

Optics experiments at home during lockdown

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Optics for Mechanical Engineering students

- Master with track in opto-mechanics
- The students have no background in optics (except a bit from high school)
- The students like hands-on activities (mechanical engineering!)
- Text book of the course is Introduction to Modern Optics by Fowles, it is an interesting book for this course since it introduces basic optics with a higher level in mathematics than other basic books in optics
- Each topic that is treated during the course is complemented by practicals
- The topics for the practica are: polarisation, interference, diffraction, geometrical optics

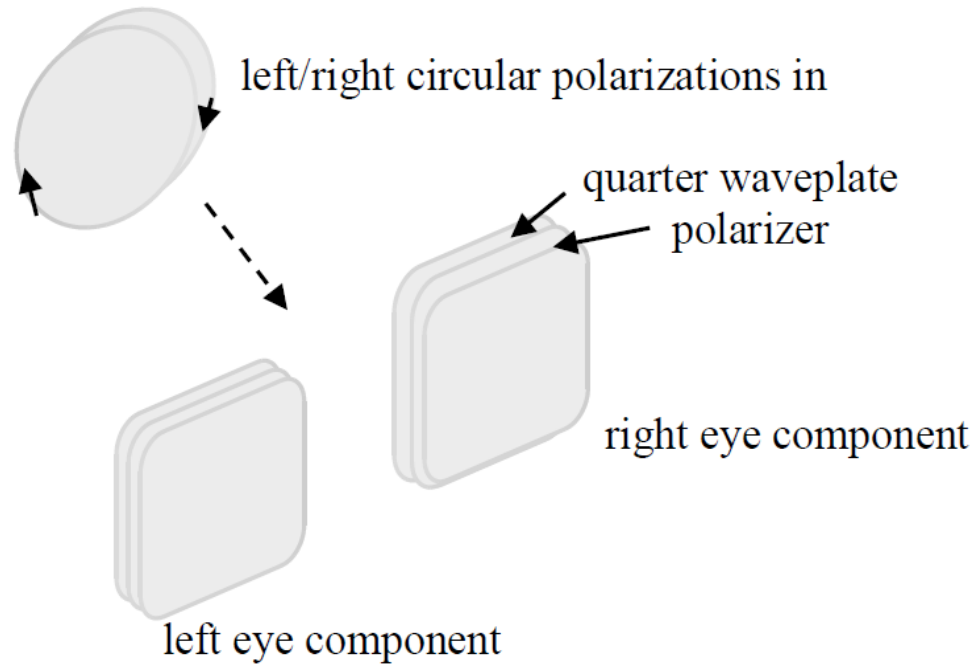
Practicum 1: Polarisation

Analyse how a 3D cinema glass works

Materials: 2 glasses (real 3D), transparent cellophane tape



Polarisation

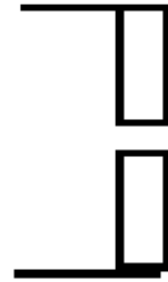


This information is given to the students. By assembling the glasses in different ways (one after the other) while looking through the window, the students analyse the polarization properties of the glasses

Polarisation

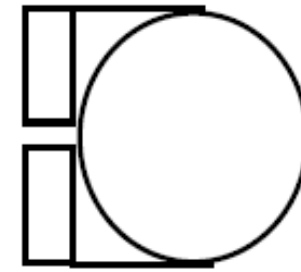
→
Light in

3D glasses 2



←
temples

3D glasses 1



observer

$$J_{L2,R1} = \begin{bmatrix} 0 & 0 \\ 0 & 1 \end{bmatrix} \cdot \frac{1}{\sqrt{2}} \begin{bmatrix} 1 & i \\ i & 1 \end{bmatrix} \cdot \frac{1}{\sqrt{2}} \begin{bmatrix} 1 & -i \\ -i & 1 \end{bmatrix} \cdot \begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix} = \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} \quad (1)$$

$$J_{L2,L1} = \begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix} \cdot \frac{1}{\sqrt{2}} \begin{bmatrix} 1 & i \\ i & 1 \end{bmatrix} \cdot \frac{1}{\sqrt{2}} \begin{bmatrix} 1 & -i \\ -i & 1 \end{bmatrix} \cdot \begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix} \quad (2)$$

