# Schlieren Optics

## Single Mirror Imaging System

## Concept

The goal of this experiment is to observe the changes of refractive index of air, due to changes in its density, by visualizing them with a one-mirror Schlieren optical system.

This system consists of a spherical mirror, a point light source, a light block with a sharp edge, and a camera. By positioning the light source at the double focal length of the mirror, the reflected light is focused symmetrically on the opposite side of the source. To capture deflected light passing through a different medium, a light block is placed at the point where non-deflected light focuses, as seen in figure 1, and a camera captures the deflected light only. The angle of deflection is proportional to the density change of the medium.

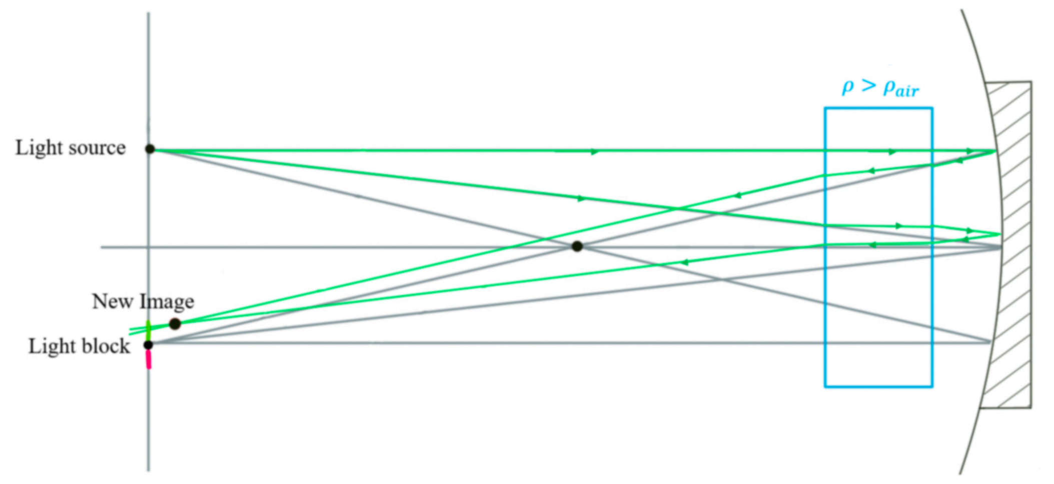


Figure 1. Ray tracing of a single mirror Schlieren optical system

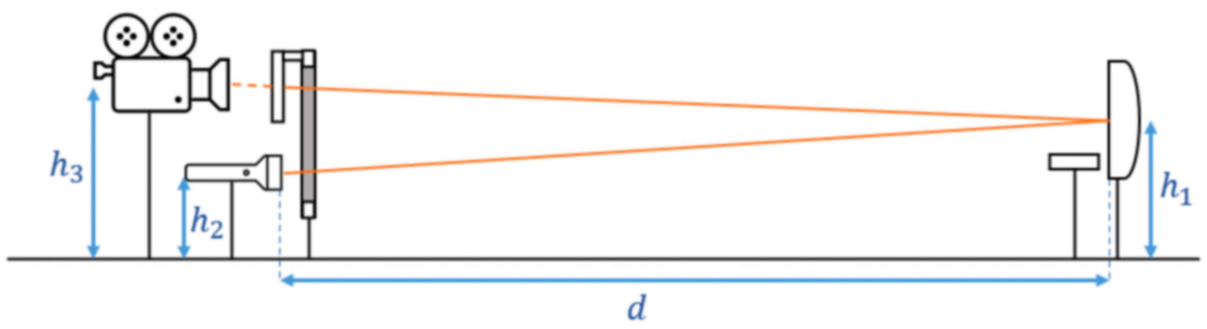


Figure 2. Sketch of our setup

## Setup

In our experimental setup, we used a spherical mirror with a focal length of 1.5 m, a camera and a powerful white LED attached to a 0.5 mm optical fiber as our light source. We used a wire with a diameter of 0.7 mm as a light block and added pink and green color filters. To ensure stability and precision, we built the setup on an optical TriRail and attached each component to a mounting post. The light block was mounted on a slidable C-shaped mount to avoid blocking the outgoing light. Additionally, we placed a small table-like stand in front of the mirror as seen in figures 2. and 3. The base of the setup consisted of two TriRails, one with a length of 1.5 m and another with a length of 0.4 m, connected to meet the minimum required distance of 3 m.

Due to high sensitivity of this system, we carefully calibrated it by adjusting the distances shown in figure 2. to ensure that the undeflected light is focused at the light block.

