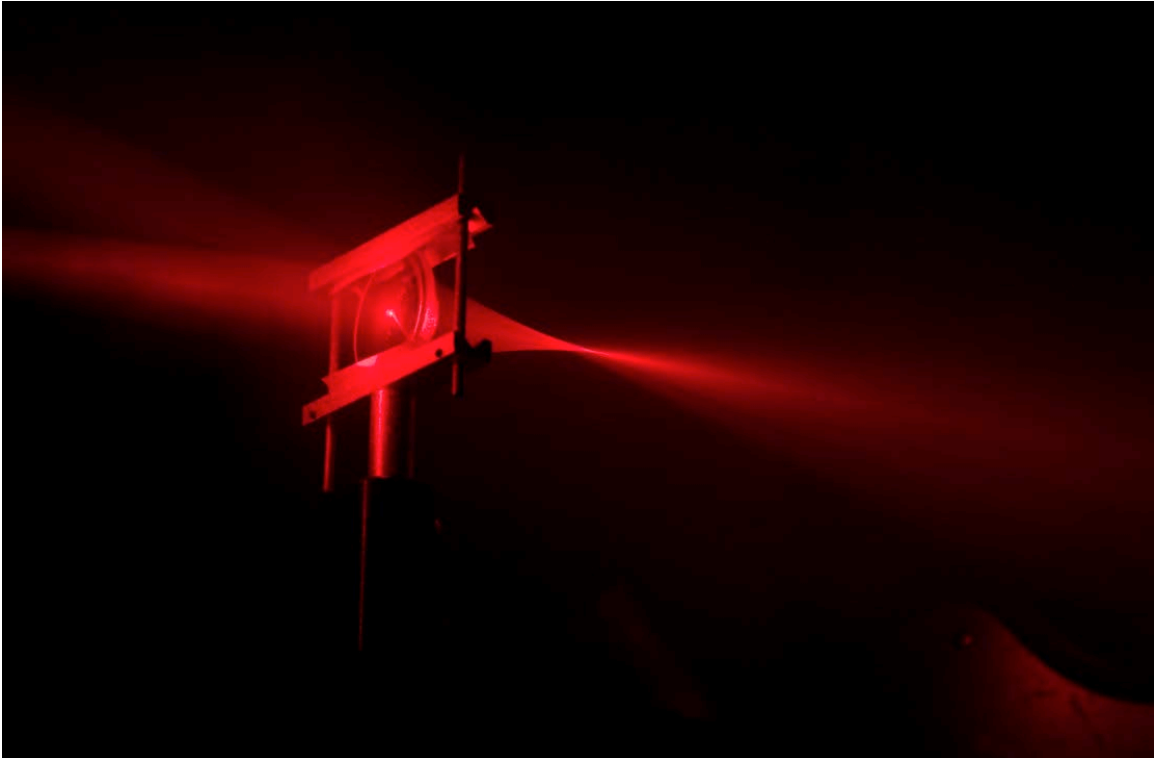


Laser Light Through a Converging Lens

Flow Visualization

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For this last project our team decided to work with laser light to explore reflection and refraction. Our teammate Sam had a red laser from his Senior Design project that was going unused so he donated it to this project. It was an extremely strong laser so we had to proceed with much caution. When working with lasers it is very important to know where the laser beam will go at all times, and never let its beam hit your eye. It could cause lasting damage to retinas if we're not careful. For the image included in this report I set up a laser and a converging lens in the shed behind my house. There, I used a fog machine to visualize the laser beam. From the image one can see many effects on light travelling through air and glass.

In the shed, the red laser was set upon a stack of books to achieve the same height as the lens in the stand. The red light is representative of a sinusoidal wave with a wavelength of 650 nanometers [1]. The camera was positioned slightly below and right of the apparatus, perhaps two feet away from the focus point of the lens. The fog machine was placed just behind the laser, pumping fog into the field of view. The picture was taken as the fog machine was on, saturating the air with turbulent fog. As it was, the thick fog scatters light relatively evenly, producing the soft image above, and allowing us to see the laser beam. If the fog machine was off, and the fog was not in a turbulent state, there would be visible swirls in the light of the laser. Another effect of the fog in this image is the lack of a neat focal point after the converging lens. This is because the light interacts with the fog as it travels through, causing some light to scatter before and after the lens. This skews the focal point of the lens just a bit, smoothing the converging to expanding transition. If there was no fog present, there would be a very precise focal point.

In most cases, lasers put out a collimated beam of light, meaning all of the light traveling from the laser is parallel. In this case, however, the light is passed through a focusing lens on the end of the laser. This lens in the body would be a converging lens as well, but it was adjusted so its focal point was inside the body of the laser. This is why the beam is expanding as it travels from the laser. Please refer to the figure below for a diagram of this situation. When the red light encounters the strong converging convex lens, the light converges in about two inches. Using the lens equation we can find the focal length as well as the magnification of the converging lens used.

Using these two equations we can know that the focal length of the lens was probably 2 inches, as the equation returned a value of 1.8. It is likely that the lens was actually 2.25 inches from the focal point. This translates to a magnification of .125x [2]. We can know that the focal point seen in the image is more than two inches from the lens, because the

laser is clearly beyond two focal lengths from the lens. Lens physics indicate that this translates to the image after the lens that is somewhere between one and two focal lengths. The calculations above agree with theory.

For this shot I set my camera up on a table below the laser setup. I chose to view the laser setup from here to enhance the striking emotion of the shot. Seeing the lens from this vantage point gives the lens a powerful feeling, like the Tower of Saruman in Lord of the Rings. I took the shot with my Nikon D70, with an 18-70mm lens. The aperture was set to f/6.3 and an exposure of 1/8 second. The laser was very bright in the dark room, so I avoided over saturating the face of the lens. The ISO was set to 250 and the focal length was 50mm. The lens apparatus was about three feet from the camera for this shot. For this shot there was no post processing necessary. I found it interesting that there was some blue light in the shot analysis but no green light at all.

Overall, I love the feeling of this shot. I like the dark emotion portrayed from the powerful tower. The fog shows how light travels through a lens, and how some gets scattered as it travels through. The reflection is also visible, but is not as strong as the refraction, of course. To develop this idea further I could imagine using a series of lenses, or working with fog that is not in a turbulent state.

Appendix

1. What Wavelength Goes With What Color? http://science-edu.larc.nasa.gov/EDDOCS/Wavelengths_for_Colors.html
2. The Mathematics of Lenses. The Physics Classroom, <http://www.physicsclassroom.com/class/refrn/U14L5f.cfm>