Photonics workshop template.

Title of the workshop: Advanced spectrometry using 3-D printed spectrometer and raspberry pi zero with camera

Target audience: Young professionals

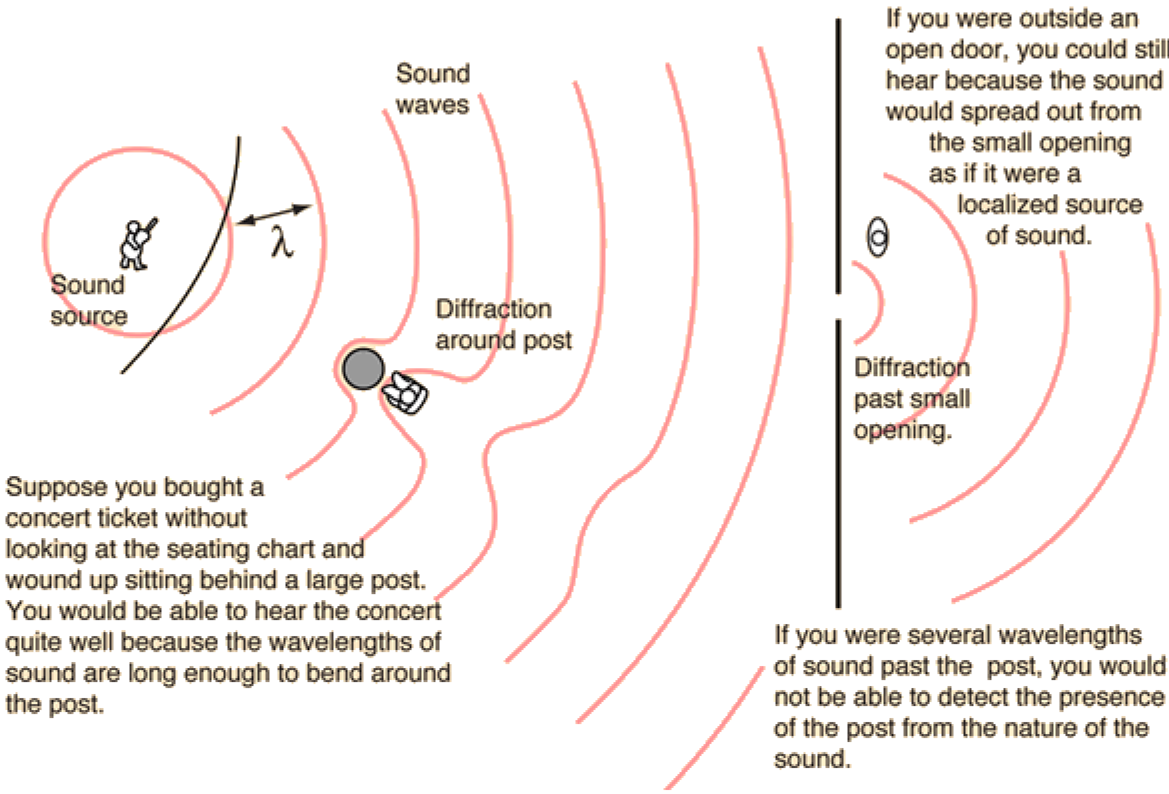
Time planning: Total time for workshop 2h 20mins:

1. Understanding the concepts of 'Diffraction, Interference & Single slit experiment'': 20 minutes
2. Construction of the 3-D printed spectrometer with diffraction grating: 15 minutes
3. SD card mount and Raspberry pi software & setup: 45 minutes
4. Imaging of different light sources and calibration of picamera vs wavelength: 60 minutes

Estimated cost: € 62.00

Step 1

Interference and diffraction of waves not only produces interesting visual effects by interaction of waves in nature, they can be harnessed as a powerful tool for the study and measurement of tiny objects. Although the phenomenon has been known about for centuries, it is of special interest today. More and more technology relies on micro-- and nanometer--sized particles – too small to be seen by a normal microscope. By understanding diffraction and the interference of light waves and using them smartly, not only can we peek into this microscopic world, we can even
manipulate objects in it.



To gain an intuition about light diffraction, where our wavelength is in the nanoscale, we can look at our experiences with sound involve diffraction. The fact that you can hear sounds around corners and around barriers involves both diffraction and reflection of sound. Diffraction in such cases helps the sound to "bend around" the obstacles.

