Mobile phone spectroscope

Spectroscopy is an important analytical tool in several areas of science. In the classroom, however, spectroscopy is not used as much as we would like due to the relatively high cost of the equipment.

In 2008, a design for a simple, home-made spectroscope made out of card and using a section from a CD or DVD as the diffraction grating was published. (A version can be found on the SSERC website [1]). It is cheap and works reasonably well.

Recently, however, we have come across a variation of this design that can be attached to a webcam or to a phone or tablet, allowing the spectra to be captured and analysed.

Background

A diffraction grating is an optical device with a structure which splits light into several beams travelling in different directions. They can do so either by reflection or transmission. The directions of these beams depends on the spacing of the grating and the wavelength of the light. If you shine white light on a diffraction grating, the grating will cause the white light to spread out into a spectrum.

Figure 1 *- DVD layers.*

In a CD or DVD, the tracks containing the data spiral in to the centre, resulting in an array of parallel lines which can work as a diffraction grating. This is what produces the array of colours you see when you look at the reflections in a CD or DVD (Figure 1).

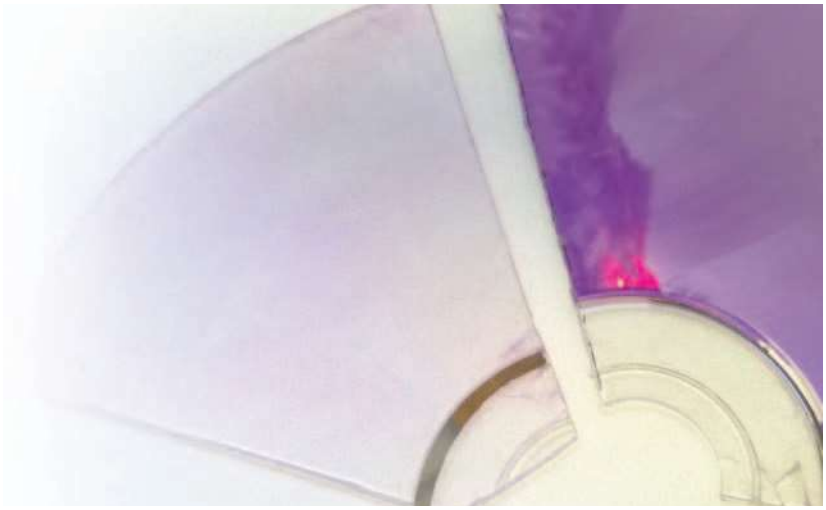

Figure 2 *- Cleaning the dye.*

Making the spectroscope

The design here (the first one at least) was developed by the Public Laboratory for Open Technology and Science (www.publiclab.org).

1) Preparing the diffraction grating

You will need a recordable DVD (DVD-R).

Cut the DVD-R into halves or quarters with a pair of scissors and then you should be able to get a fingernail in and separate it into two layers: the metallic layer with the label on and a clear plastic layer with a purple sheen. (Figure 1) You need the clear layer. Try to handle the surface as little as possible to avoid marking it.

You can remove the purple colouring using some ethanol (methylated spirit works well) and cotton wool (Figure 2).

Cut a piece from the edge of the now clear plastic, approximately 1 cm x 1 cm. This is your diffraction grating.

2) Getting and preparing the template

You can find the template on the publiclab website [2] (Figure 3).

You need to print this out onto black card: card so it is stiff enough and black to reduce internal reflection. You might think printing black lines onto black card is a daft thing to do but it is still possible to see the design clearly enough to cut it out.

Cut round the outside, scissors are probably easiest.

Use a scalpel or sharp craft knife to cut out the square (top right of the diagram) where the grating goes. Then use the scalpel/knife to cut a narrow slit (lower left of the diagram) - the narrower the better.