$$J_{R2,R1} = \begin{bmatrix} 0 & 0 \\ 0 & 1 \end{bmatrix} \cdot \frac{1}{\sqrt{2}} \begin{bmatrix} 1 & i \\ i & 1 \end{bmatrix} \cdot \frac{1}{\sqrt{2}} \begin{bmatrix} 1 & -i \\ -i & 1 \end{bmatrix} \cdot \begin{bmatrix} 0 & 0 \\ 0 & 1 \end{bmatrix} = \begin{bmatrix} 0 & 0 \\ 0 & 1 \end{bmatrix} \quad (3)$$

$$J_{R2,L1} = \begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix} \cdot \frac{1}{\sqrt{2}} \begin{bmatrix} 1 & i \\ i & 1 \end{bmatrix} \cdot \frac{1}{\sqrt{2}} \begin{bmatrix} 1 & -i \\ -i & 1 \end{bmatrix} \cdot \begin{bmatrix} 0 & 0 \\ 0 & 1 \end{bmatrix} = \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} \quad (4)$$

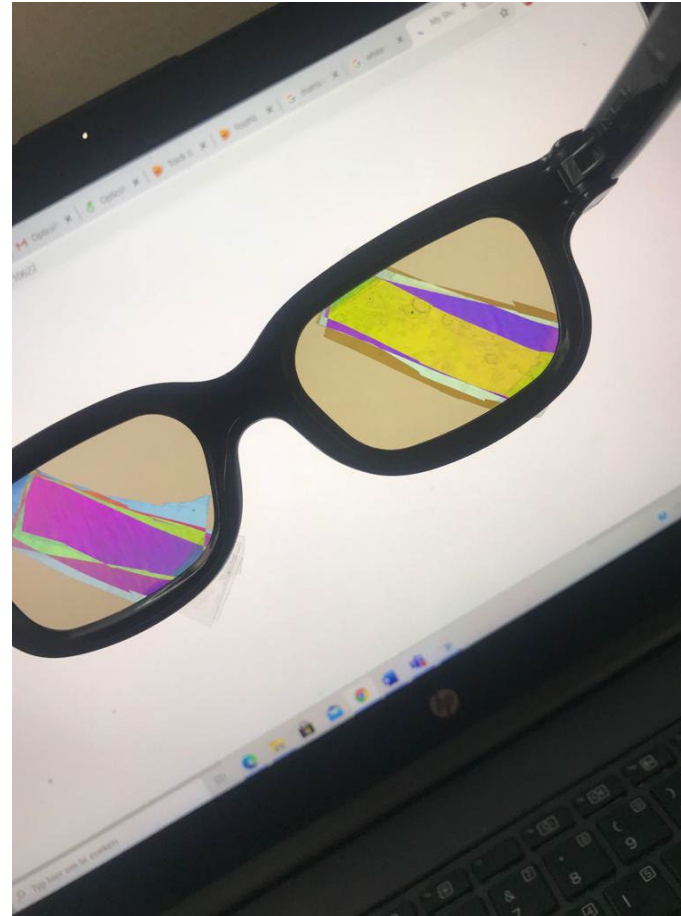
This is one of the configurations of the glasses.
They also calculate the Jones matrices of the system
for the different configurations as shown here

Polarisation

Birefringence

Add layers, different colours

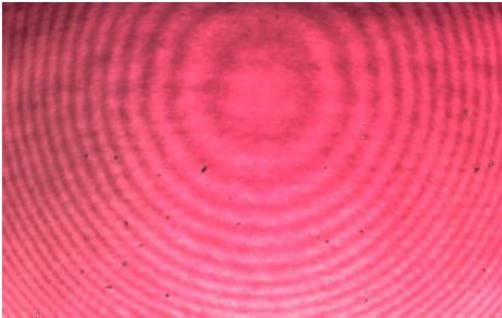
By adding a few layers of cellophane tape between two glasses, following a certain configuration, the students observe and try to explain the birefringence effect of the cellophane



