# PHGN 480 Laser Physics
# Lab 2: HeNe gain and lasing

*Turn in your write-up in class on Wednesday, 25 Sept.*

For this lab, you work on testing the gain of the HeNe tubes and to align the lasers.

The goals of this lab are to:

1. align the laser tube so that it is level to the table
2. measure the radius of curvature of the high reflector
3. set up a system to measure the double-pass gain at three different wavelengths.
4. install the output coupler and get the laser to lase. Use the power meter to optimize the output power.

**1. <u>Alignment of the HeNe laser tubes:</u>**

a. You should verify that your setup from last week with the alignment laser and the two fold mirrors gives a beam that is 6" above the table height and that the beam is level to the table and straight along the table holes. The beam should be collimated with the telescope. Make sure that you have a pair of irises that is well aligned to the beam. Later you will be sending laser light in from other lasers, so you will need to be able to use the fold mirrors to direct the new laser beam along the direction of your current alignment.

b. Coarse leveling the HeNe tube:

**i.** place the single-window HeNe laser tube on the table, and send your beam into the entrance window.

**ii.** If the height of the tube is not very close to the center of the window, use the three nylon screws to adjust the height of the tube.

**iii.** Turn the tube around, and adjust the other end to make sure it is centered on the input beam. Get the beam back through the entrance window, and iterate if necessary.

**iv.** Most tubes have a tilted Brewster window. If yours does, rotate the tube so that the reflection from the window stays level.

**2.** Measurement of the HR radius of curvature

We will need to know what curvature there is on the high reflector mirror bonded to your HeNe tube. Use your collimated beam to reflect off the back of the HR mirror as a small angle, then focus the beam with a lens of known focal length. If the mirror is curved, the focal point will be shifted to a longer position. Use the knife edge test to measure the new focal position. Measure the distance from the HeNe HR to the lens, then use the lens equation to estimate the radius of curvature of the mirror. (The beam will diverge if the surface is convex, and will appear to come from a source point at the focal length of the mirror. **Make a schematic of your setup, showing your measurements. Show your work for the calculation.**

**3.** Fine alignment through the HeNe tube.

a. Turn the tube back around, orient the beam down the length of the tube so that it reflects back on itself. If the vertical reflection is off, you can fine-tune using the screws holding the base to the tube.

b. Install a beamsplitter into the beam path before the laser tube. You should be able to do this without introducing clipping on the laser tube. The beam should go through the tube without any clipping, looking like a smooth Gaussian beam. If the beam is too wide to pass through the tube without clipping, add a long focal length lens to the beam path before the beamsplitter, making sure it is centered.

4. Double-pass gain measurement:

The beamsplitter will allow you detect the return beam with a power meter. Set up a power meter head on a post, and center the return beam on the sensor. Get the background signal by blocking the beam near the laser output. Measure and record the initial power, then power on the test laser tube and measure the output power. Subtract the background, and calculate the ratio of the signal with to without power to the tube. Be careful not to let room light or glow from the HeNe tube affect your measurements. You should see roughly a 10% increase for the 632.8nm light.

Test gain for other wavelengths: We have at three different color HeNe lasers, red, yellow and orange. Use your mirrors to align the other test laser beam through the irises. Measure and record the gain for those wavelengths.

**5. <u>Alignment for lasing:</u>**

In principle, the degrees of freedom for lasing are the two mirror angles and the cavity length. The transverse position of the mirror just needs to centered enough to avoid any clipping of the beam on the mirror. As we will learn soon when we discuss resonators, there is a range for the separation between the two cavity mirrors that allows the light to stay trapped in the resonator in a stable way.

a. Before using the output coupler, measure its transmission using an alignment laser running at 632.8nm and a power meter.

b. Install the output coupler mirror (OC) a few cm from the end of the tube. Be sure the curved surface is on the side of the laser tube. Center the mirror on the beam by looking at the spot on the mirror. Adjust the angle of the OC so that the back reflection is directed back through one of your alignment irises. You should also see a bright back reflection from the beamsplitter. Try one of the two following methods to align the OC angles:

c. If you detune the OC reflected beam, you should be able to see a faint return beam from the HR. Inserting the OC may have deviated the beam to the HR, so you may need to adjust the transverse position of the OC to get a clean return from the HR. Then align the OC so that its reflection is directly on top of it.

d. In the other technique, put a CCD camera right near the outside of the HR mirror. You should be able to see a beam leaking through the HR. With the OC installed, you may also see a second beam that makes one extra round trip through the cavity. Alignment of these on top of each other will make sure the cavity is aligned.

e. Turn on the laser tube, and look for lasing. If it does, go to step (e). If it doesn't, try a small tweak back and forth on the OC angles, to see if you can see the laser flash. If that doesn't work, you can try walking the cavity: detune the OC in one direction, then moving the other adjuster back and forth (around +/- one turn). Then increment the first adjuster by a bit (about 1/10th of a turn) and repeat, looking for the lasing flash.
f. After you get it to lase, then put the power meter on the output beam (no beamsplitter), and optimize the output power with the OC angles. Note the sensitivity range of those adjustments.

**6. Power vs cavity length:**

Once you have the laser running, it is possible to gradually move the end mirror to different separations and maintain lasing. Try different cavity lengths, in increments of about 2", record and plot the optimized output power vs cavity length. It will help to clamp a straight edge (e.g. meter stick) to the table and slide the base of the OC mount along it. As you move the mirror, make fine adjustments to the OC angles to keep the laser lasing. Also check to make sure the beam location on the OC doesn't drift to the side. Make measurements over as large a range as possible, trying to find the limits of the cavity stability. Also note observations about the beam profile at these different positions.

**7. HeNe tube spectral measurements:**

We have one fiber-coupled spectrometer which can be used to measure the emission spectrum of the discharge. Placing the fiber tip in a mount so that the spectrometer can pick up the glow of the discharge, record the emission spectrum under the following conditions:

a. when your tube is not lasing, and when your tube is lasing
b. place a mirror that takes the output of your laser and directs it right back into the laser. This is normally "bad" for the laser: for higher power lasers and diode lasers this feedback can lead to optical damage. But it's ok for a HeNe. This feedback can allow other HeNe gain lines to lase simultaneously. Use the fiber spectrometer to look at scatter from the OC and see if you can see other laser lines as you align the feedback mirror. If you optimize one of those lines, re-check the spectrum of the HeNe tube with and without lasing.
c. Using the spectrometer software, compute the difference spectrum for cases (a) and (b) and discuss the differences.
d. For reference, record the spectrum of a neon discharge tube. This tube does not have the helium, which helps to preferentially pump the lasing levels of neon.