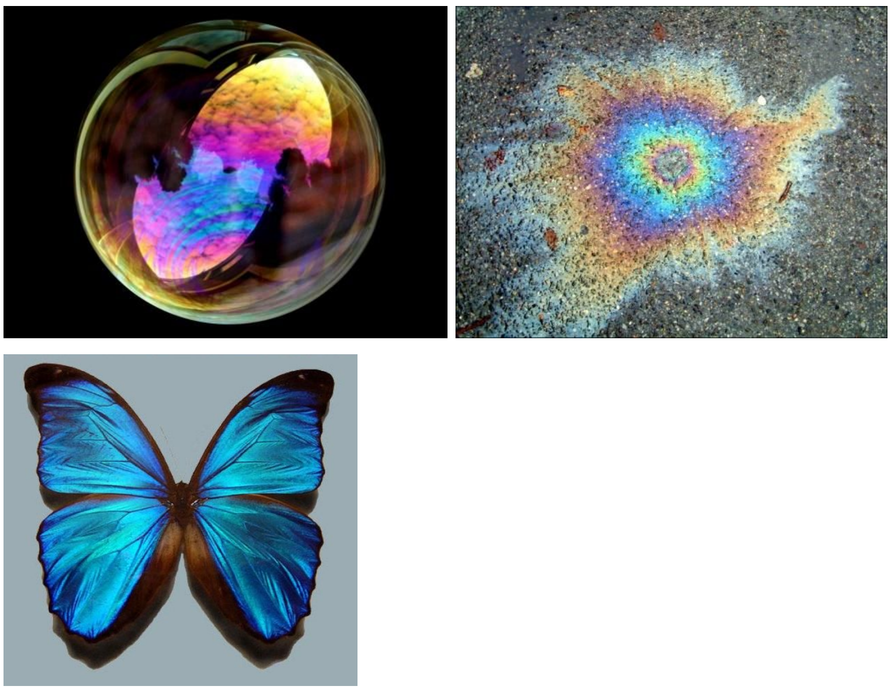
PHOTONICS WORKSHOP

Title of the workshop: Interferometric Laser Droposcope
Target audience: Young students (10-14 years old)
Time planning: Total: 3h
Estimated cost: < 32€

Step 1: Physics behind every day



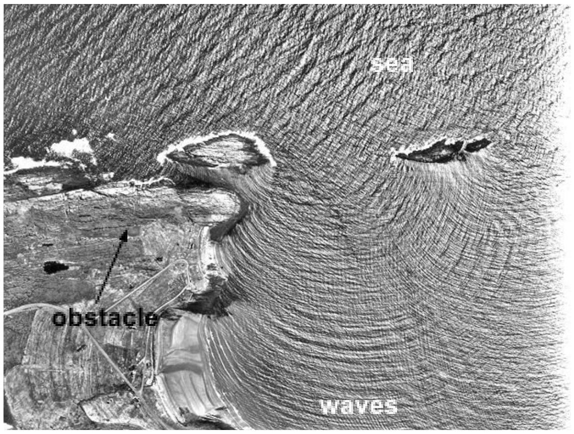
Picture A. Every day beauty

Have you ever wondered why soap bubble shine in various colors? Why oil on the road has all these colors even though oil itself is colorless? Or why butterflies have all these beautiful shining colors that changes when you look at butterfly at different angle? Well, now you can find out.

Picture B. Light as wave

First of all you have to know that light most of the time is characterized as a wave – similar to the ones like we see in the oceans or seas. Different color has its own wave structure (see Picture B). So if we want to find out why soap bubbles have these colors, we have to find out some properties of waves. So it would be easier to understand, let see how waves behave at sea.

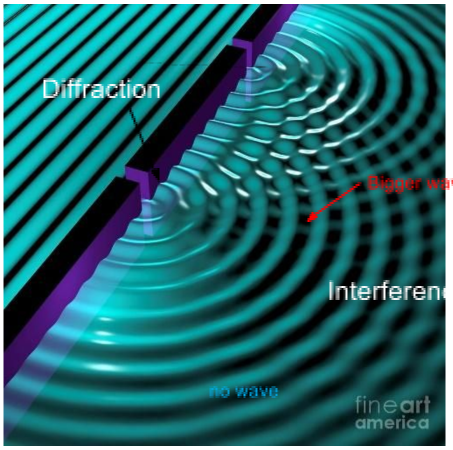
Diffraction is a process that takes place when any wave on its way meet an obstacle. For example, in Picture C you can see a diffraction process that occurs in sea – even though there is an obstacle (rocs) in the sea but waves manages to reach the shore. This happens because waves can bend around obstacles. This can occur when the wave encounters a small object in its path (like in Picture C). The same thing happens when the wave is forced through a small opening (see in Picture D).



