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Amateur spectroscope

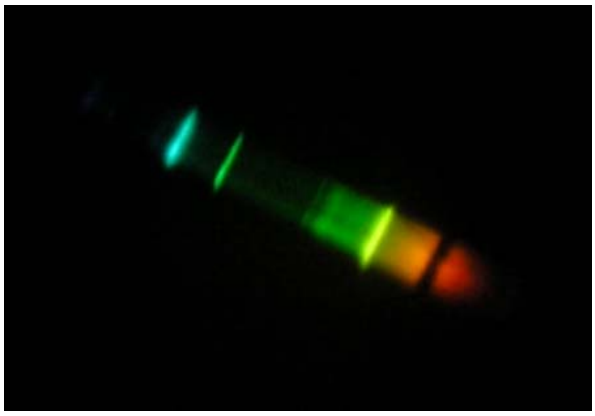
Angela Turricchia
Laboratorio per la Didattica Aula Planetario
Comune di Bologna, Włochy

Ariel Majcher
Centrum Fizyki Teoretycznej PAN
Warszawa, Polska

we would like to present you an interesting tool, easy to make, which helps to realize that different sources of light do not shine in the same way. We provide two versions: the basic one, which can be constructed from elements around you and the "lux" one, which is also easy to make, yet requires custom-made elements.

A spectroscope decomposes light that comes to you into components in a form of spectrum with use of diffraction grating. An example of spectrum can be seen below:





To prepare a spectroscope we will need:

1. Casing:

- basic version: a cardboard tube from inside of the roll paper towels, a piece of a thin cardboard, e.g. from an empty tea or rice box etc;
- "lux" version: you can use a long cardboard tube used for carrying papers.

In general, the longer is the tube, the better is the angular resolution of the spectroscope, but also the more light has to fall on the slit i.e. one has to look at brighter sources.

Apart from that you will need opaque adhesive tape (I used insulating tape). It is comfortable to use two-side adhesive tape in order to make a slit, though it is not absolutely necessary.

Fig. 1: A tube for carrying pictures and other elements necessary for making a spectroscope.

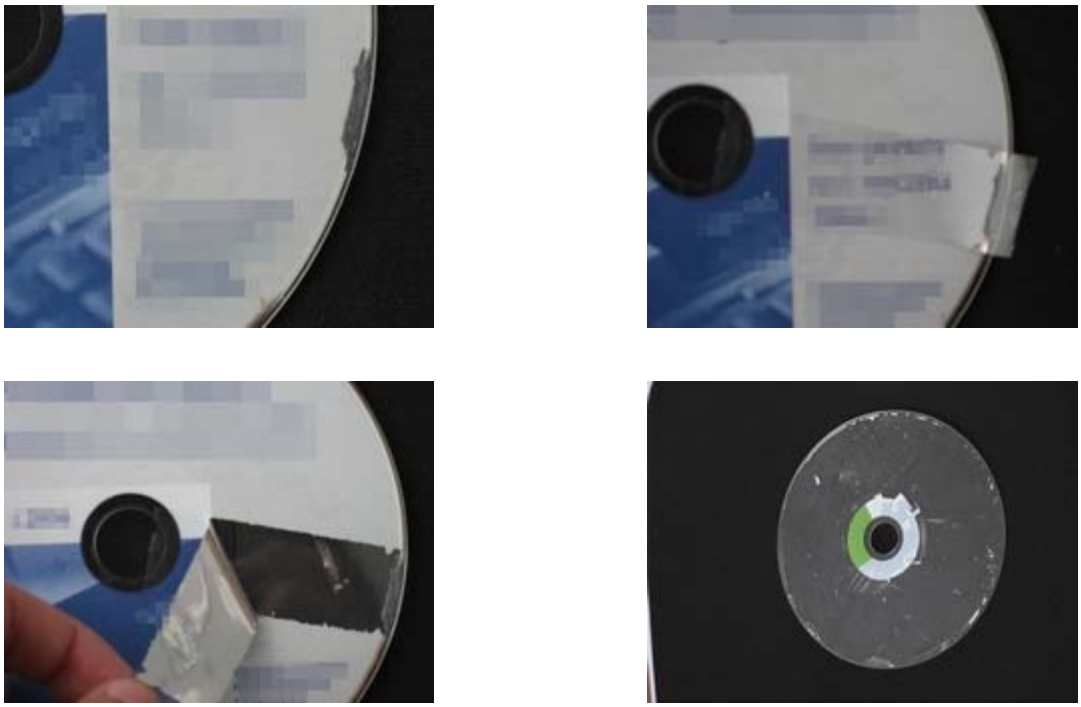
2. Slit:

- **in basic version:** from a cardboard box,
- **in "lux" version :** from unused razor blade (**pay attention to safety of children!)**.

