Simple spectroscopy with a digital camera

And a few problems with spectroscopy in class.

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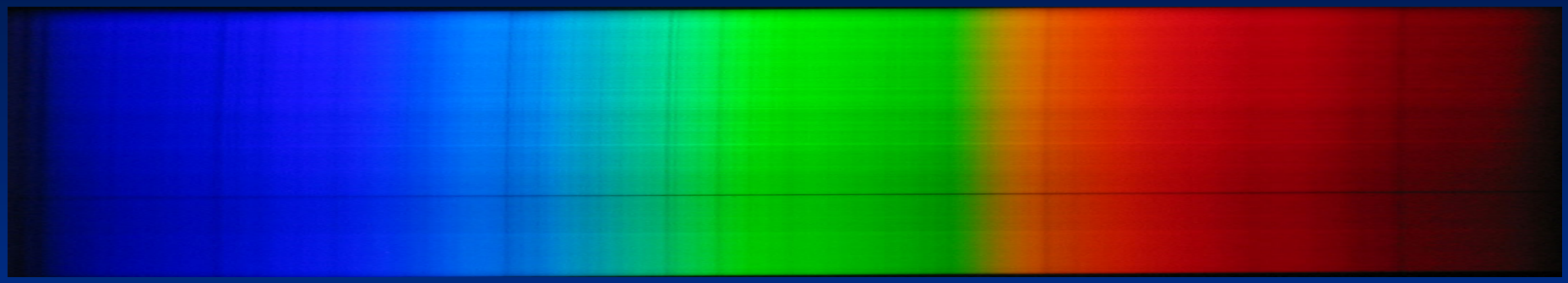
Problem1: What is a spectral line?

- Ask any physicist:
- *A spectral line is the energy difference between two QM ensembles between which allowed transitions can take place.*

Problem1: What is a spectral line?

- *Or: A spectral line is a narrow feature in a spectrum.*

But when students see this:



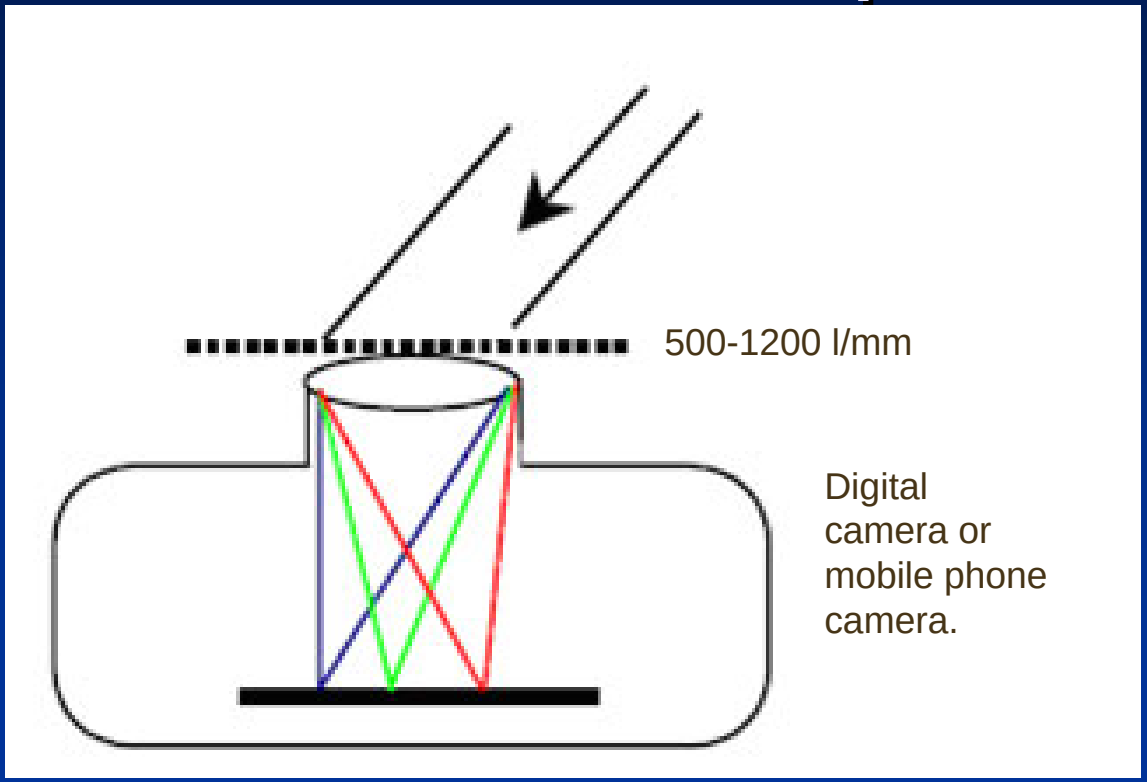
- They cannot see the Fraunhofer lines
- (And neither could Newton)