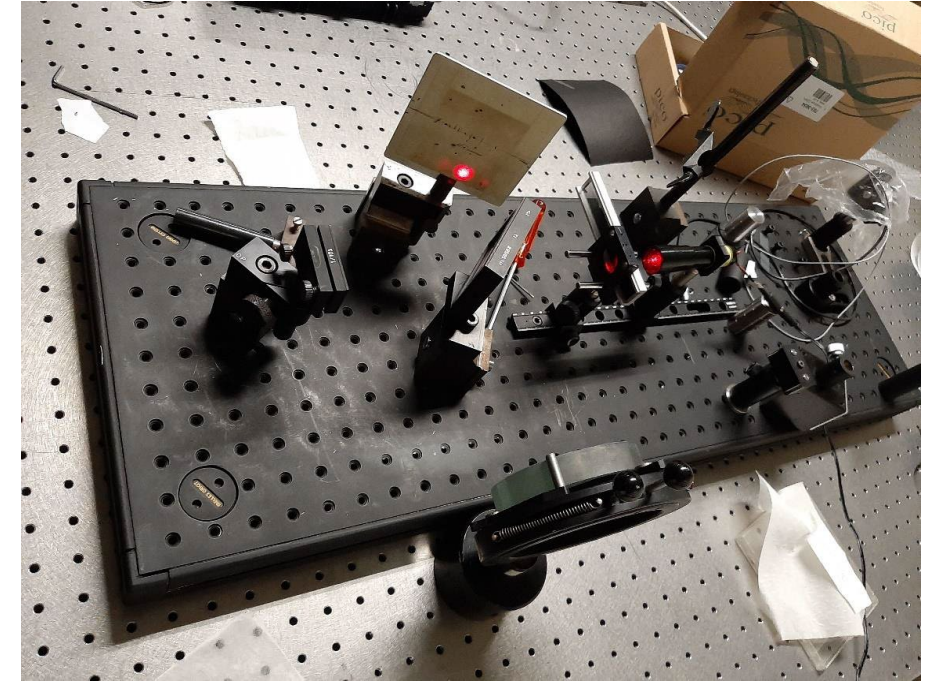
Practicum 2: Interference

Michelson interferometer:

- The interferometer is used for optical testing
- Data such as below is given to the students



Interference fringes from a spherical mirror, when this is placed in one arm of the interferometer, with a flat mirror in the other arm

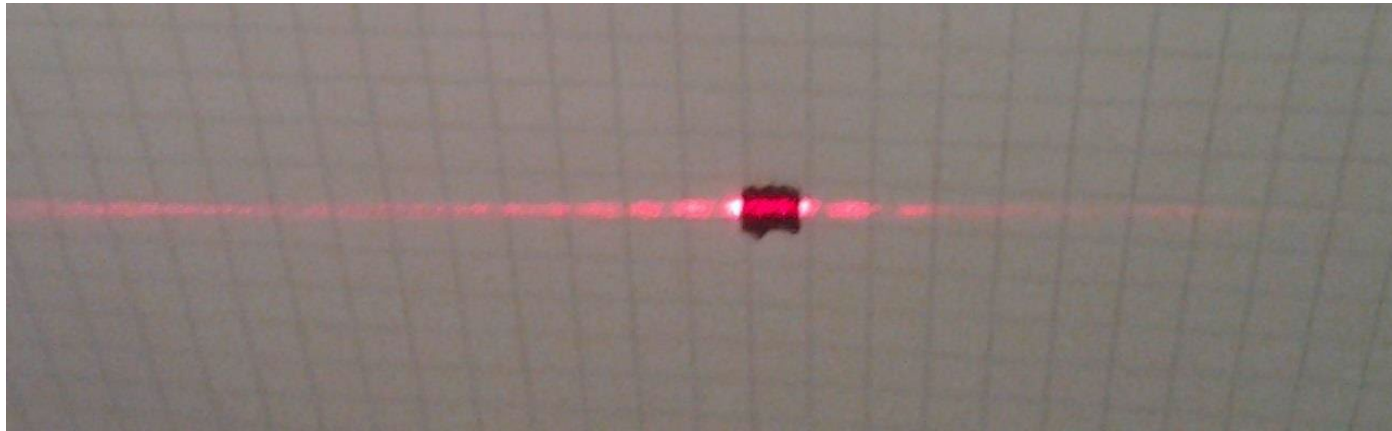


Setup that is used to take the data (at the TU Delft)

