Part I: 50points, Please describe your answers as complete as possible

1. (12%) Describe what happens to unpolarized light incident on birefringent material when the OA is oriented as shown in each sketch in Fig. 1. Please comment on the following considerations: Single or double refracted rays? Any phase retardation? Any polarization of refracted rays? (OA stands for Optical Axis)

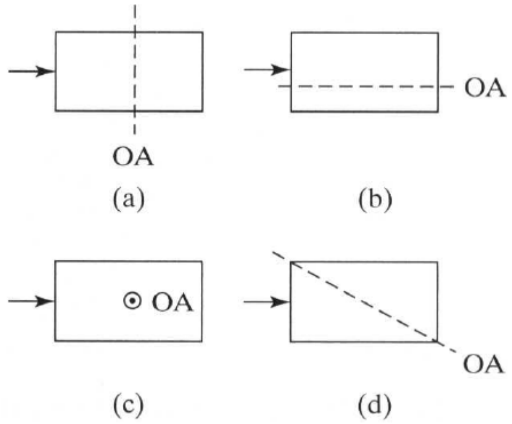

Fig. 1

2. (12%) A TEM_{00} He-Ne laser (λ = 0.6328 μm) has a cavity that is 0.34 m long, a fully reflecting mirror of radius R = 10 m (concave inward), and an output mirror of radius R = 10 m (also concave inward).
   (a) Determine the location of the beam waist in the cavity.
   (b) Determine the spot size at the beam waist, ω_0
   (c) Determine the beam spot size $\omega(z)$ at the left and right cavity mirrors.
   (d) Determine the beam divergence angle for this laser.

3. (11%) Consider the transmission of 10 Gb/s signals at λ = 1500 nm in a single-mode fiber, with a group velocity dispersion of D = 17 ps/nm-km. Determine the pulse spreading after a transmission of distance 100 km.

4. (15%) A Fabry-Perot interferometer is to be used to resolve the mode structure of a He-Ne laser operating at 632.8 nm. The frequency separation between the modes is 150 MHz. The plates are separated by an air gap and have a reflectance (R) of 0.999.
   (a) What is the finesse of the instrument?
   (b) What is the resolving power required?
   (c) What plate spacing is required?
   (d) What is the free spectral range of the instrument under these conditions?
   (e) What is the minimum resolvable wavelength interval under these conditions?

Part II: 50points

1. (10%) A two-concave resonator has the cavity length of 10 cm, in which the radius of curvature is 20 cm for each mirror.
   (a) What is the frequency difference between longitudinal modes? What is the frequency difference between transverse modes? Do the cavity configuration satisfy the transverse mode degenerate? (Please interpret your answer.)
   (b) If the cavity length is tunable, what is the maximal cavity length for the stable condition?
2. (10%) What is the spectral hole-burning? Please use the gain curve to explain the multimode oscillation in an inhomogeneous broadening laser system.
3. (15%) The index ellipsoid for the KDP with a dc field, E_z, along the crystal z axis is given as

$$\frac{x^2}{n_o^2}+\frac{y^2}{n_o^2}+\frac{z^2}{n_e^2}+2r_{63}E_z xy=1$$,

   where r_{63} is the electrooptic coefficient, and n_o and n_e are the indices for the ordinary and extraordinary rays, respectively. Calculate the V_π, the voltage yielding a retardation of π, for the wavelength of λ. Design an electrooptic amplitude modulator based on this KDP.
4. (15%) The optical fields transformed from $E^{(\omega)}$ to $E^{(2\omega)}$ in the second-harmonic generation satisfies the equation:

$$\frac{dE^{(2\omega)}}{dz}=-i\omega\sqrt{\frac{\mu}{\varepsilon}}d[E^{(\omega)}(z)]e^{i(\Delta k)z}$$,

   where $\Delta k = k^{(2\omega)} - 2k^{(\omega)}$, and d is the nonlinear coefficient. Drive the conversion efficiency from ω to 2ω for a crystal of length *l*. Explain the condition for the phase-matching and calculate the coherence length for the wavelength of 1 μm and $n^{(2\omega)} - n^{(\omega)} = 10^{-2}$.

Part III: 50points

1. (a)Please draw the luminescence intensity of the LEDs as a function of the material energy bandgap. (5%)
   (b)According to the (a) results, please proof its peak value at a frequency v_p determined by

   $$hv_p = E_g + \frac{1}{2}kT\ .\ (5\%)$$

2. GaAs has an intrinsic carrier concentration n_i=1.8×10^6 cm^{-3}, a recombination lifetime τ=50 ns, a bandgap energy E_g=1.42 eV, an effective electron mass m_c=0.07m_0, and an effective hole mass m_v=0.50m_0. Assume that T=0 ^oK. Determine the (a)center frequency, (b)bandwidth, and (c)peak net gain within the bandwidth for a GaAs amplifier of length d=200 μm, and thickness l=2 μm, when 1 mA of current is passed through the device. (24%)
3. A conventional APD with gain G=20 operates at a wavelength λ_0=1550 nm. (a) If its responsivity at this wavelength is R=12 A/W, calculate its quantum efficiency η. (b)What is the photocurrent at the output of the device if a photon flux Φ=10^{10} photons/s, at this same wavelength, is incident on it? (16%)