Picture C. Diffraction in sea

Picture D. Diffraction in sea

When we have several small openings near each other, we can notice a phenomenon called **interference**. Also, interference we can notice when we drop at least two rocs into water and we make small waves by ourselves (see Picture E).



Picture E. Example of wave interference.

How from two waves bigger wave forms

How from two waves no wave forms

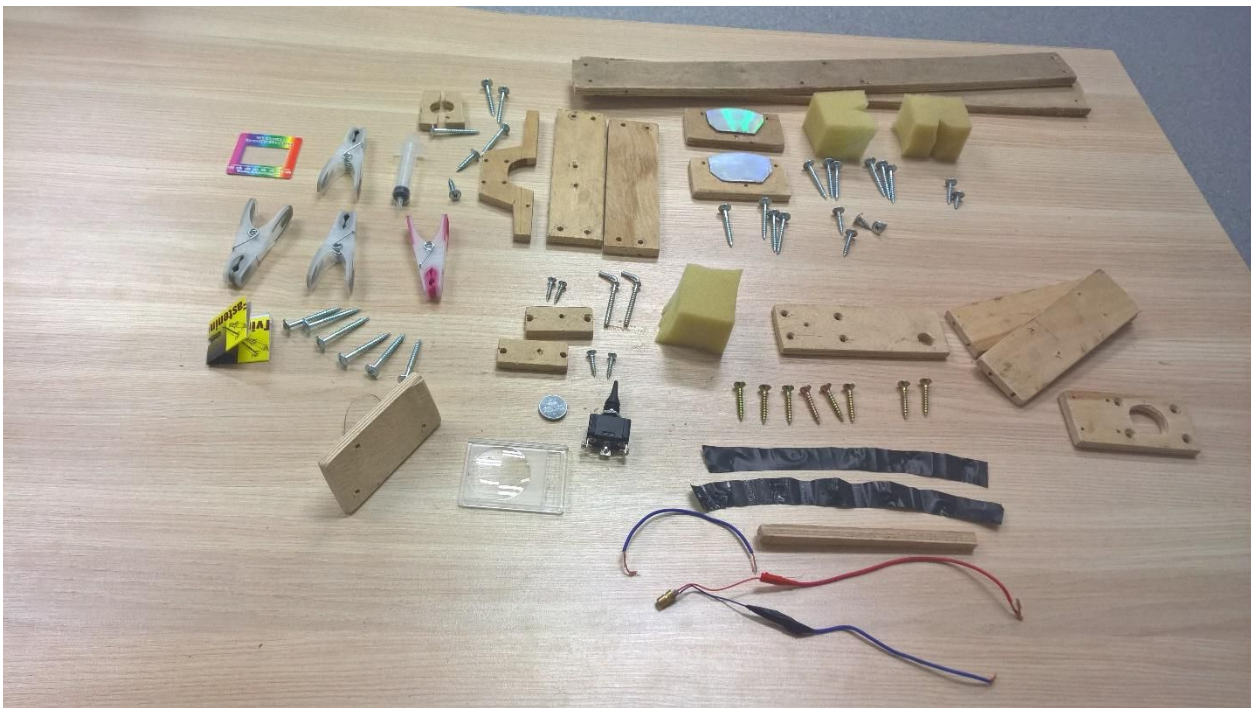
Interference happens when one wave comes into contact with another wave and they interact. Where two peaks of the waves meet – we get a bigger wave, where we have peak of one wave and minimum of the other wave – we have nothing (blank space). This means that with interference we can get bigger intensities of waves or blank spaces.

The same thing happens with light. But don't forget that white light consists of many colors (red, orange, yellow, green, blue, indigo and violet) and their waves. Every wave of color interacts in different places – we see interference (higher intensities) of different colors in different places. Because of the interference phenomena and different color waves, when we look at soap bubble, oil spill or etc. at different angles we see different colors.