The students determine the curvature of the spherical mirror by analysing the fringe pattern
They also have data of a tilted mirror, where they calculated the direction and value of the tilt of the mirror

Practicum 3: Diffraction

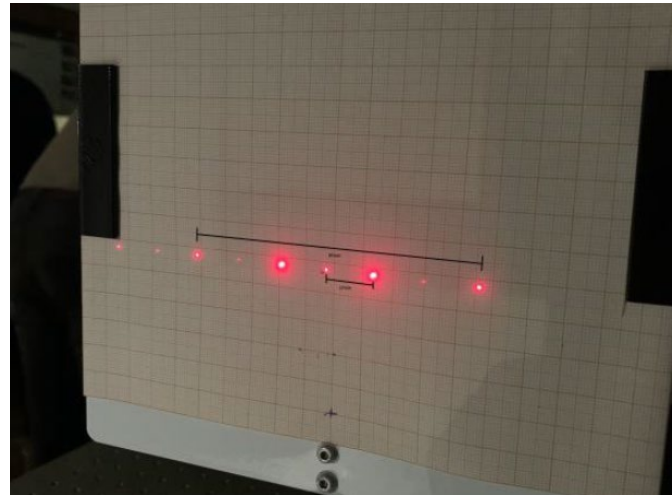
Simple experiment with two pencils next to each other, illuminated by a laser pointer. The diffraction pattern as shown below is observed at a certain distance:



The students determine the gap between the pencils using the diffraction pattern data

Diffraction

- Also data of the diffraction pattern of 2 gratings are given

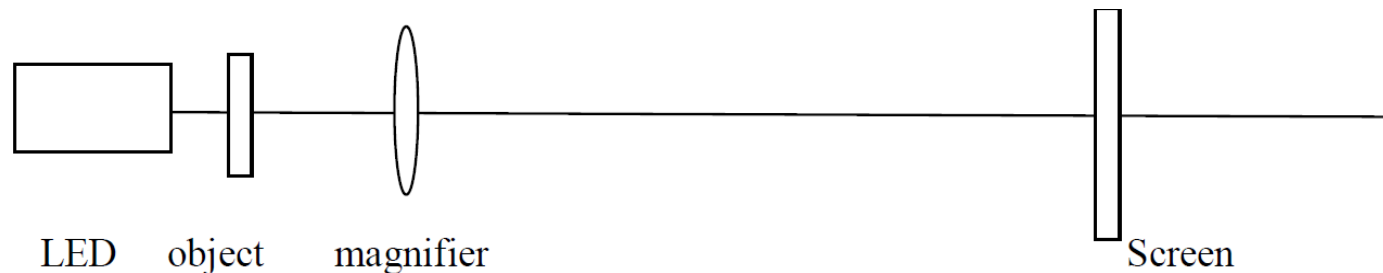


With the data, the students determine the period of the grating

Practicum 4: Geometrical optics

- Material: magnifier, bicycle lamp (LED), smartphone, some self-made “objects”