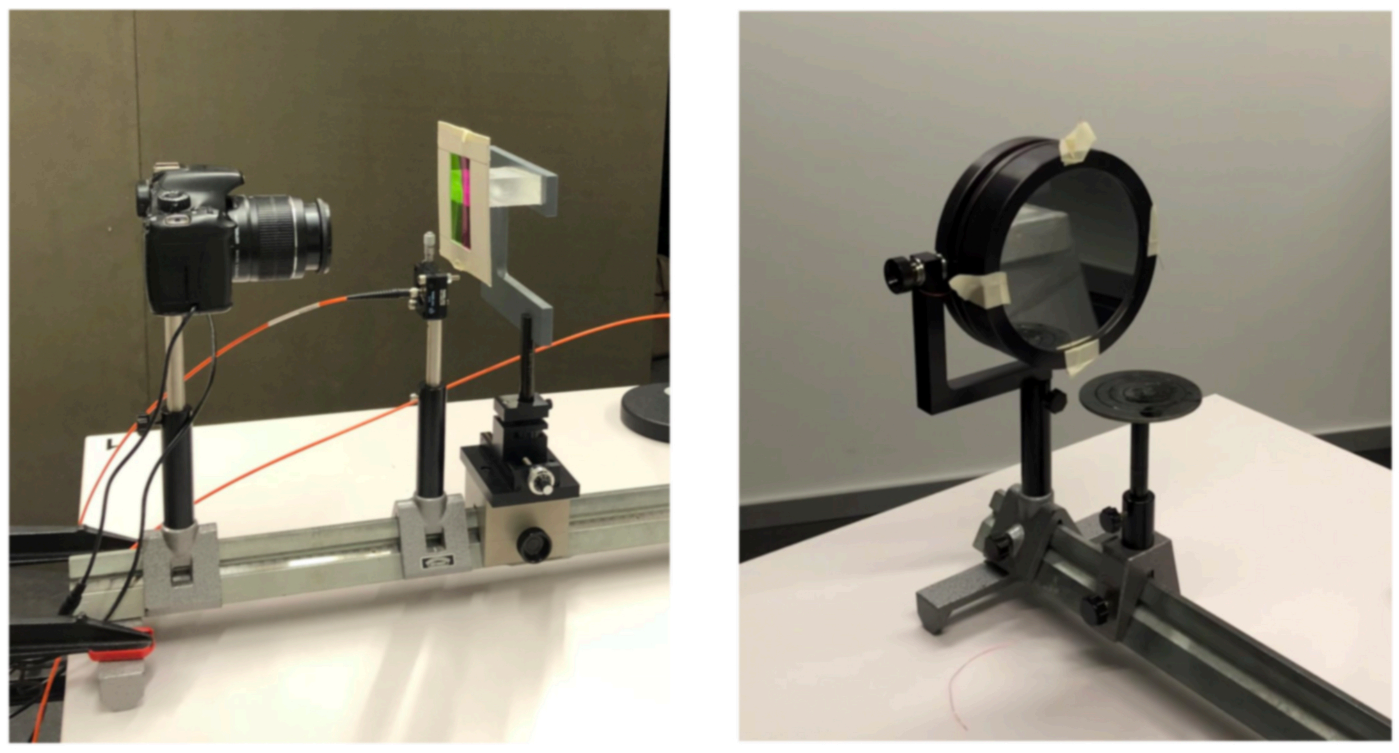

Figure 3. Our physical setup

## Experiment and results

We visualized changes in air density resulting from temperature variations, as presented in the first three images of figure 4. Several objects were sequentially placed in front of the mirror, including a tealight candle, liquid nitrogen, a human hand, ice cubes, dry ice, and a metal block cooled in liquid nitrogen. We recorded the images captured by the camera for each object.

By analyzing the recordings, we explored the relationship between temperature and the illuminated area around the latter three objects. The result is presented in figure 5.

Furthermore, we sought to visualize changes in refractive index caused by pressure differences in the air surrounding a model wing within a laminar flow. To achieve this, we employed a wind canal to generate airflow in front of the mirror. The wing was then introduced into the flow, which allowed us to capture the last image of figure 4.

Other phenomena that can be visualized using this system are, among others, ultrasound standing waves, shock waves, surface structure of transparent solids and many more.