Knowing that light can diffract and interfere we can make more beautiful thing by ourselves. One of them is droposcope. It is a simple microscope which uses drop of water as a lens. Image of organisms inside a water drop is projected on a screen using the laser (see Picture D). Due to the diffraction they appear surrounded with fringe contours. But how do we get an interference?

When laser light is falling into the drop, we see the enlarged image on the wall because water drop behaves like a lens. When we put a diffraction grating on the way of laser beam, from one laser beam we get several beams. The central one is the brightest and it is surrounded by two less bright beams. By blocking the central beam and redirecting another two beams using mirrors into water drop, we can get observe an interference!

Step 2: Part list



Photonics parts:

- Green or red laser diode (or a pointer)
- Lens with focal distance *f* = 150 mm
- Diffraction grating
- Two mirrors (or a CD)

Electronic parts:

- Two wires (blue and red)
- Battery, 1.5V Lion lell
- Charger
- On/off switch

Other parts:

- Plywood (6 pieces, 60 cm x 5 cm)
- Screws
- Isolation tape
- Clothespins (4 units)
- Syringe
- Foam
- Paper

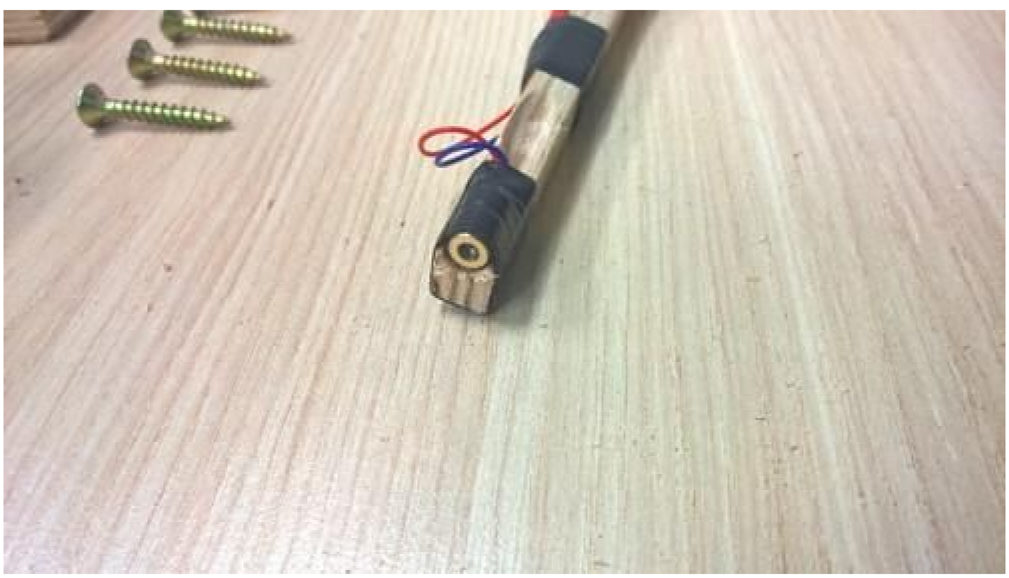
The photonics parts can be bought by EYESTvzw.
The electronic parts can be bought by Fablabfactory.

Step 3 - Preparation

BASIC

Step 3.1. Making a laser pointer.

Take an isolating tape and cut two 10 cm long pieces. Cut from a plywood a 6-8 cm long stick. We will use it to host a laser diode. Take a laser diode and use first piece of the isolating tape to secure the laser diode on the first end of a stick. Use the second piece of isolating tape to secure wires from the laser diode a bit further on the wood stick.



Step 3.2 Making of a laser housing

You will need 8 screws, four pieces of plywood and a small piece of foam.