Figure 4 *- The slit.*

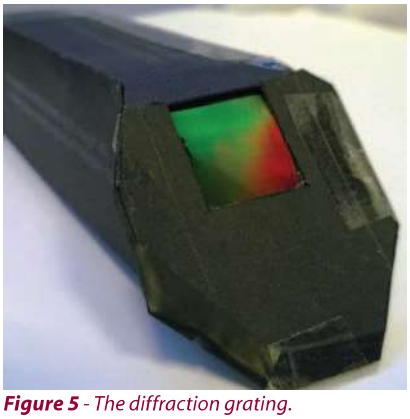

Figure 5 *- The diffraction grating.*

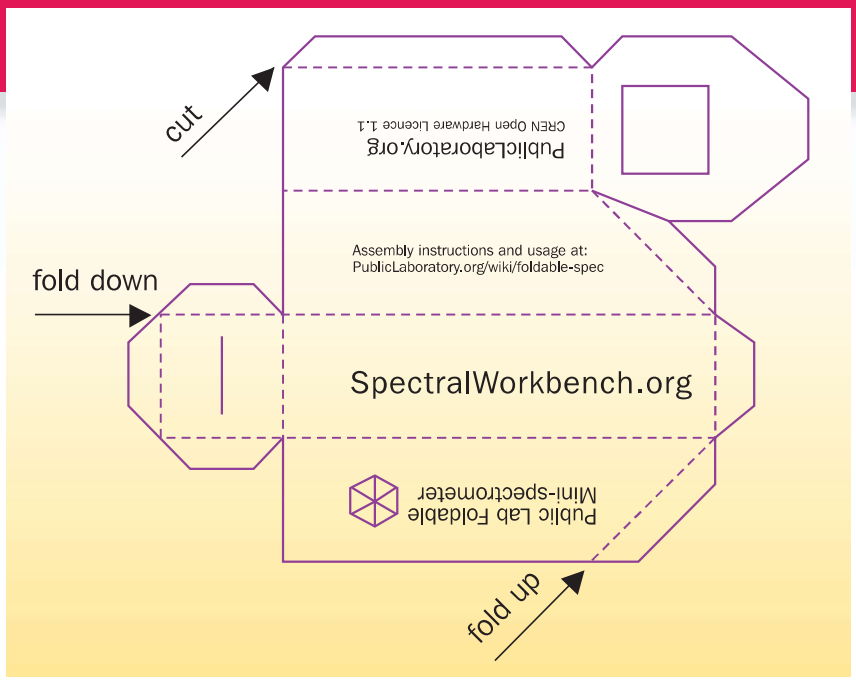

Figure 3 *- The template.*

3) Assembling the spectrometer

Use tape or glue to fix your 1 cm x 1 cm piece of diffraction grating on the inside of the 'door', over the square hole you cut out for it. The lines need to be horizontal so make sure that the edge of the DVD-R is at the top or bottom rather than to one side. Then fold the device as shown in the diagram and tape or glue it shut (tape is probably easier and black electrical tape is best).

You will now have a rectangular box, approximately 10 cm long with a slit at one end (Figure 4) and a slope at the other end with a window containing the diffraction grating (Figure 5).

4) Attaching the spectrometer to your phone

You can simply do this using tape (again, black electrical tape is best). Launch the camera app. Place the 'window' with the diffraction grating against the lens, check that you are getting a pattern and then tape it in place. This is a bit tricky with an iPhone as the camera lens is stuck away in the top left hand corner. It is possible, however, to get it in place with a bit of care.

Once in place, launch the camera app (if you closed it) and then you can point it at various light sources and get photographs of their spectra (Figures 7, 8 & 9).

Figure 6 *- Spectrometer attached to an iPhone.*

5) Tips and Improvements

The device works pretty well and it is possible to get some decent pictures of spectra. It is, however, a bit fragile.

It is possible to improve the construction by using a piece of plastic tubing as the body. 19 mm plumbing overflow pipe is ideal. You can cut it easily with a hacksaw and use a file or craft knife to smooth it off (Figure 10). The pipe is white so you will need to either spray paint it black on the inside or line the inside with black paper or card.

It is easy to cut card for the ends and if you make a series of cuts round the edge, you can fold it down and tape it.

You need to make sure that you tape the spectrometer to your phone well - you want to make sure that there is no light leaking in as that will decrease the contrast of your image.

Resolution - at present the resolution is not quite good enough to separate the two sodium bands. A narrower slit does improve resolution but then it also reduces the light level which is not good for photography.

