EECE7105— OPTICS FOR ENGINEERS— Fall 2025

Homework for Ch. 7–9

1 Laser Cavity

A helium–neon laser has a gain line with a center wavelength of 632.8nm and a linewidth of about 1.5GHz. We design such a laser with a cavity length of 35cm.

a. What is the free–spectral range of this laser? How many modes are under the gain line?

b. Let's assume incorrectly that the laser will only operate on the cavity mode closest to the peak of the gain line? On what cavity mode is it operating? In other words how may wavelengths are contained in the round trip? What is the frequency difference between the operating frequency and the gain line center frequency?

c. In fact the laser will run on all modes above the gain line. In order to ensure single–longitudinal–mode operation, we need to make sure that only one mode is under the gain line. What is the maximum length of the laser cavity to ensure this?

d. What problem does this present if we want to make a high–power single–logitudinal–mode laser?

2 Resolution

Over the last few decades, global images of the earth's surface have become available to the public through a number of commercial sources. Let's consider what would be required to image with a resolution of of 10cm. Such resolution might make it possible to identify a specific vehicle or even a person. Let's use green light in all our examples.

a. For a satellite in low–earth orbit at 200km above the Earth's surface, what aperture would be required on a camera?

b. For an aircraft at 12km what aperture would be required?

c. For the human eye, what would be the maximum altitude at which this resolution would be possible? Assume a maximum pupil size of 8mm. This would be likely at night, but during the day, the pupil would normally be smaller.

3 Gaussian Beam

In confocal microscopy, we usually illuminate a sample by focusing a laser beam with a microscope objective, where the laser beam is a plane–wave Gaussian beam at what is normally the back focal plane of the objective, and then focuses at the object. Let's consider a $30X$ objective from a vendor that sells microscopes with a 200mm tube lens. The laser beam is 9mm in diameter.

a. What is the focal length of the objective?

b. What is the value of q, the complex radius of curvature as it exits the microscope objective going toward the object?

c. What is the location of the waist of the beam, and what is it's diameter?

d. We have a laser with a 1mm plane–wave Gaussian output. How would we couple this to the microscope objective? You don't need to design the coupling optics. Just explain what you would do.