

110B Homework 10

1. (20 points) Semiconductor lasers are often fabricated from crystals whose surfaces are cleaved along crystal planes. These surfaces act as reflectors and therefore serve as the resonator mirrors. (The reflectance is given by Fresnel equation.) Consider a crystal with refractive index $n = 3.6$ placed in air ($n = 1$). The light reflects between two parallel surfaces separated by the distance $d = 0.2$ mm. Assume that the loss coefficient of the material $\alpha_s = 1 \text{ cm}^{-1}$. Determine the spacing between resonance frequencies ν_F , the overall distributed loss coefficient α_{eff} , the finesse, and the spectral width $\delta\nu$.
2. (20 points) Resonator Spectral Response. The transmittance of a symmetrical Fabry-Perot resonator was measured by using light from a tunable monochromatic light source. The transmittance versus frequency exhibits periodic pulses of period 150 MHz, each of width (FWHM) 5 MHz. Assuming that the medium within the resonator mirrors is a gas with $n = 1$, determine the length and finesse of the resonator. Assuming that the only source of loss is associated with the mirrors, find their reflectances.
3. (20 points) Optical Decay Time. What time does it take for the optical energy stored in a resonator of finesse $F = 100$, length $d = 50$ cm, and refractive index $n = 1$, to decay to one-half of its initial value?
4. (15 points) Amplifier Gain and Rod Length. A commercially available ruby laser amplifier using a 15-cm-long rod has a small-signal gain of 12. What is the small-signal gain of a 20-cm-long rod?
5. (25 points) Number of Longitudinal Modes. An Ar^+ -ion laser has a resonator of length 100 cm. The refractive index $n = 1$. (a) Determine the frequency spacing ν_F between the resonator modes. (b) Determine the number of longitudinal modes that the laser can sustain if the FWHM linewidth (Lorentzian lineshape) is $\delta\nu = 3.5$ GHz and the loss coefficient is half the peak small-signal gain coefficient. (c) What would the resonator length d have to be to achieve operation on a single longitudinal mode?