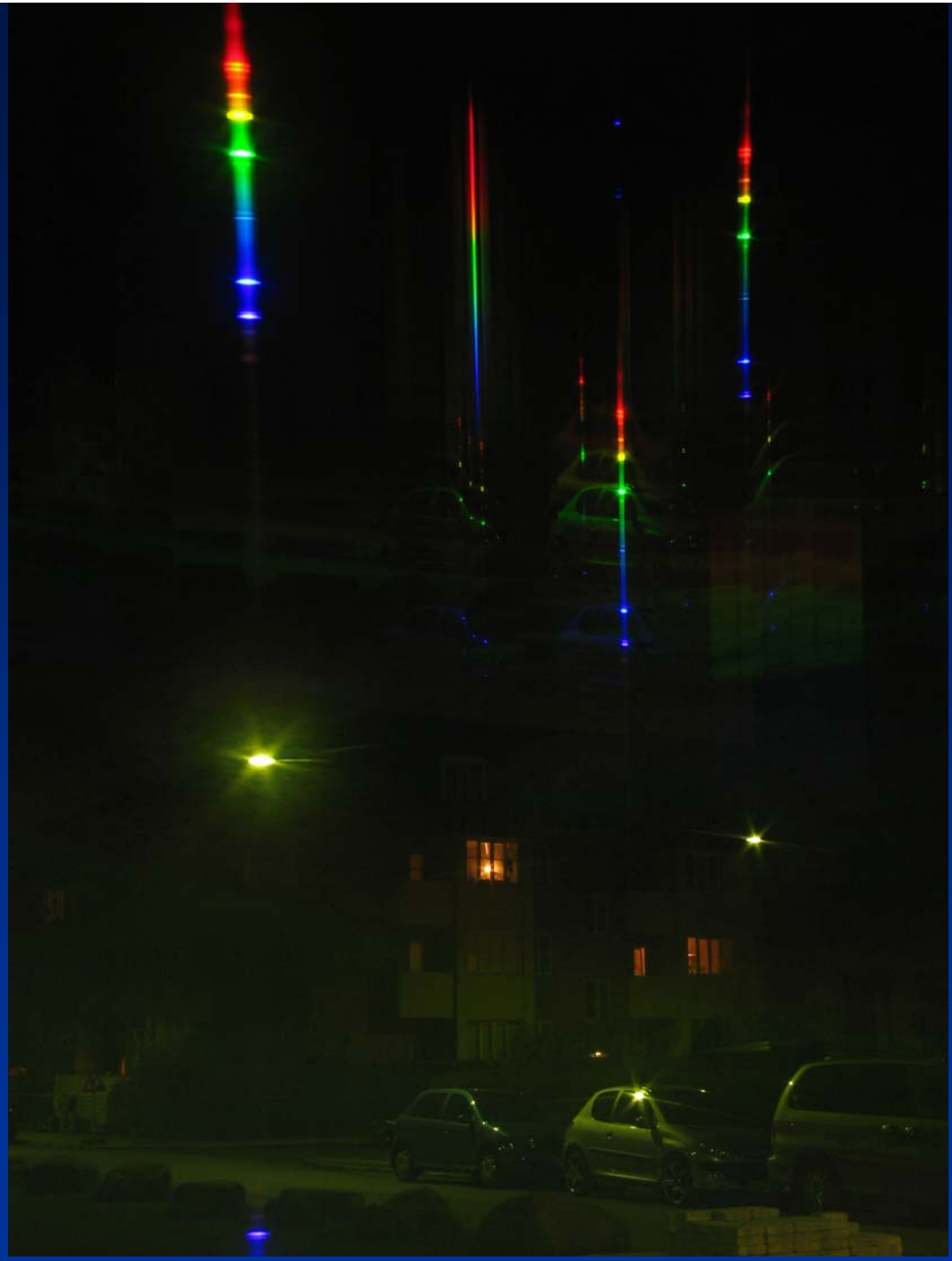
Problem 2: Geissler tubes, spectral lamps and goniometers are considered to be:

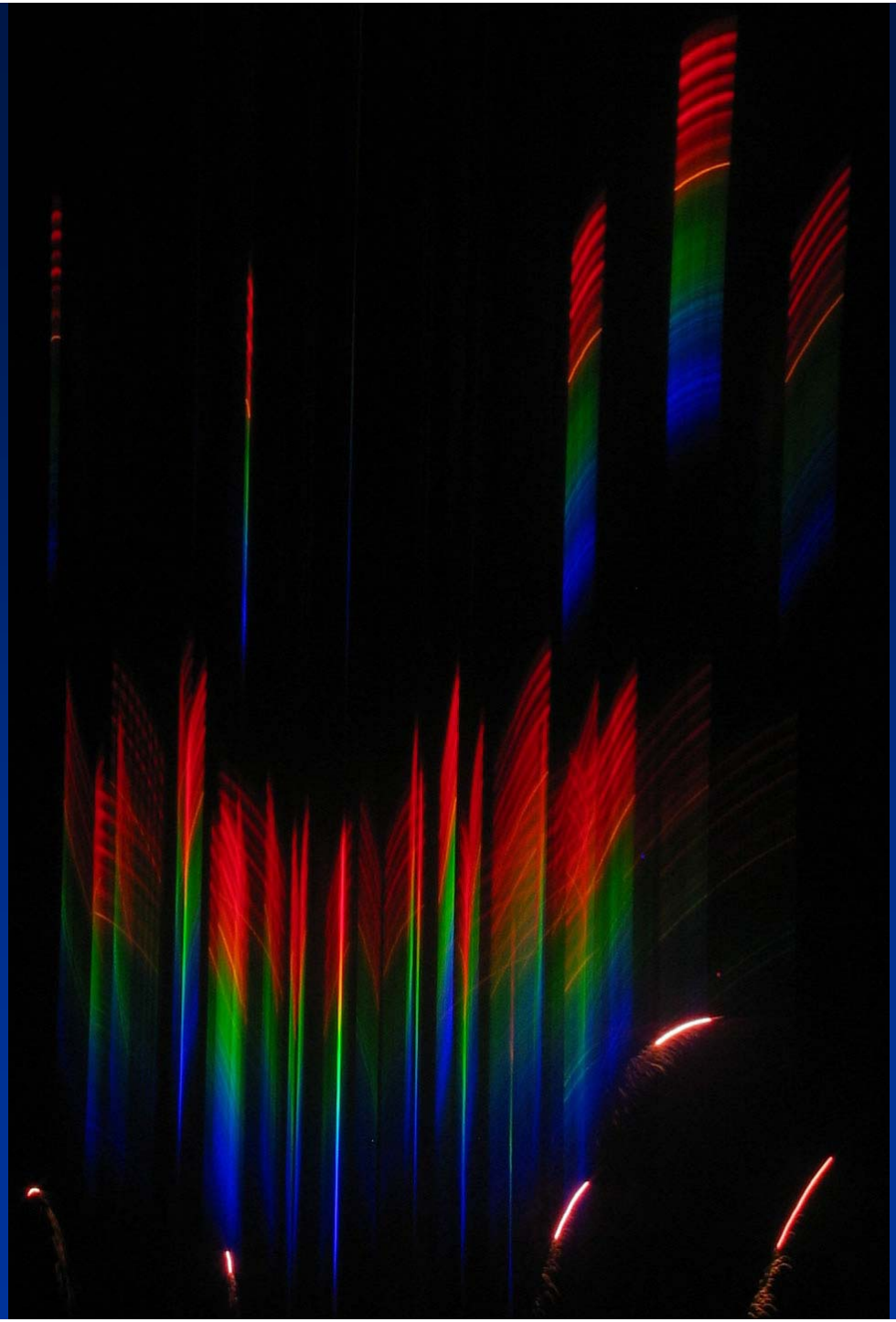
- Tedious to use
- Old fasioned.
- Filled with physics light, only relevant to physics lab.
- Full of answers that you can look up in any book, but never get right.