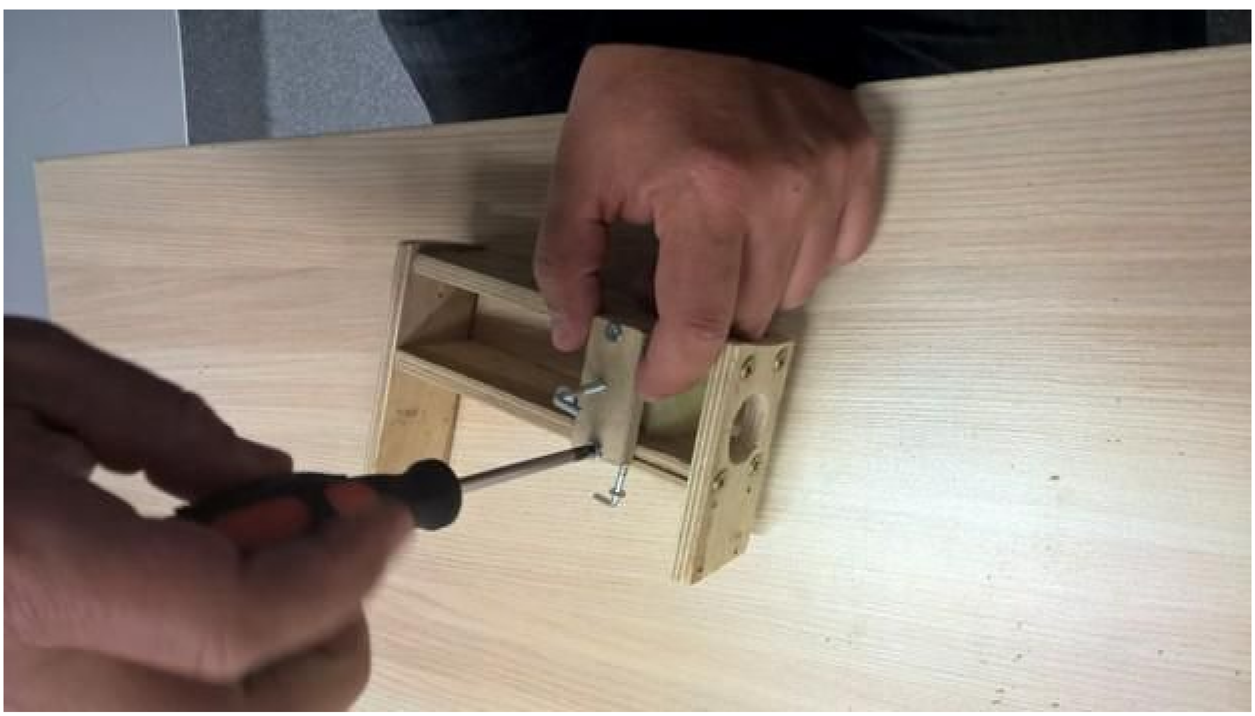
Before cutting plywood, carefully plan lengths. The side walls have to be longer than the length of the stick, on which a laser diode was secured. Two another pieces can be smaller, however they can’t be too small. Why? Keep in mind that the laser beam has to go out of the laser housing. Therefore you will have to drill hole (a laser beam exit) in one piece of plywood. Note, that you should also plan some place for four smaller holes around the laser exit, which will be used to mount the plywood piece with the beam exit to two other pieces.
Use a screwdriver and mount the piece with the beam exit to other two walls of the laser housing. After you finish, make four holes for screws in the last part. Use a screwdriver to assemble the last piece of a laser housing

__Step 3.3. Constructing laser positioning system__

Now, you have made a laser and its housing. It is time for a laser to find theplace inside the housing. Keep in mind, that photonics is a very sensitive thing, so the laser has to be placed so, that its beam goes out of the laser exactly there, where we intend it to have. For this reason you will need here a piece of foam, six additional screws and two small pieces of a plywood.

Drill two holes for two mounting screws in each small piece of plywood. Holes should be on the ends of the pieces. The height of the wooden pieces should be exactly the same, as the height of the laser housing. Drill a hole in the center of each wooden piece. Those holes are for our laser. We will use screws to adjust the position of our laser. Make a hole on the top of the house for an adjusting screw. Place a piece of foam inside the laser housing.

