Laser Experiments Recording Light: Long Range

By: 4/C Cully, 4/C Forristall, 4/C Rosenthal, 4/C Stephenson

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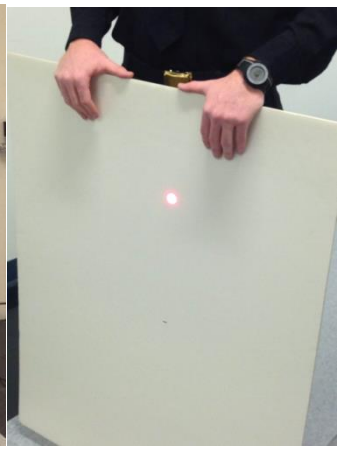
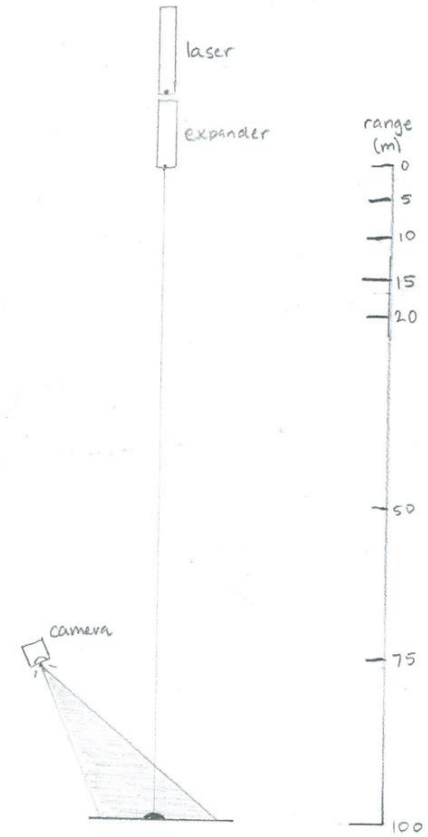
Introduction:

The purpose of the experiments was to study laser propagation over a 75 meter range. Moreover, what our group was looking for in particular was the variation in beam diameter and diffraction patterns.

Set-Up:

Our group was given a 632.8 nm HeNe THORLABS laser with an aperture radius of 0.315 mm, two tripods, a beam expander, whiteboard, digital camera, and laptop for data collection. We collected data at five different distances (x): five meters, 15 m, 20 m, 50 m, and 75 m. At one end, two experimenters, the laser, beam expander, and two tripods were constructed such that an expanded beam propagated about the 75 m test zone. At the other end, two experimenters moved the whiteboard, digital camera, and laptop to collect image data on the laser beam. A range finder was used to establish accurate distances from which to collect the data.





Procedure:

Two experimenters from both end parties communicated via walkie-talkie to establish distance from which to collect data. Once acquired, mobile party with laptop and camera recorded beam image. Procedure was repeated for each of the five test points.

Data:

Trial	Target Distance (m)	Laser Source Aperture Diameter (mm)	Beam Expansion Factor	"x"	Angle of Divergence (mrad)	Beam Diameter at Target (Theoretical) (mm)	Beam Diameter at Target (Experimental) (cm)	Percent Error (%)
1	75.000	0.630	10.000	0.657	1.300	10.500	10.114	3.676
2	50.000	0.630	10.000	0.985	1.300	8.388	9.086	8.321
3	20.000	0.630	10.000	2.463	1.300	6.741	4.441	34.120
4	15.000	0.630	10.000	3.284	1.300	6.564	3.912	40.402
5	5.000	0.630	10.000	9.852	1.300	6.332	2.455	61.229

Results/Analysis:

The difference between theoretical beam diameter at target (found using our MatLab program by inputting the various parameters) and our experimental findings was very small at the larger ranges (75, 50m). However, the values varied greatly as the range decreased, ending with a 61.229% difference. These percentages indicate that at longer distances, the error in the beam (or error from humans) will become less and less important to the overall measurements, thus resulting in a “nicer” beam.

One large discrepancy we discovered was the difference between our experimental and theoretical beam diameters. Experimentally, we found diameters that were larger by a factor of 10 (in centimeters rather than millimeters). This could possibly be due to an error somewhere in our formula or an issue with the expander.

We learned that the saturation and filter on the camera lens were critical to a good picture, especially when the picture was to be interpreted in MatLab. Our initial photos were too

light, while our final pictures had good contrast but were so dark that MatLab took a long time to calculate the contours. Additionally, the filter amount is key to protecting the camera.

The contour pattern displayed on the screen is due to the Gaussian nature of the beam. The pattern is evidence of the bell-curve representation of the power of the beam as it moves away from the center to the edges of the beam (powerful to weak). It fades at the edges so that the true diameter of the beam cannot be determined. This is a possible source of error from our measurements because the diameters could not be measured perfectly. We used the $1/e^2$ definition of the beam diameter in our theoretical measurements. We also believe this contour pattern could possibly be caused by constructive and destructive interference within the beam itself. However, we are unsure of the cause of this interference since we did not have multiple slits that the beam passed through (as seen in the online experiments by the MIT professor).

Comments on First Experiment:

In regard to the first experiment we performed, this one was much more accurate. It was simple and easy to measure diameter when the beam was photographed and we could measure distance with a computer instead of by eye. And, with more experience with lasers gained since then, we were comfortable with what we were doing and able to complete the experiment more efficiently. For example, the walkie talkie improved communications, knowing how to use the range finder perfected distances, understanding which direction the expander pointed helped actually expand the beam, etc. With better equipment and experience, we were able to conduct a smoother experiment and find better data.

Conclusions:

In conclusion, we find that our laser beam behaved as expected. It propagated across the hallway, expanding more as it traveled a greater distance. The contour pattern of the beam is evidence that it is stronger at the center and fades toward the edges. With the addition of heat, the beam vibrated due to the vibration of the medium it travels through. Our experimental beam

diameter had a moderate correlation to the theoretical diameter, although the data differs by a factor of 10. We also learned about the importance and technique of the imaging of laser beams.