It is simply more fun to use your camera or mobile to spy on your neighbours in the night.

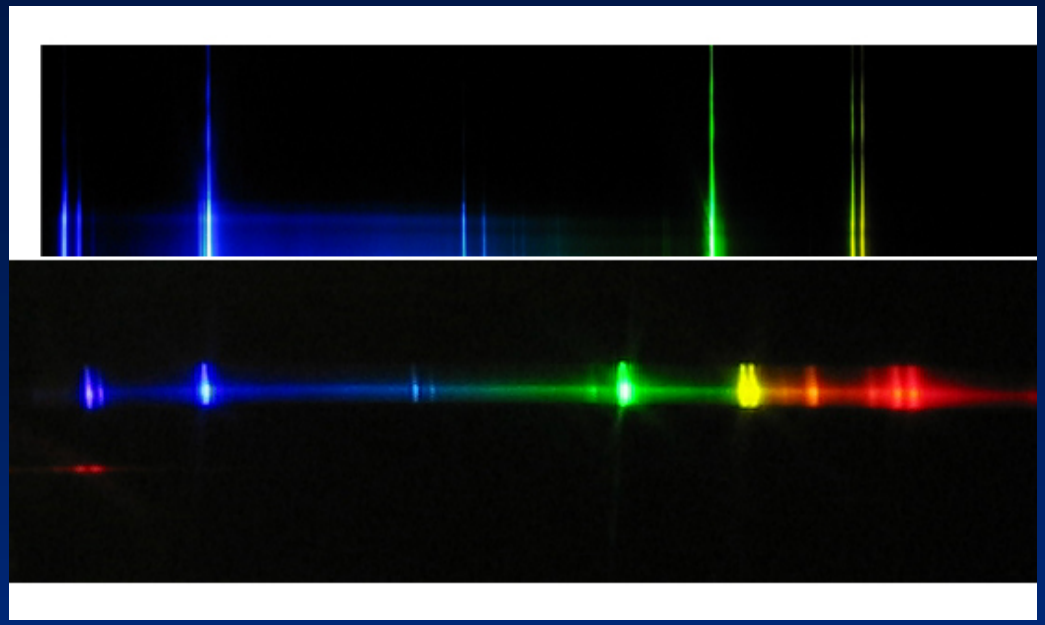
The basic setup

