

## Lab 11: Laser Speckle

### 1 Introduction

In this lab you will observe the phenomenon of laser speckle as well as investigate some of its unusual properties. This lab is designed to be an exploratory lab. Therefore, feel free to experiment with the procedures and add observations of your own. An extra objective of this lab is to understand this behavior and think of possible applications for laser speckle.

Laser speckle is an interference phenomenon. It arises because the light reflected from a diffuse surface is really reflected from many different facets of the surface, each of which has a different path length en route to your eye (or other observing device). These path lengths depend on distances and angles in a very complicated way. Nevertheless, there are certain properties of the speckle that are relatively universal, and you may discover these. Similar phenomena exist at longer wavelengths, of course, and radar speckle is used for everything from meteorology to aircraft identification.

**CAUTION:** Laser beams are potentially dangerous and can cause blindness if looked at directly. Do not look directly into the laser beam.

### 2 Experiments

Set up the laser so that it is shining on the wall directly across the room. Put a lens in the path of the laser beam as you did in previous labs, but choose a short enough focal length so as to get a large spot on the wall. Probably about 5 - 10 cm diameter spot would be suitable. Describe what you see. Do you see more bright spots or dark spots? Are all of the spots the same size? Why or why not? Try walking toward and away from the image. Does the speckle pattern change? Does the size of the speckles change? What happens if you squint?

Now try moving your head from side to side. Do the speckles move? If so, which way? You may notice that your lab partners observe the speckles moving in different directions. If you wear glasses, take them off and notice how the speckles look. Are they blurry without your glasses? Move your head side to side without the glasses. Which way do the speckles move now? Try swapping glasses with your lab partners and observe if the direction of movement stays the same or changes. What did you notice?

Make these observations again, this time moving your head up and down. What happens? Does anything change if you are closer or farther away from the image? Also try covering one eye and repeating the observations. Now cover the other eye and repeat again. Do you notice the same phenomena or different phenomena?

It has been observed that the direction of movement of the speckles is somehow associated with nearsightedness and farsightedness and that by observing the movement of the speckle pattern when you move your head, you can determine if you are nearsighted or farsighted. If you were an optometrist and used this to determine a patient's "sightedness" and the patient told you that without their glasses they saw the spots moving in the same direction as their head moved, would you diagnose the patient as nearsighted or farsighted?

Experiment with lenses of different focal lengths. How does changing the focal length change the speckles? Does the pattern change? Do the speckles get bigger or smaller? Speculate on why or why

not. (You can also try combinations of different lenses.) Try changing the distance of the lens from the wall. What happens to the speckle pattern? Why? What happens to the speckles? Why?

Observe the image with a piece of frosted glass. Try putting the glass on the wall in part of the image. What do you notice about the speckles in the glass? What happens if you put the frosted glass in front of the laser beam? About how far away from the laser can you see the image? Use a piece of paper to view the image. What do you observe about the speckle pattern now? Why doesn't the laser image go all the way to the wall?

Try looking at the image on other different surfaces, for example, on the brick wall instead of the flat wall, or on a piece of paper or your shirt (be careful). How does the speckle pattern change?

### 3 Further Exploration

Use the Cal-Tech glass diffraction slide intended for the diffraction lab in front of the laser beam. Observe the diffraction patterns on the wall. Do the images confirm your previous observations?

Set up a procedure of your own and report what you see.

For extra information including applications for laser speckle, look on the web. Try using key words "LASER" and "SPECKLE". Also have a look at the Laser Teaching Center, especially the projects page: <http://laser.physics.sunysb.edu/projects/>.