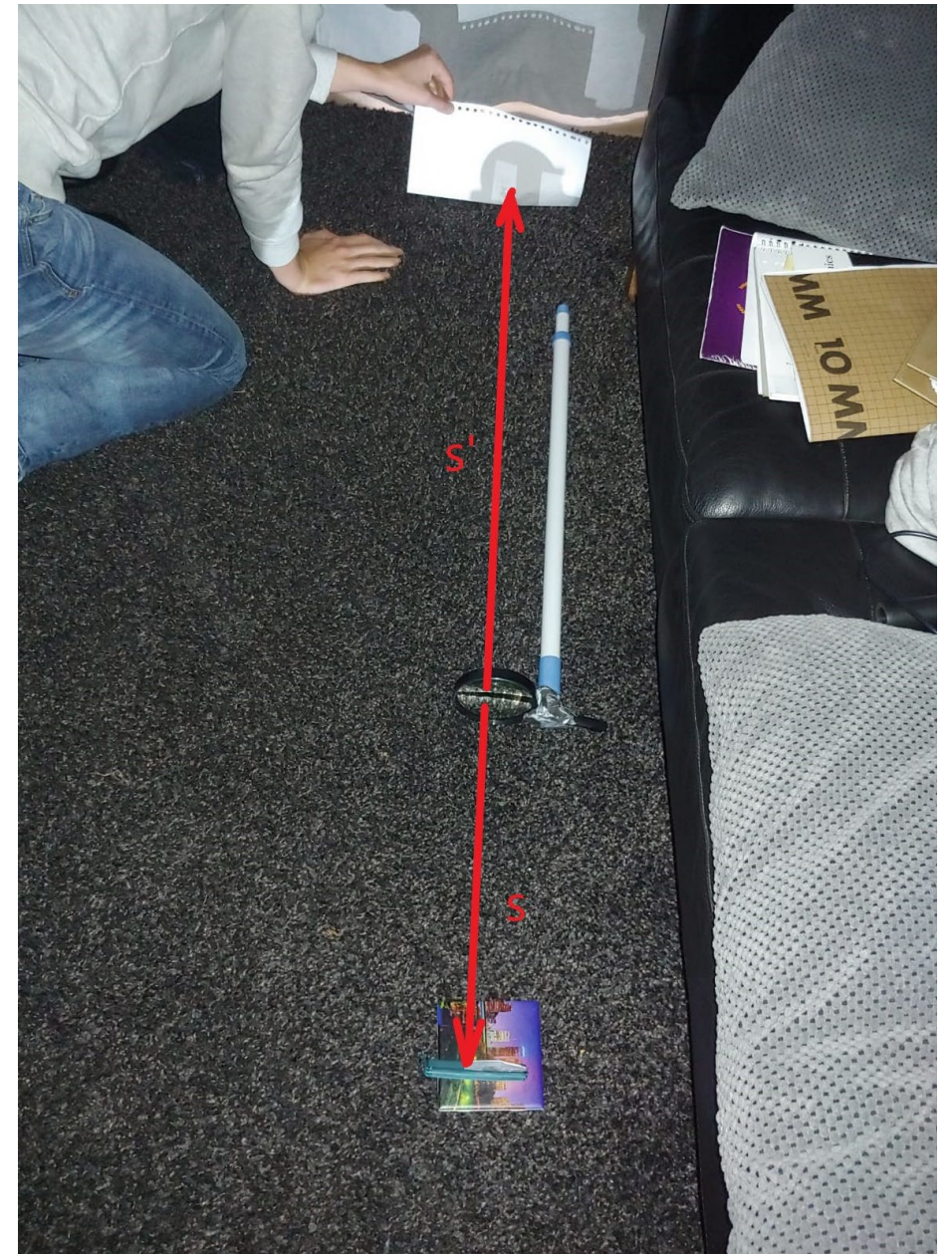
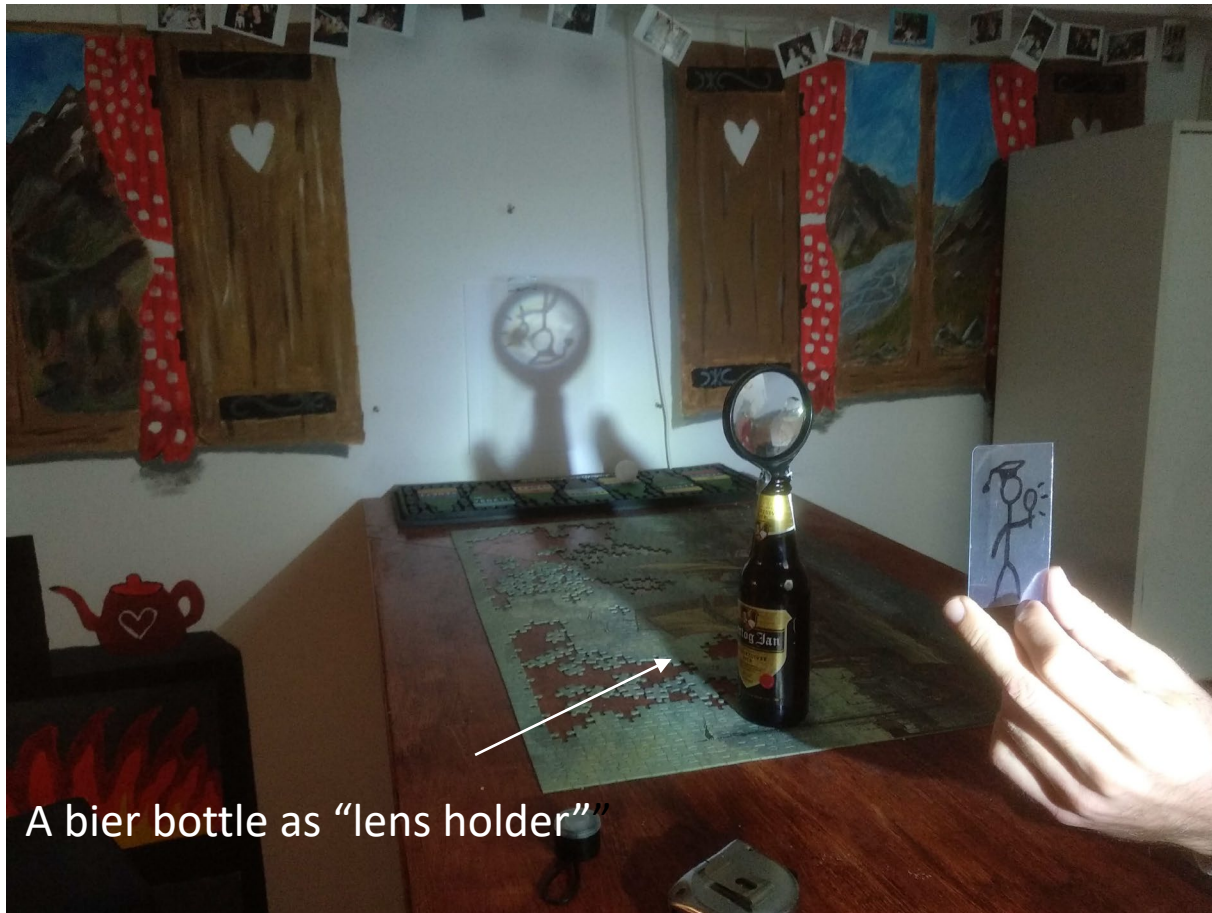
Exercise 1: the students make an image of a transparent object with the magnifier at a screen



