Due: Wednesday, 4/21/99

24. Estimate SHG efficiency (in %/W) in a $LiNbO_3$ quasi-phase matched waveguide device (L=1 cm, transverse mode size: 5 μ × 5 μ). At which input power will the undepleted pump approximation fail?

25. It can be shown that for a light source that simultaneously has some Lorentzian broadening (due to radiative decay and/or collisions) with parameter γ and some Gaussian broadening (due to Doppler effect, inhomogenious electric fields, etc.) with parameter δ, the degree of first-order coherence is given by:

$$g^{(1)}(\tau) = \exp(-i\omega_0\tau-\gamma|\tau|-\delta^2\tau^2/2) .$$

Using this formula, a). write out the spectral lineshape form. Hint: you may find that the integral you write is hard to take. If this is the case, leave it in the form of an integral. This lineshape is called Voigt profile. b). Show that for large enough detunes, the lineshape becomes Lorentzian. c). Consider a cell with dilute atomic vapor (e.g., Na, T~500 K). How far do we have to detune from an allowed optical transition, so the lineshape would become Lorentzian?

26. Consider an empty Fabry-Perot cavity in which losses are determined by finite mirror reflectivities. a). Give definitions and derive expressions in terms of mirror reflectivities for the cavity finesse and the Q-factor. b). Suppose we couple laser light of power P_0 into the cavity through one of the mirrors. The frequency of the light is resonant with a cavity mode and mode-matching has been achieved. The power build-up factor can be defined if we think of the overall light field in the cavity as a superposition of a wave traveling 'to the right' and a wave traveling 'to the left'. The power build-up factor is then the ratio $2P_c/P_o$, where P_c is the intensity of one of these traveling waves. Calculate this factor in terms of mirror reflectivities. How is it related to finesse and the Q-factor?

27. When coherent light falls on a beamsplitter, the two resulting light beams are also in coherent states. This implies that if we insert a (100% efficient) photodetector in any one of the three beams and measure the number of counts in time intervals Δt, we will see Poissonian distribution of counts around the value $\overline{N}_i$ with rms deviation $\Delta N_i = \sqrt{\overline{N}_i}$ (for $\overline{N}_i$ >>1). As we discussed in class, one way to explain this result is to consider the interference between the incoming light field and the zero-point fluctuations entering the 'unused port' of the beamsplitter (Carlton Caves, 1980). In an alternative explanation, one uses the 'indivisibility' of a photon: each photon falling onto the beamsplitter can go into either of the resulting beams, but cannot be split. Consider for simplicity a 50-50 beamsplitter and explain how this picture leads to Poissonian photon distributions in the resulting beams. Is this really a consistent explanation?