Once you have your photographed spectrum, you can then analyse it. This aspect will be covered in a future issue of the Bulletin.

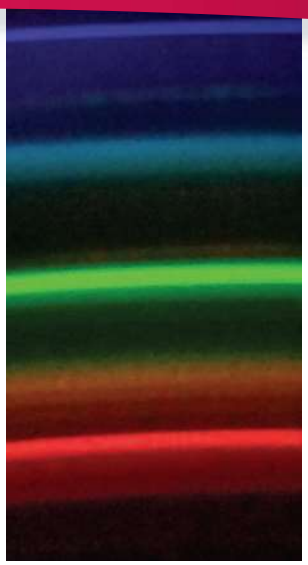

Figure 7 *- Spectrum of a compact fluorescent lamp.*

Figure 8 *- Spectrum from a sodium flame test.*

Figure 9 *- Spectrum from a strontium flame test.*

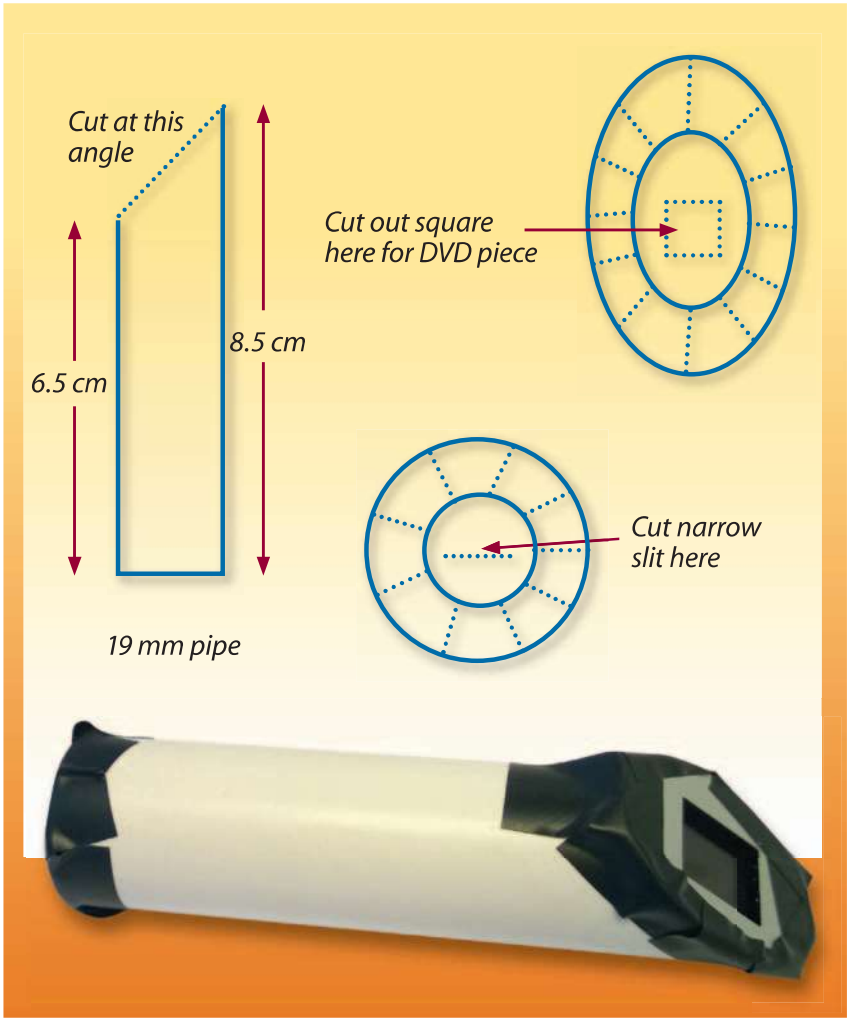

Figure 10 *- Using pipe instead of card.*

References

[1] http://www.sserc.org.uk/index.php/advanced-higher-revised/inorganic-and-physical-chemistry/3074-dvd-spectroscope.

[2] http://publiclab.org/sites/default/files/8.5x11mini-spec3.8.pdf.