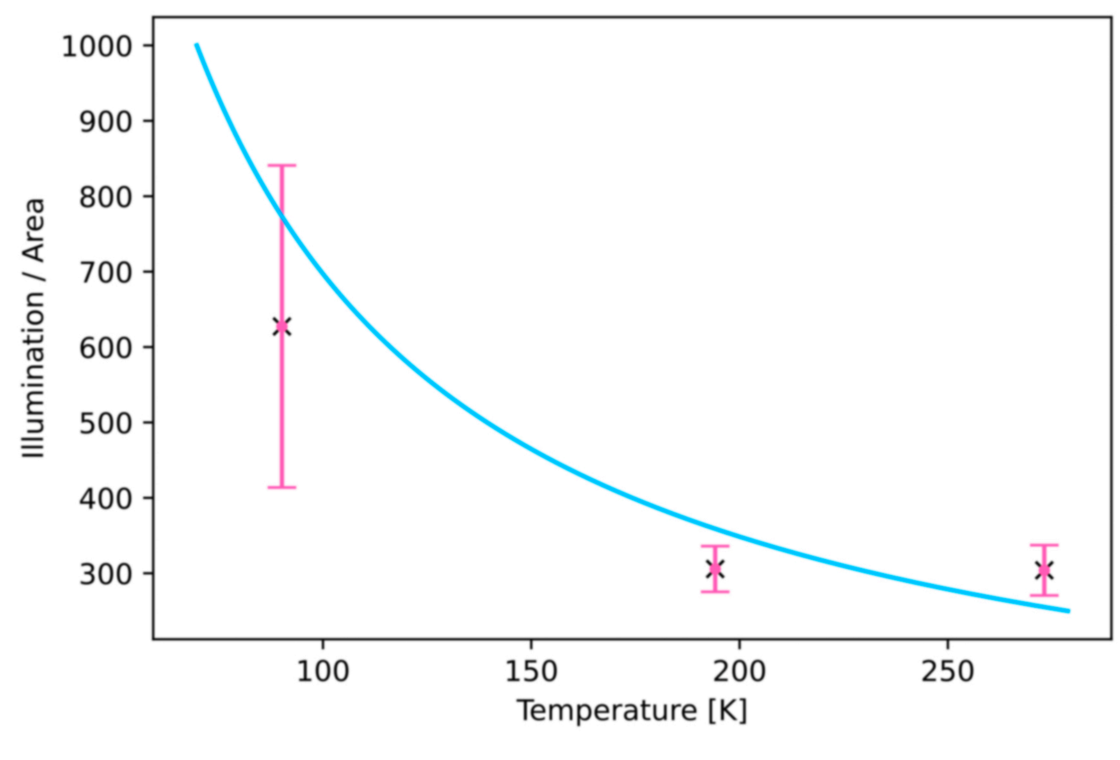


Figure 5. The relationship between the illuminated area and temperature of a metal block cooled in liquid nitrogen, dry ice cube and an ice cube

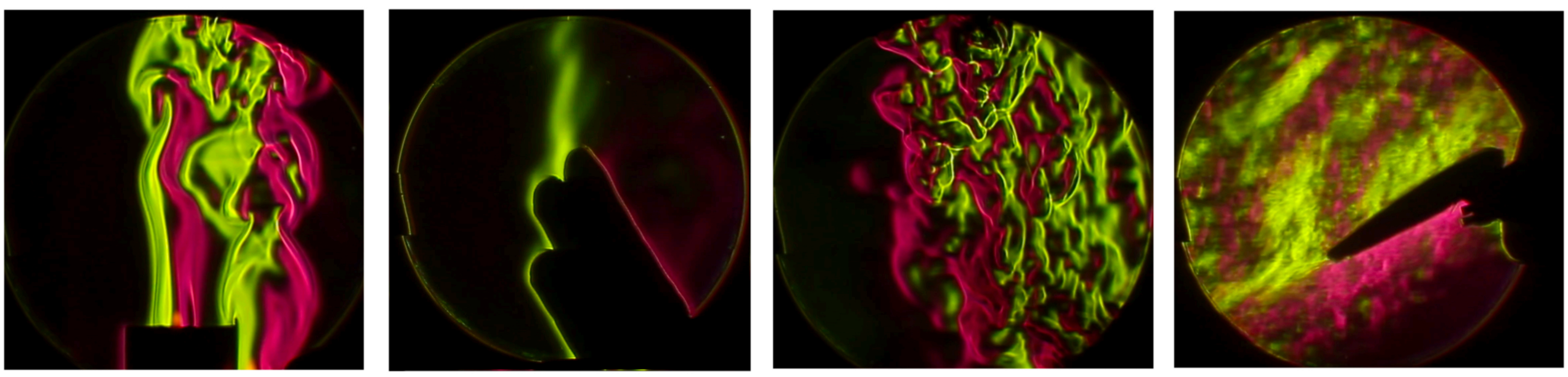

Figure 4. Images taken with our Schlieren optical system of following objects: a lit candle, a hand, liquid nitrogen, a wing in a presence of strong air flow

Authors: Group 1. P+ FS23