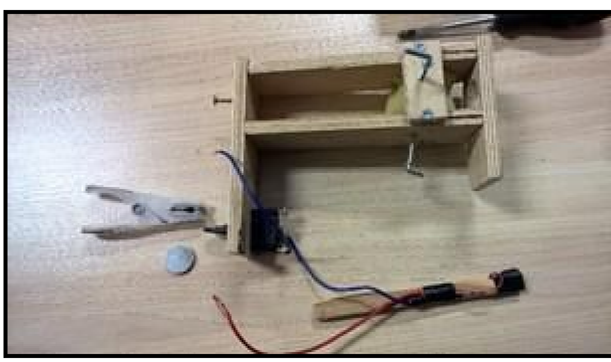


Now mount a piece of wood with the second adjusting screw to the laser housing. After you finished, carefully place inside the box the laser, to check whether it fits. Now it's time to install our laser.

Step 3.4. Installing the laser inside the housing

Now prepare a battery, on/off switch, one additional wire and a Clothespin. Drill a hole for a switch of the back-wall of the laser housing. It should be big enough to accommodate the switch. Place the switch inside the hall and secure it with a screw. After you finish, connect the red wire from the laser wires to the switch. Connect now the third wire to the last pin of the switch. Take that wire and place on one side of the battery, the loose wire from the laser connect to the opposite side of the battery. Before proceeding make sure, that the switch is in off position. While holding everything in your hands take a Clothespin. Carefully secure battery with wires on the laser housing. Check whether the laser lights on when you turn it on with the switch. If nothing happens, try to change sides for the wires on the battery. After that, carefully place the laser inside the housing and secure it with adjusting screws. When you rotate the adjusting screw, the laser should move to the left/right and to the top/bottom. The laser housing is ready!

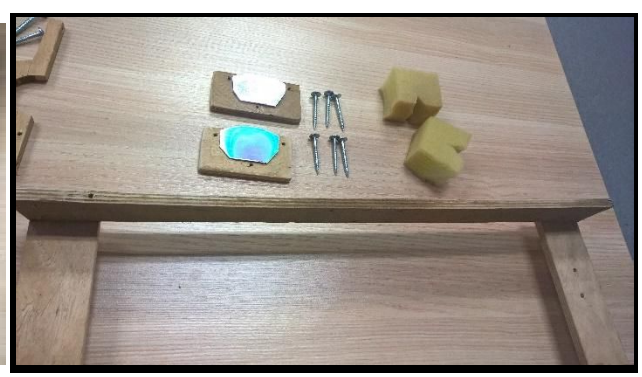





Step 4 – Construction of the interferometric table

You will need now six different pieces of the plywood, two mirrors, two pieces of foam and 16 screws of different sizes. Two long pieces of the plywood will serve as interference arms, two smaller pieces will be used to hold interference arms together. Smallest pieces of the plywood will be used as mirror holders.

Drill 4 holes at the end of middle sized pieces of plywood. Use them to construct the casing of the interferometric table.

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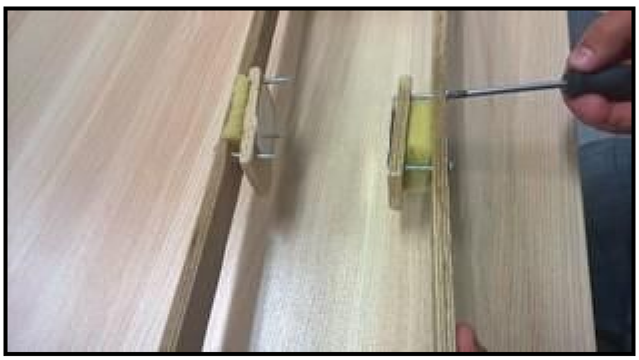
Now move to the mirror holders. Carefully measure the size of the mirror and make holders big enough for the mirrors. Leave place around the mirror for 3 screws. Please note, it's important to have here three screws. It will allow us to change direction of the beam reflected from the mirror.

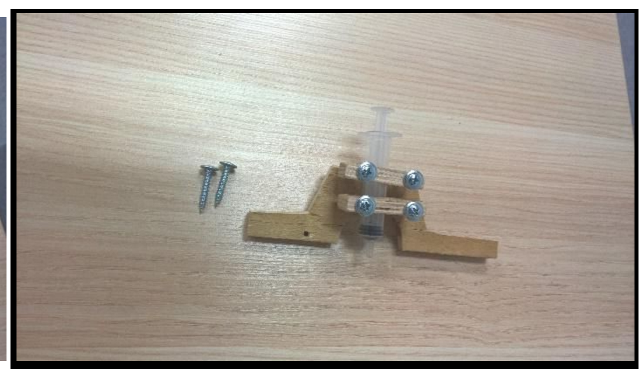
Carefully place mirrors on the holder and secure mirrors with screws. Is it okay? Remove now screws for later use.
Now place mirror holder against the wall of the interferometric table and make holes for screws in the sidewalls. Please, keep in mind that mirrors should be at the half of the distance between the laser and the end of the table.