The students determine the image magnification using geometrical optics

Geometrical optics

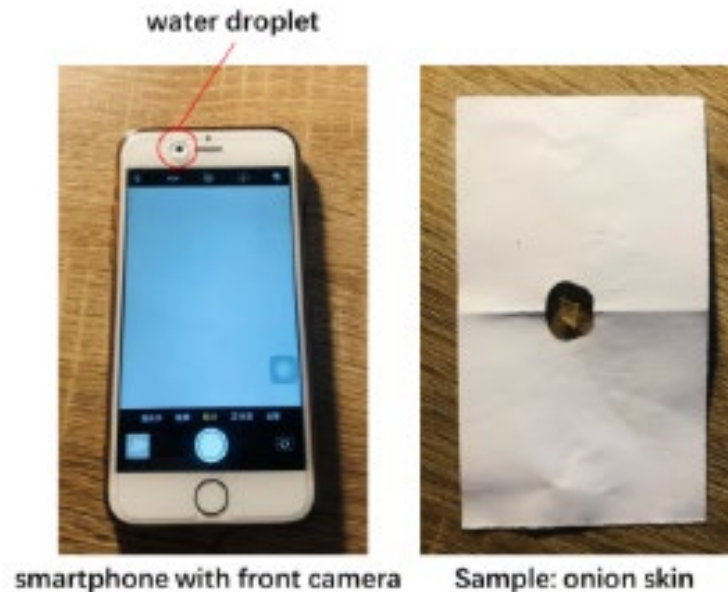
Setups from students:



Geometrical optics

Exercise 2: make a microscope with the smartphone

- Add a water droplet on the front lens of the smartphone (this is the “objective” of the microscope), make a transmission sample, carefully bring the sample close to the smartphone, take a picture



Photos from the setups of the students

Geometrical optics

Microscope photo “gallery”
from the students

The students made photos of leaves, pollen, cookie
crumbles, onion skins, insect legs and wings