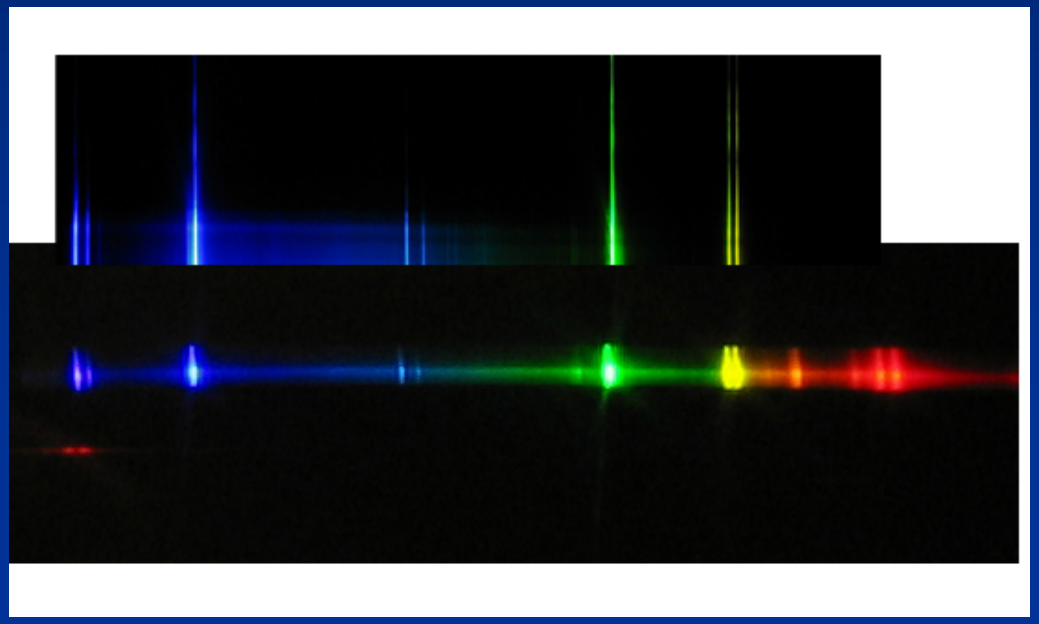






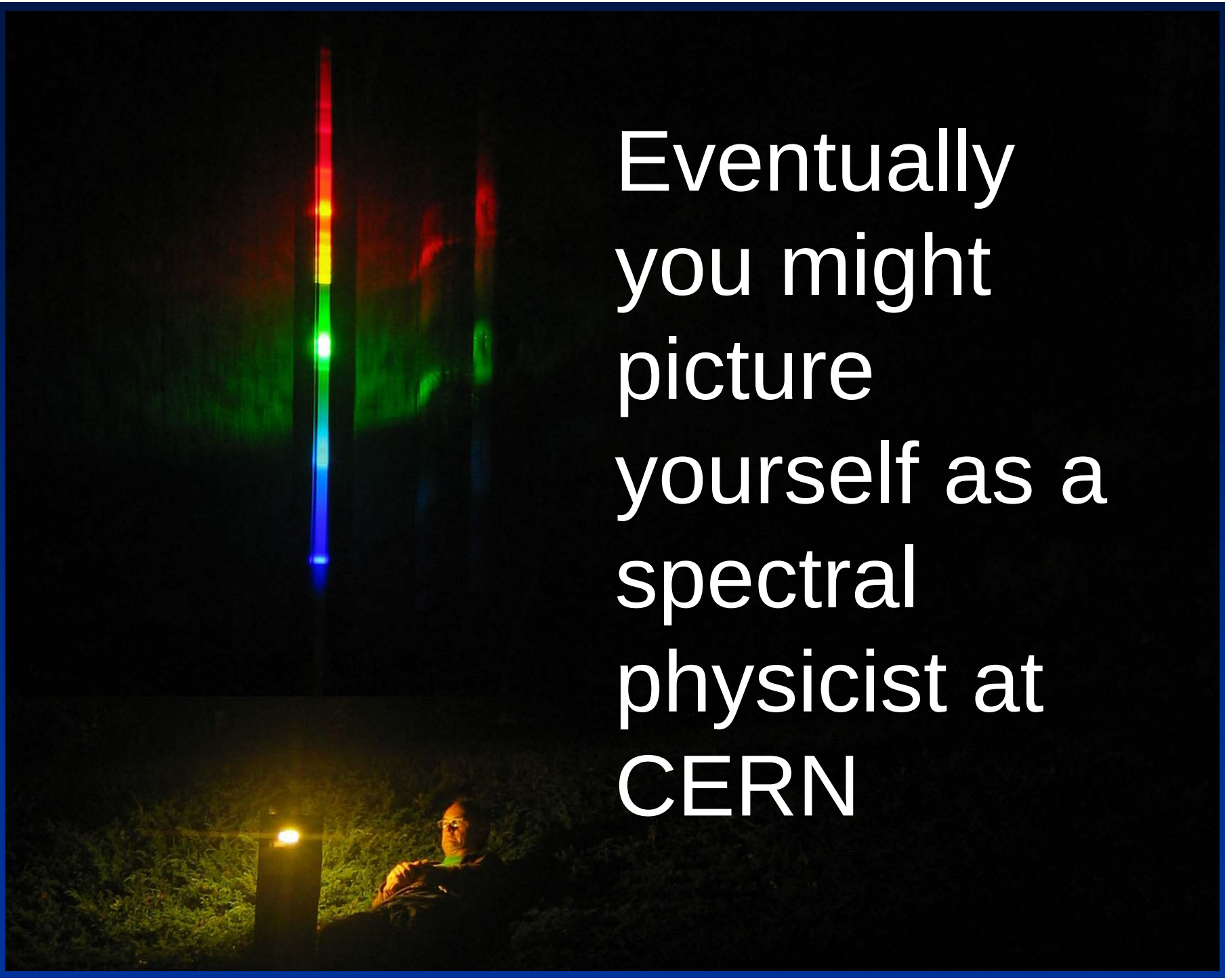
A spectral line is a picture of the spectrograph slit taken with single wavelenght light