Step 5 – Construction of the droposcope and assembly

You will need here 6 screws, a squared piece of plywood and a droposcope housing, which should be prepared separately. Take additionally 6 screws and a Syringe.

Drill a hole in the squared piece of plywood. The size of the hole should be big enough to put inside a syringe. After you done it, cut the piece into. Turn it around and drill in each piece two holes. This will be holders holding syringe attached to the casing of a droposcope.
Now check, whether you can attach the syringe to the casing of the droposcope. It works? Well done!



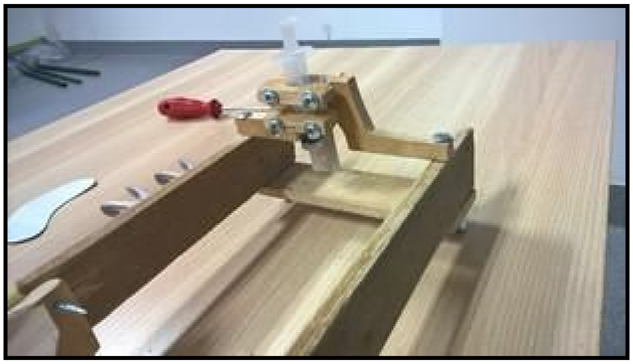
Now place the droposcope at the end of the interferometric table. Check where you should make holes to attach the droposcope to the table. Make holes and assemble it.


Now it’s time to place a laser inside the interferometric table. Take laser casing into hands. And carefully find place, where the distances between the laser and mirrors and between the droposcope and laser are nearly equal. Mount the laser.

Now turn on the laser and take a small piece of paper. Track the laser beam with the piece of paper along the table. Place the piece of paper behind the droposcope. If you see a laser light near the syringe, it’s okay. Now time to do some laser tuning magic.

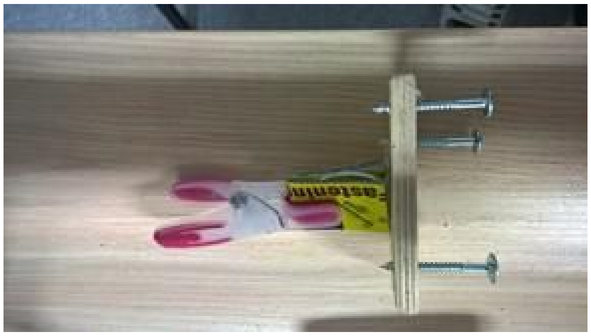
Step 6 – Tuning of the interferometric droposcope

Now, it’s time to tune our droposcope! This is a perfect opportunity to undo our smaller wrongdoings user some screw magic. Let us start with fine tuning of laser.
Collect water with syringe and secure it back into the droposcope. Press a small drop of water. Take a white piece of paper and place it behind the drop. Turn the laser on. You will see, that the laser spot is away from the drop. Now use screws on the laser casing to move the laser beam. Carefully move the beam till it is directly on the drop.



Now it’s time to have fun with some interference! Take two Clothespins and a diffraction grating. Carefully place diffraction grating in the front of the laser and secure it with clothespins.

Now, use a piece of paper to look at what’s happening after the grating. You will notice that you have now not one but three laser beams! Track those two new beams. If everything is fine, they should go to the mirrors on the sidewalls.

