PHGN 480 Laser Physics

Lab 2: Measuring Gaussian laser beam sizes

Do this by the end of the day Monday, 12 September. Turn in your write-up in class on Tuesday, 13 Sept.

Equipment:
HeNe alignment laser
1 iris on post, 1 lens mount, lens (check out lenses from Chip or Rezwan)
2 neutral density filters, mounted
power meter, CCD camera
posts, post holders, bases (located in cabinet in adv lab. Return when you're done.)

Initial setup:

Set up an alignment laser: either the green DPSS laser or a HeNe laser, pointing the beam roughly parallel to the table surface and parallel to the table holes. Put a lens in the beam path so that the beam diverges to roughly 3mm in diameter at some convenient distance from the laser. Place the power meter head after that position so that the beam hits the middle of the exposed photodiode. Don't focus onto the power meter head, and be sure the whole beam gets onto the central sensitive area!

Iris method:

This is the easiest method to measure the beam size, but only works for fairly large beams. Mount an iris so that it is well-centered on the beam at the position you want to measure the spot size. With the iris open, measure the power, then slowly close the iris until the power drops to half its original value. Use calipers to measure the diameter of the hole, $d_{1/2}$. For a Gaussian profile beam, there is a connection that you will derive later between the measured half-power diameter and the $1/e^2$ radius of the beam: $w = 0.85 d_{1/2}$.

Knife edge scan method:

This method works well for most size beams, even focused beams, since a translation stage can be moved precisely over small distances.

1. Mount a razor blade on a post, and mount the post in a post holder and base on a translation stage.

2. First scan the blade across the beam in the same z position as your previous measurement without taking readings, but estimate the number of turns on the knob are required to cross the beam. From this, determine a step size that will give you at least 10 readings across the beam. Back the blade just out of the beam, then move the translation stage in the increments you have selected, and write down the power on the power meter for each reading. Also, more directly, dial the knife edge to a position that transmits 90% of the power, then measure the distance the knife edge must translate to drop the power to 10% of the total power (x_{90-10}).

3. **Make a plot of the transmitted power vs. position.** The relationship between the distance from the 10% and 90% transmission points and the $1/e^2$ radius is $w = x_{90-10}/1.28$. Compare your two measurements.

CCD camera technique:
This is a method that works for any beam profile. The laser beam will be too bright for the camera, so you will need to take care to avoid saturating the camera. There are several ways to attenuate the power of the beam. There are a couple of mounted filters you can use – they can be taped to the camera with scotch tape. Also see notes below about operation of the camera exposure time.

1. Mount the polarizer and put it into the beam path. As you rotate the polarizer, you should notice that the transmitted power can be controlled.

2. Mount the CCD camera on a post, post holder and base, and then put the assembly onto a translation stage that can move the camera sideways to the beam. Put the CCD (without any additional lens) into the beam path. You can reduce the intensity of the laser beam with the filters, and also set the camera for minimum gain and minimum exposure time (go into the camera settings menu in the software). Try making a lineout across the center of the beam. You'll see a line on the screen, and you can move it with the mouse to select your cross section of the beam profile. Select the line plot display, and use the right mouse click/drag on the lineout display to change the zoom on the lineout. If you see a flat top on the lineout, the camera is saturated and you need to make adjustments to the exposure.

3. Instead of reading in actual distance, the camera reads out in pixels, or you can use the grids on the lineout display. To calibrate the lineout, you can take a couple (or more) measurements of the beam at different known sideways positions using the translation stage. Then look to see how many pixels the peak of the beam moves and calibrate the lineout that way.

4. Look at a lineout of the beam profile, and measure the FWHM of the peak. Be sure to account for any baseline offset. Convert the FWHM in distance, then convert this to a $1/e^2$ radius. You don't need to do this, but a more accurate measurement involves fitting the measured curve to a Gaussian, then extracting the beam size from the fit.

Write down any observations or questions that came up while you did this lab.