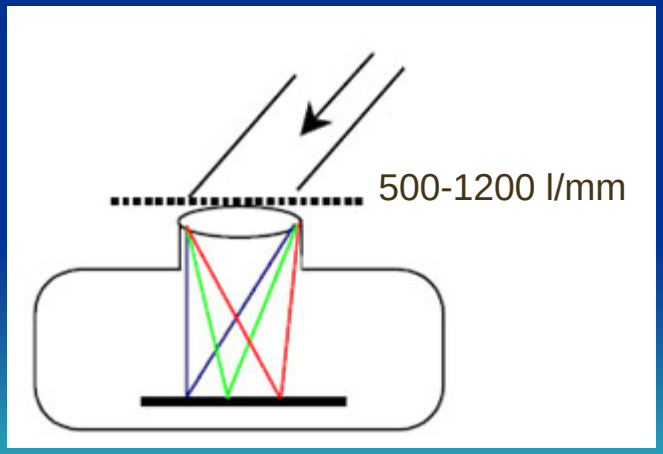


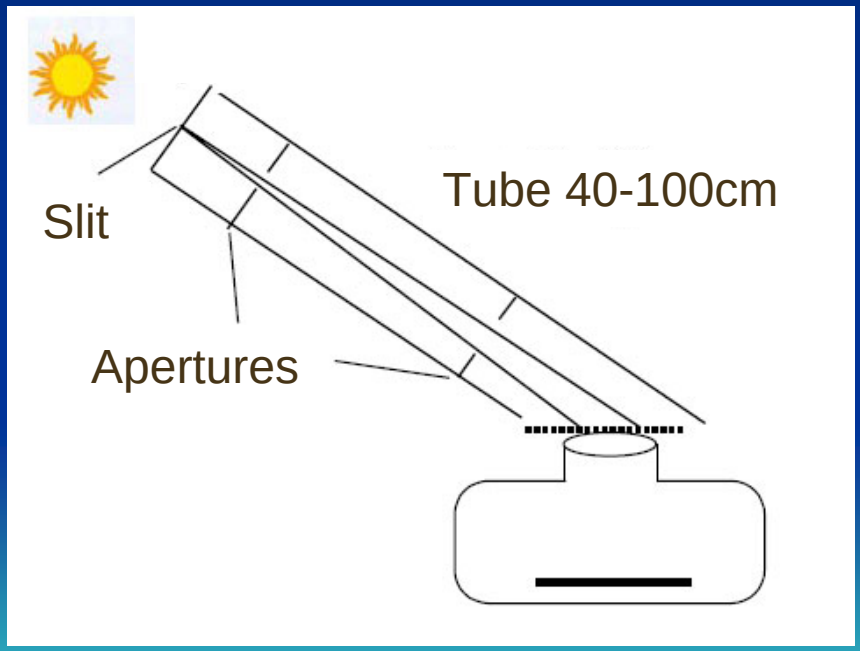
Ressources

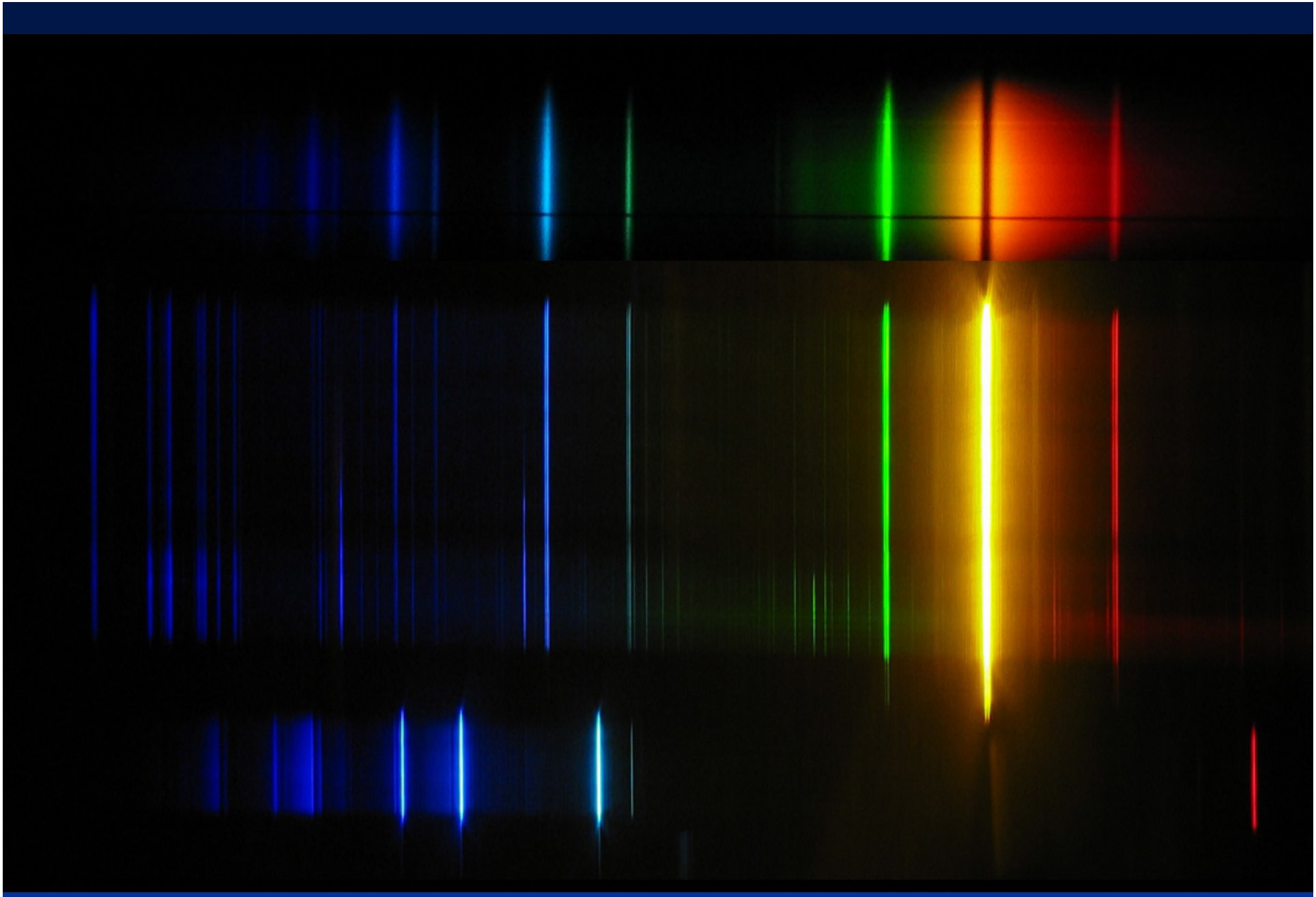
- Spectra of most school spectral lamps taken with this setup. (index in english)
  http://www.emu.dk/gym/fag/fy/inspiration/forloeb/spektrografi/
- Gratings:
  ”Holographic Diffraction Grating”
  http://www.starlab.com/psprod.html
  http://store.yahoo.com/rainbowsymphony/difgratfilsh.html
  https://www.edmundoptics.com/