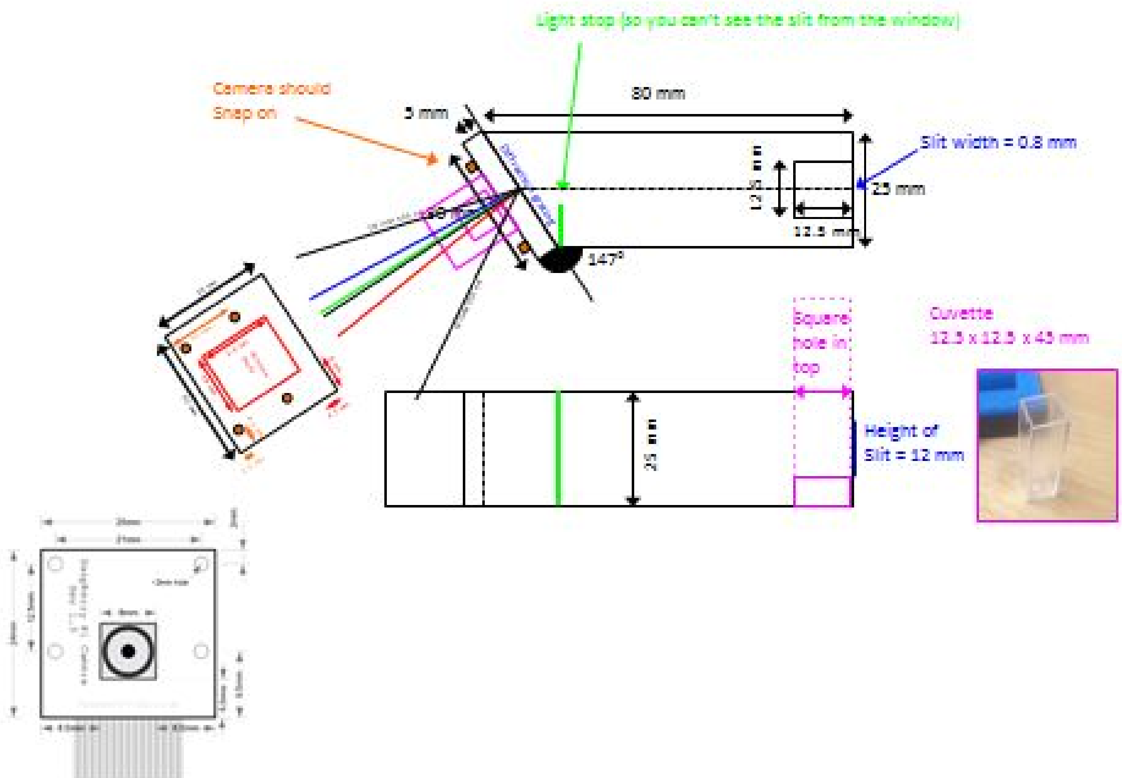
Light too can bend when it around corner, we have have designed a spectrometer to exploit this feature using single slit interference. This following video explains this in detail:

https://www.khanacademy.org/science/physics/light-waves/interference-of-light-waves/v/single-slit-interference

Step 2

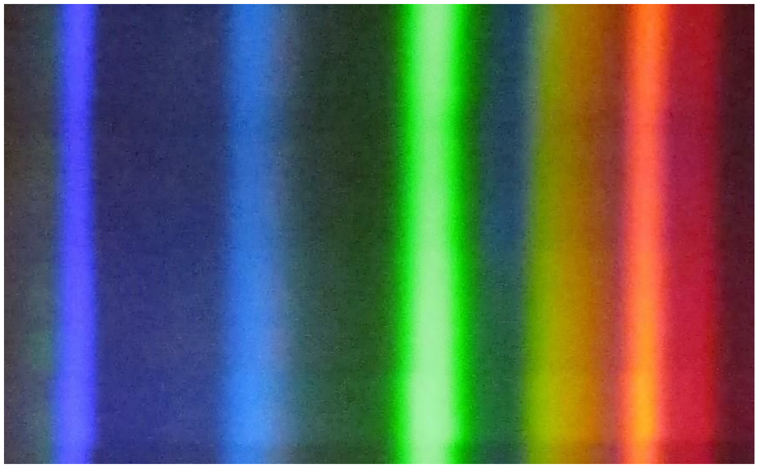
This workshop is also based on the science of spectroscopy. The participants will construct an advanced spectrometer through which they can image a variety of samples. They will learn about diffraction and light sources with different spectral content.

