is broader than the longitudinal mode spacing of the cavity, multi-mode lasing can occur. In order to force the laser into single-mode operation, one technique is to use metal foil mode selector. The selector is just a thin foil positioned inside the cavity. Frequency tuning is accomplished by translating the foil along the axis of the resonator. Explain how this works. Where in the cavity should the selector be? Estimate maximum allowable thickness of the foil.

18. A commercial Q-switched flash-lamp-pumped Nd-YAG laser has a 60 cm long resonator with the output coupler having transmission 1-R=65 %. It delivers 500 mJ of output energy at λ=1.06 μ in a 7 ns (FWHM) pulse. The output radiation has a nearly Fourier-limited spectrum. Estimate the following quantities: a). Photon lifetime in the cavity $\tau_c=1/\gamma_c$ (at high Q; what is the value of Q if cavity loss is determined by transmission of the output coupler?), b). The total number of photons in a pulse, c). The peak pulse power, d). The maximum number of photons in the cavity (i.e. the number of photons in the cavity at the time when the output power peaks), e). Pulse build-up time after the Q-switch has been (nearly instantaneously) opened, f). The atom-photon coupling coefficient K.