Eventually you might picture yourself as a spectral physicist at CERN

A better setup:







Upper: Yellowish street lamp (high pressure sodium lamp)
middle and lower: lab. Na with Cd-reference spectrum from above ressource. Cut and pasted together in photoshop.

Tips and trix:

1) Measuring spectra: Raw picture without slit but with some kind of reference source in the picture. (ie street photos with Hg discharge lamps):
   Be carefull to zoom little enough so that both 0.order(direct) and 1. order (spectrum) images is present in the picture
   Measure the distances from the direct image to known spectral lines in reference spectrum.
   Use regression on this data to get linear translation equation.
   Measure and insert similar distances from unknown source to the unknown spectral features in equation to obtain wavelenghts.

2) Hg-lamp lines: 435.8 nm, Most promint blue. 546.1 nm. Totally dominating green. 577.0 and 579.1 nm. Close yellow pair.

3) Above measurements can be made by reading pixel coordinates in a graphics package.
   Better for report purposes is to draw and measure on a printed out spectrum. This will give original documentation to a report.

4) Reversing spectra into negative version saves printer ink and gives white space to draw on. Additionally weak lines become more prominent. (Try this on my hydrogen spectrum and count Balmer lines.)

5) Measuring spectra: When working with a slit to obtain high resolution:
   Bring both object and reference light to the slit. Use for example a compact fluorescent lamp as reference (Hg-spectrum) and use a small chip off a mirror to illuminate part of the slit with this light.
   In this case you need not to see direct slit image on picture but you can measure pixel coordinates or distances from edge of paper since both spectra will have same offset.

6) Fingerprinting: Learn your graphics package sufficiently well as to be able to work with selections and be able to scale these easily.
   Cut, paste and scale suspected reference spectrum onto your spectral picture until two lines coincide in position and (check) colour. Check that a reasonable number of other spectral features match.

7) Black screen or tube without slit can help isolating relevant object. Ie when photographing pyrotechics experiments.

8) Irregular illumination of slit help to see weak lines without totally overexposing strong lines.

9) Reflection in a shiny cylinder (chromed tube) can be used as a high efficiency – and self aligning - slit for light sources of relatively low angular size (sun, streetlanps)
   black box background. Illumination from side, (reduces angular size in one direction with factor r/R, r = cylinder radius, R = cylinder to camera distance)

10) Discussion of these matters: Mhammerich@vip.cybercity.dk