1. 3D print a miniature spectrometer through which they can look or attach to raspberry pi camera

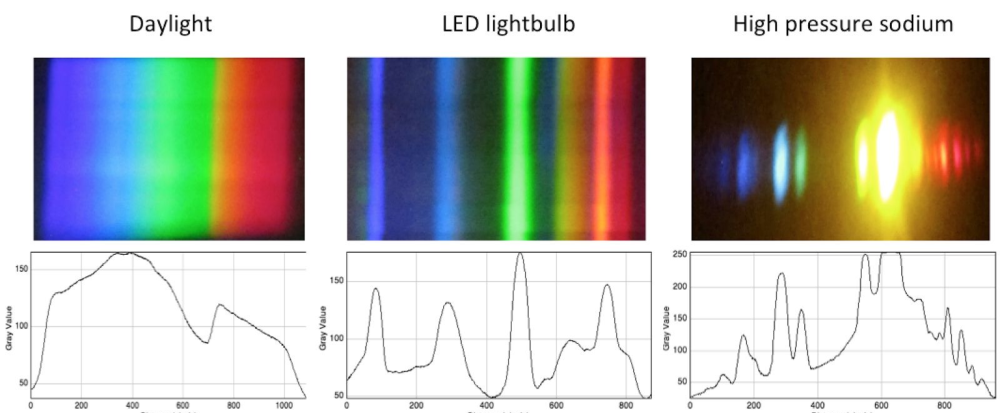


Each participant will get to take home

1. The 3D printed assembly including diffraction grating
2. Raspberry pi zero, camera and usb hub and sd card, they will learn to flash an OS onto their computer
3. Images of output spectra



Example of the spectrum of a broadband light source



Spectral images of various spectra

Step 3: Part list

Photonics parts:

Diffraction grating, mercury lamp, sodium lamp, different samples to put in cuvette

Electronic parts:
Raspberry Pi Zero kit
NoIR Camera
Camera ribbon
SD card
7 port hub
Power cable

Other parts:
Printing materials
Monitors
Keyboards
Mice

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

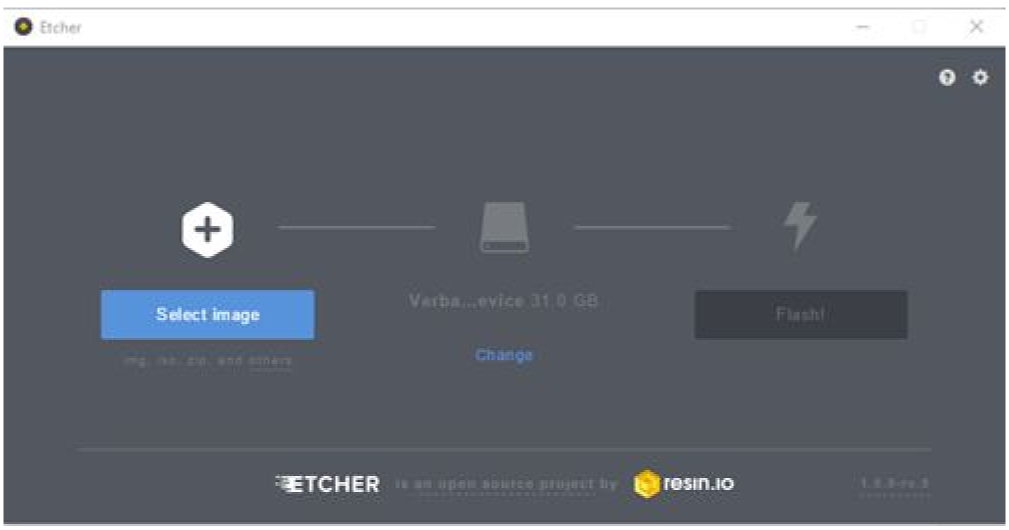
Step 4

The software for the raspberry pi system is available:

