Fun with Diffraction

SAFETY ADVISORY: *Prolonged exposure to even low intensity laser light can cause permanent, debilitating eye damage. Do not allow students to stare directly into the laser. Do not set up your laser at eye level. Do not allow students to move the laser around once it is in place. Watch for beam-like reflections from material placed in the beam (e.g. aluminum).*

Materials:
- Red diode lasers
- White led light source
- White paper screen
- 35 mm polaroid slide holder or similar frame
- Metal foil
- Fine copper wire
- Clothing pins or something to poke small holes in foil
- Masking tape and binder clips
- Alternate grooved/grated surfaces: DVD, a strand of your own hair, pencil graphite refills
- folders

Purpose: The purpose of this lesson is to suggest that the particle interpretation of light, while perhaps more intuitive, is not always correct. Students with intuitive understanding of wave superposition may recognize diffraction as evidence of the wave nature of light, but all students should at least understand that light isn't necessarily particle-like. Diffraction of white light (if observed) may also reinforce the nature of incoherent light sources.

Part 1 - Discussion:
- What is light? *A particle or a packet of energy we can see called a 'photon.' Alternately, a wave of electricity and magnetism called an 'electromagnetic wave.'* You can give the definition of whichever interpretation(s) they suggest.
- What is a shadow? *The absence of photons or the flatness of the wave.*
- What is special about this laser compared to normal lamps? *It's only one color. Red lightbulb as in holiday lights are actually all colors which are then screened through colored glass. This is actually just red.*
- What will we see on a screen if we put something between the screen and the laser? *It will block the light and cast a shadow in the same shape.* What about a different object? Will this happen for all objects?

Part 2 - Diffraction around and obstruction:
1. Hang a large piece of white paper from a vertical surface such as a wall or book shelf.
2. Place laser on a horizontal surface such that the beam projects onto the white paper. This distance should be at least 1 meter, preferably further.
3. If necessary, carefully turn the collimating lens so that the beam is not so diffuse as to be invisible in the far field. Now that your laser is prepared, you may want to turn it off to conserve battery power.

4. Affix a length of thin copper wire vertically to your slide holder using masking tape or clips
5. Predict what will happen if we place this into the beam of the laser. Draw your prediction.
6. Carefully place the wire in the beam of the laser, supporting the holder with binder clips. This will be finicky; it may take several tries to get the wire oriented properly to observe diffraction.
7. Record and discuss the pattern on the wall; is it consistent with a particle interpretation of light? *It should look something like this:*

<u>Part 3 - Diffraction through a slit:</u>
Repeat the process in Part 2 but this time we will use a hole, rather than an obstruction. This can be done either with a linear pattern - which will look the same as the wire - or a circular pattern. Time permitting, do both! Note that both these objects will be reflective - place a folder at the back of your laser to block back reflections. As before, sketch your prediction and result.

1. For the linear pattern: take two small squares of metal foil (thicker is better) and tape them to your slide, directly next to each other but for a small gap. The gap should be on the order of one mm. You may have to try several times to get the spacing right. Optionally, you can draw the diffraction pattern on the board and then try to change the gap to see if you can alter the pattern. *The pattern should be the same as in part 2.*
2. For a circular pattern: Tape a (thin) square of metal foil to the slide. Place the slide in the beam. Use a pin to poke a small a hole as possible in the metal foil, centered on the beam. You may have to try several times before getting a hole of a suitable size. *The pattern should look as below.*

<u>(Optional) Part 4 - Diffraction along a grooved surface/miscellaneous diffraction patterns:</u>
What other objects can you observe cause diffraction? What do they have in common?

You can see diffraction on grooved surfaces as well. However, you cannot transmit through them. For such an experiment, turn the laser such that it points away from the screen and use the back of a CD/DVD to reflect the light back onto the screen. The pattern should be different for CDs and DVDs - DVDs are more densely grooved.

You can try having the students use a strand of their own hair - the pattern may be significantly different for each student; you can sketch the pattern for each person and compare.

<u>(Optional) Part 5: Diffraction of white light</u>
Can you observe diffraction of white light through any of these obstructions?

The most difficult thing is to see the relatively diffuse beam at a large enough distance for the fringes to be resolved. You may need to project the light into a darker space - under a desk or into a corner.

You should observe separate fringes for each color. This suggests that white light is composed of all different colors and each color passes around the obstruction differently.