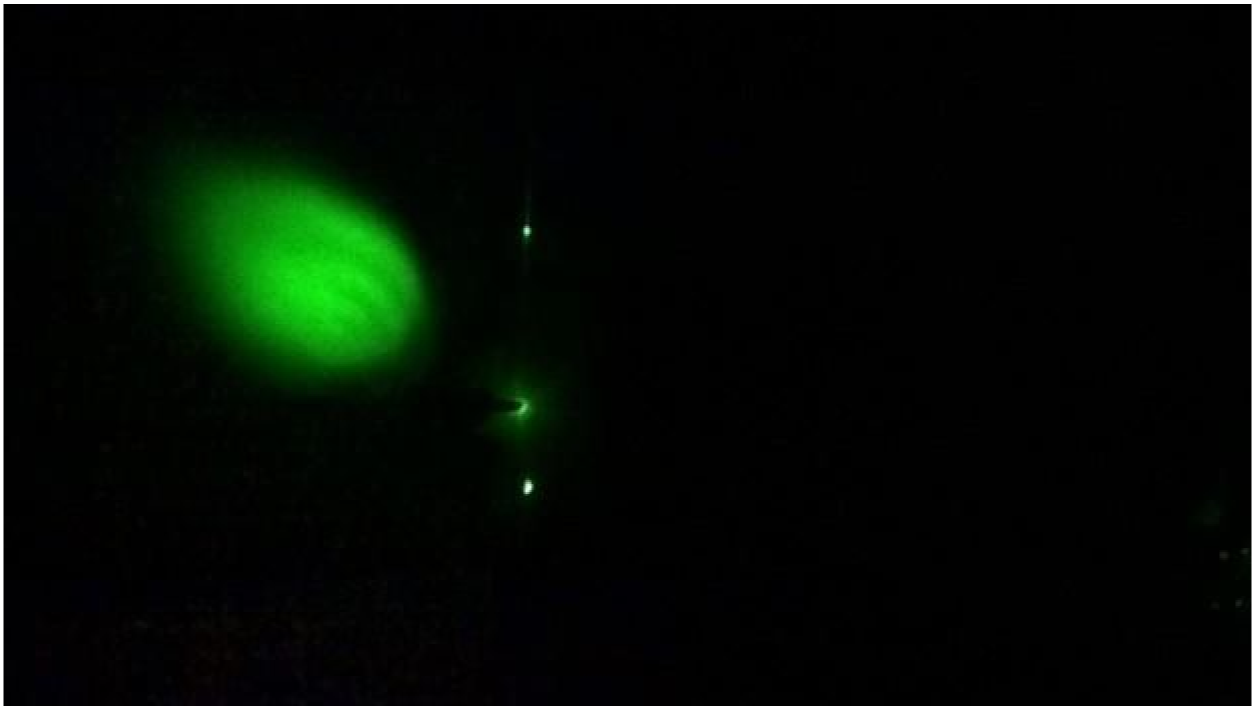



The central beam is very bright, so we will need to block him. Make a beam blocker from a piece of plywood and 3 screws. Put something not transparent on top.
Dim the light if you use red or blue laser pointer. Human eyes perceives the red and blue lasers not as bright as green ones. If you are using a green colored laser the unblocked beams might be bright enough to be seen in the room.