https://www.raspberrypi.org/downloads/raspbian/

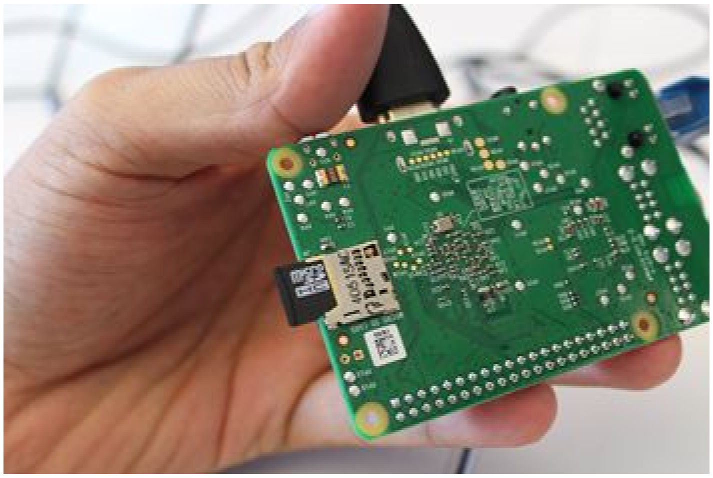
The first step will be to download the image of the raspberry pi system to a sd card using a sd card reader:
https://www.mymemory.co.uk/mymemory-all-in-one-usb-memory-card-reader-cf-ms-xd-sdhc-sd.html

The OS can then be flashed directly using Etcher software that is freely available online
https://etcher.io/



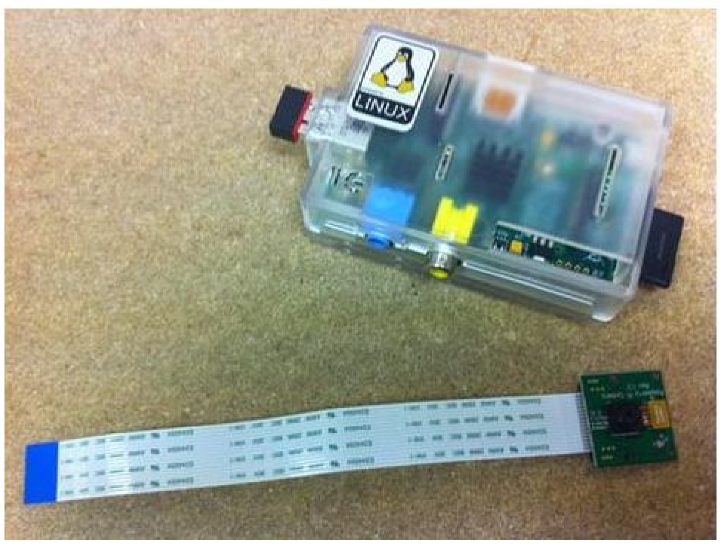
Our system image already has all the accompanying python and wifi capabilities installed, it is only necessary to construct and power the system.

The card can then be inserted in the Raspberry Pi board:



Set Up of Pi Camera

First, carefully remove the Raspberry Pi Camera module from its packaging.



Next, install the Raspberry Pi camera module by inserting the cable into the Raspberry Pi. The cable slots into the connector are situated between the Ethernet and HDMI ports, with the silver connectors facing the HDMI port.

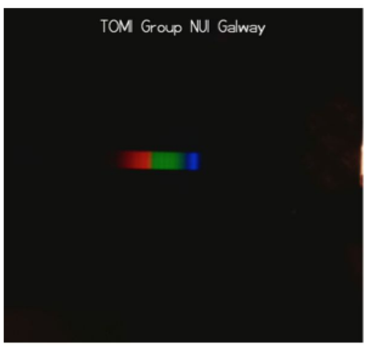
Now, boot up the raspberry pi.

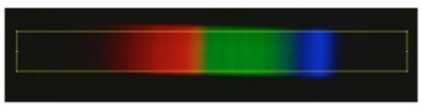
From the prompt, run "***sudo raspi-config***". If the "camera" option is not listed, the Raspberry Pi needs to be updated. To achieve this, run "***sudo apt-get update***" and "***sudo apt-get upgrade***"

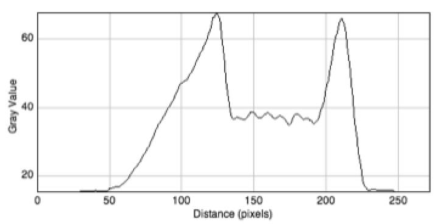
```
pi@raspberrypi ~ $ sudo apt-get update

pi@raspberrypi ~ $ sudo apt-get upgrade
```

Run "***sudo raspi-config***" again - the "camera" option should now be visible.