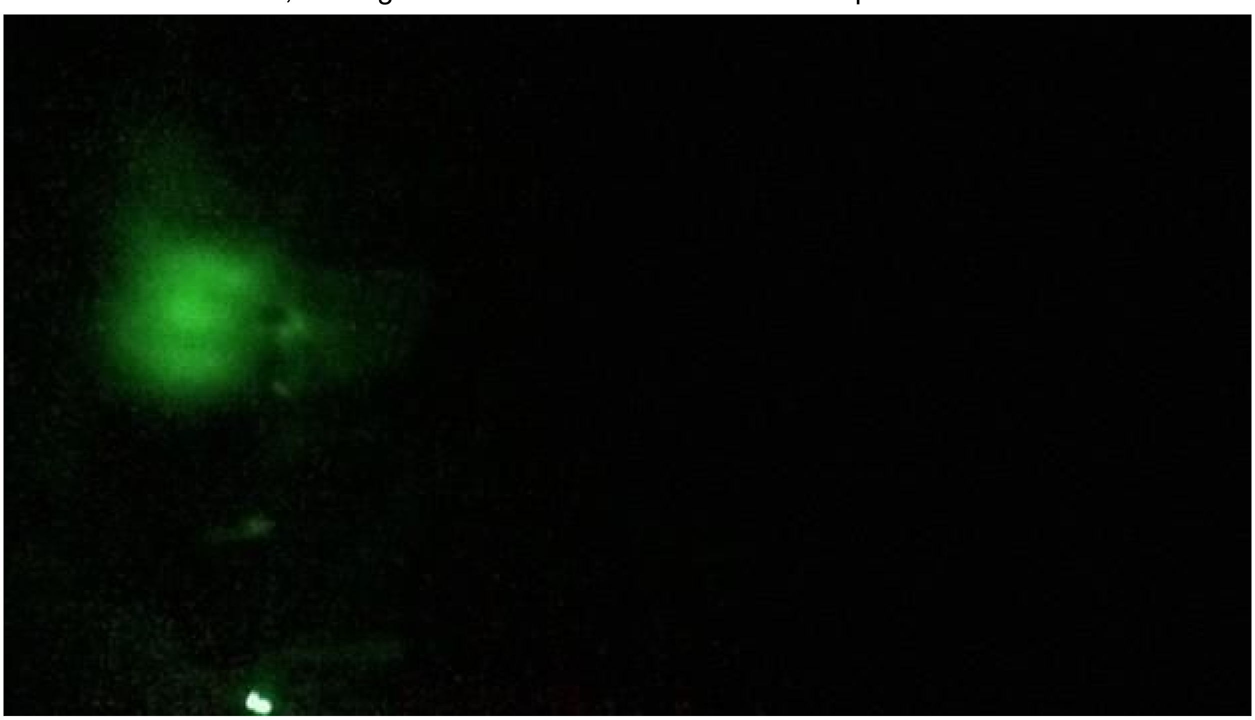
Now check whether diffracted beams hit mirrors. Track them after they reflect from mirrors to the droposcope. You will notice that they have different positions on a white piece of paper. Now take a screwdriver and change positions of individual beams so that they overlap exactly on a drop.

Step 7 – Observing diffraction and interference

Notice: This part of the experiment includes a green laser diode for better visibility.



We start here with observation of diffraction. For this reason we remove the diffraction grating from the interferometric table and remove the beam blocker. If everything is fine and the beam hits the water drop, you will see on the wall a very bright green or red spot. Within the spot you might observe some water bubbles and dust particles floating in the water. We might even see some circular fringes around them. This is the light diffracted from those small particles. If the water is contaminated, we might see even some life inside the drop!



Now, let's observe some interference! Put the diffraction grating back and put the beam blocker to block the central beam. Dim the light and look what's happening. If you watch close enough, you will see, that there is not a single projection but two of them. Projections overlap and in the region where it happens you will notice two or more dark and bright interference fringes.

Last step: End result & conclusions

What we learned?

- *Light is characterized as wave*
- *Diffraction refers to various phenomena that occur when a wave encounters an obstacle or a slit. It is defined as the bending of light around the corners of an obstacle or aperture.*
- *Interference is a phenomenon in which two waves superpose to form a resultant wave of greater, lower, or the same amplitude. Interference usually refers to the interaction of waves that are correlated or coherent with each other, either because they come from the same source or because they have the same or nearly the same frequency. Interference effects can be observed with all types of waves, for example, light, radio, acoustic, surface water waves or matter waves.*
- *Droposcope - a simple microscope which use drop of water as a lens.*
- *Diffraction grating can make light interfere.*

Concluding thoughts

Photonics is an amazing science which lets us find out more about light generation, detection and manipulation. Some of the most beautiful and (some say) magical things in nature can be explained by this science. Today you have learned that light can diffract and interfere. It happens in our daily life everyday (remember soap bobble example) but, also, you can use these light properties for making amazing experiments – like investigate the drop of water by using laser droposcope. If you are lucky and water has some microorganisms – you may be able to capture it!

PHABLABS 4.0 is a European project where **two major trends** are combined into one powerful and ambitious innovation pathway for digitization of European industry:
On the one hand the growing awareness of **photonics** as an important innovation driver and a **key enabling technology towards a better society**, and on the other hand the **exploding network of vibrant Fab Labs** where next-generation **practical skills-based learning** using KETs is core but where photonics is currently lacking.

www.PHABLABS.eu

This workshop was set up by the Center for Physical sciences and technology (Sergejus.Orlovas@ftmc.lt)

CENTER FOR PHYSICAL SCIENCES AND TECHNOLOGY

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