Navigate to the "camera" option, and enable it. Select “Finish” and reboot your Raspberry Pi.







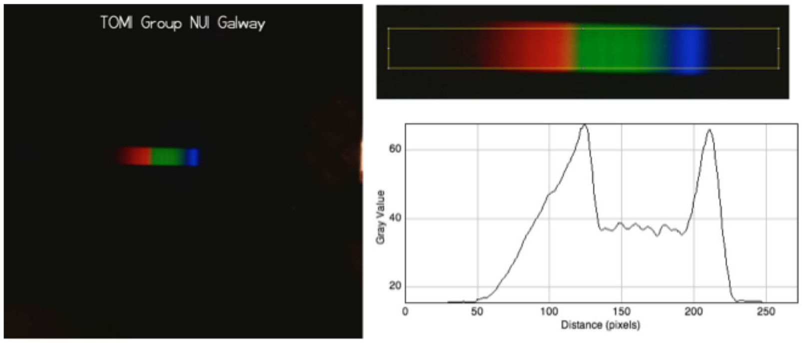
Step 5 - ...

Working with spectral data

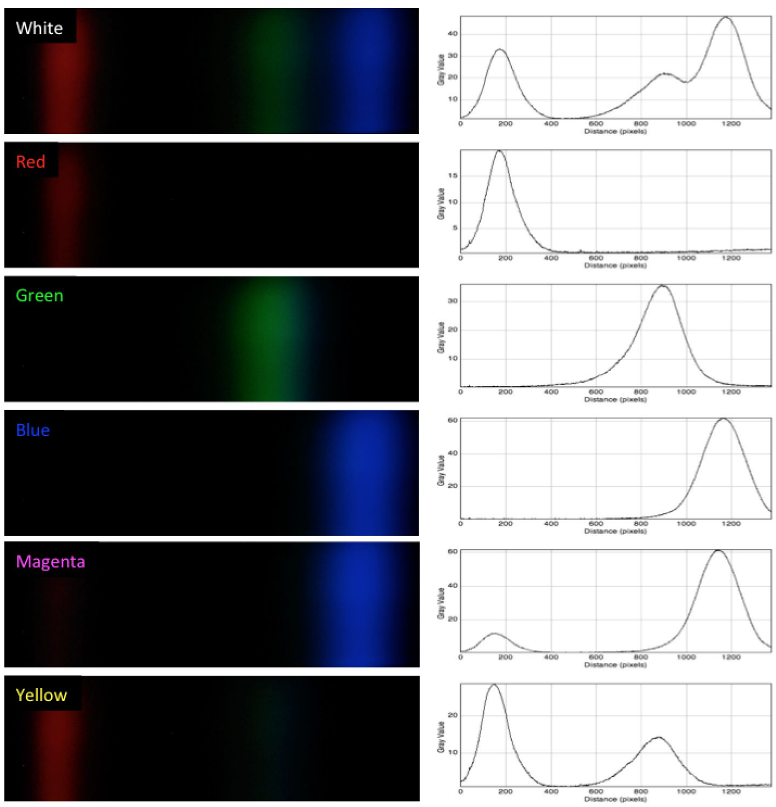
The picamera can capture directly to any object which supports Python's buffer protocol (including numpy's `ndarray`). Simply pass the object as the destination of the capture and the image data will be written directly to the object. The captured spectra can be averaged along the image plane to reduce the noise along each spectral line. The spectra of various light sources can be recorded:

Example of IR (800 nm)

The image array can be loaded into python .npy formats for further processing and calibration.



Spectral images and profiles of the LED lamp as emits various colours of light.



Last step: End result & conclusions

What we learned?

The spectral content of different lights sources can be measured using available hacker tech that gives an insight into photonics. By flashing and connecting up their own mini computer and using a 3-D printed aperture for calibrated spectroscopy, we can really get a feel for how collaborative science can be.

Concluding thoughts

The spirit of Phablabs 4.0 is to integrate photonics with existing technologies to show that light is fascinating and can be used to gain a physical understanding of our world. By leveraging hacker tech that pervades current Fablabs and Maker projects, we can excite interest and inexplicably link the concepts of technological innovation and photonics in our participants minds.

The following part will always conclude a workshop of PHABLABS 4.0. Please add the names of your institution and that of your pilot fab lab and the logo's.

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 *(name Photonics Partner's Institution)* in close collaboration with *(name pilot fab lab)*.

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