3. Diffraction grading:

- **basic version:** we made a real discovery here. A good diffraction grading can be made from plastic disks, often used to protect the last, bottom CD in CD bundles that are bought in shops. We are talking about bulk packs of CDs, which are available in supermarkets. Warning: some CD packs do not contain such additional protection disks, and not all of them are suitable. A proper protection disk shall have a rainbow glitter, when we look at it against the light. So you must watch what you buy.
  One can obtain a similar grating from a CD lub DVD disc. One should

scratch a bit the cover on an edge of the disc, put a piece of a scotch tape over the scratch and carefully remove the tape. The paint should stay on the tape. Repeating this procedure a few times one can clean the whole surface of the disc from the protective paint, obtaining a very good diffraction grating, see figures below:



Rys. 2: Przygotowywanie siatki z płyty CD lub DVD

- **"lux" version:** an authentic diffraction grading can be bought at Zamkor Publisher (www.zamkor.pl). You will need a grading of resolution of 500 lines/mm.

4. Tools:

solid scissors, the best would be utility scissors, a sharp knife (e.g. a special knife for cutting paper), a pencil, a ruler.

Making of a spectroscope

Casing:

on a cardboard from a box we draw with a pencil two circles in shape of the both endings of a roll from paper towels. It is enough to press the both roll endings to the cardboard and to outline them. Then, we cut the circles leaving a bit of additional space from each side. They will serve us as lids:

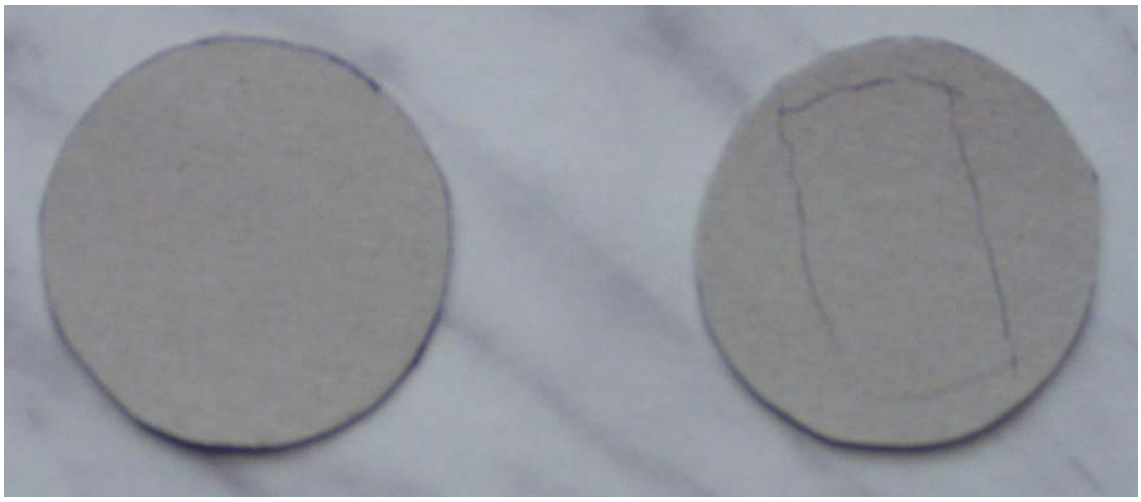


Fig. 3: Lids cut out of cardboard, we can see a shape of razor blade on the right one

Slit:

- **basic version:** we will need one more cardboard circle. We should cut it into halves with one move of scissors. It is also recommended to cut outer edges. It will allow us to form a slit in a simpler and more precise way. It will be easier to stick it to the frame. In the second circle we should cut a rectangular in the middle (not too wide, but it should have about 80% of the circle's length) and stick the both halves of the first circle to the other one in such a manner to form a narrow slit with parallel sides (two-side adhesive tape will be a great help here). In my spectroscope a width of slit is a bit smaller than 1 mm, but feel free to experiment. Narrower slits require stronger sources of light, whereas wide slits do not allow to observe solar spectrum. In the end we should carefully cover the lid with an opaque tape, so that it did not allow light except for slit.

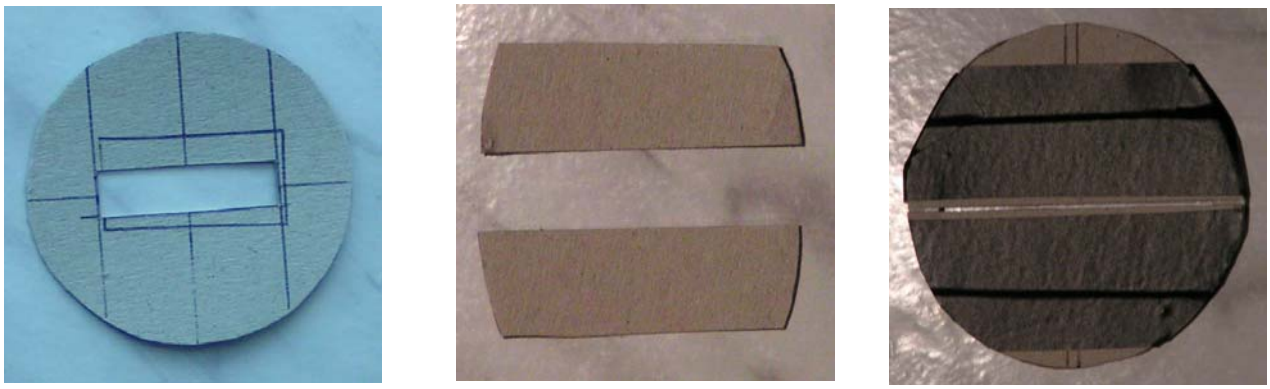


Fig. 4: Elements of slit and ready-made cardboard slit

- "lux" version: we should act in the same way. The only difference is that in case of slit we should use a razor blade instead of cardboard. We must cut the razor blade along the longer side into two more or less equal parts and then stick it to the lid with a cut out rectangular. Its blades should form a narrow slit:

Fig. 5: Elements of slit and ready-made razor blade slit

Diffraction grading

In the second cardboard lid we should cut with a knife a bigger rectangular hole. With scissors we shall cut out of a plastic disc a rectangular bigger than the hole, but smaller than the lid's area. It will work as our diffraction grading. We stick it to a circle with cut out hole in such a manner to make it completely cover the lid. The final step, just like before, is to cover the diffraction grading with opaque tape, to make it impervious to sun, except for the rectangular in the middle.

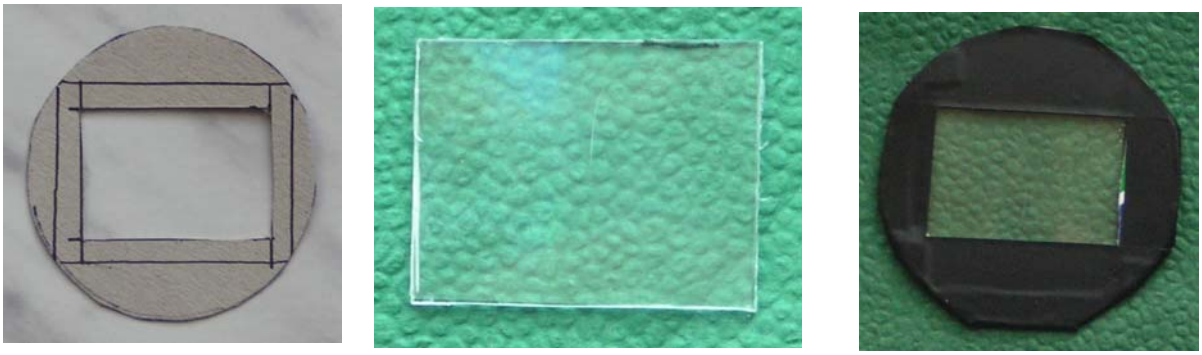


Fig. 6: Elements of diffraction grading and ready-made diffraction grading

Assembly

We shall stick the lid and diffraction grading to one end of a tube from paper towels with use of a tape, remembering to ensure light-proofness in joint places. If we do not see to it, noticing of spectrum can become very difficult, especially when we look in direction of the Sun. The slit should be placed at the other end of the roll and we should look at a bulb from the side of diffraction grading as if through a telescope. If we look at a small angle, that is "above" or "below" the source of light, we should see spectrum. Next we should twist the lid with slit, which enables to set position in which direction of lines of diffraction grading is parallel to slit – in such orientation spectrum is visible the most clearly:

Fig.7: Incorrect and correct setting of diffraction grid with respect to the slit

Now we should fix with tape the lid in that position and our spectroscope is already in working condition:

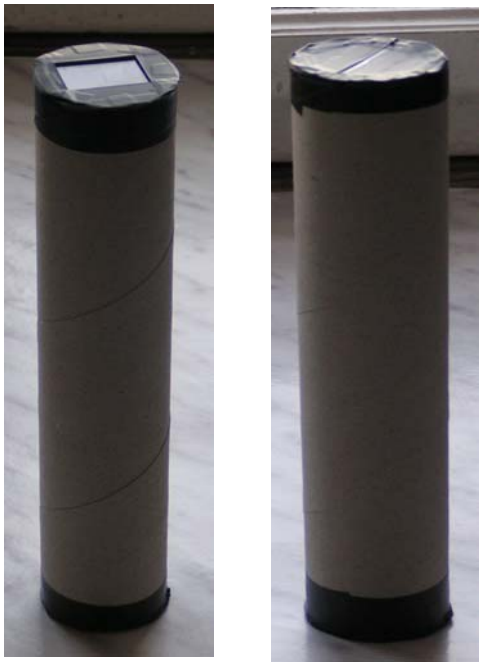


Fig. 8: Appearance of a ready-made spectroscope

The execution time, after preparing all essential materials, does not exceed half an hour.

Now we can watch various sources of light. If the source of light is strong enough – we will see a second row of spectrum, and if, instead of naked eye, we will look through a camera (it would be ideal if both a spectrograph and a camera were on a tripod stand), our toy spectrograph will change into a real spectrograph and it will be possible to register various spectra on a plate or CCD matrix.

Sample spectra:

classical bulbs have continuous spectrum (here a characteristic of digital image becomes visible, to the naked eye a view is a bit different):

Fig. 9: Spectrum of a classical bulb

the same applies to **halogen bulbs:**

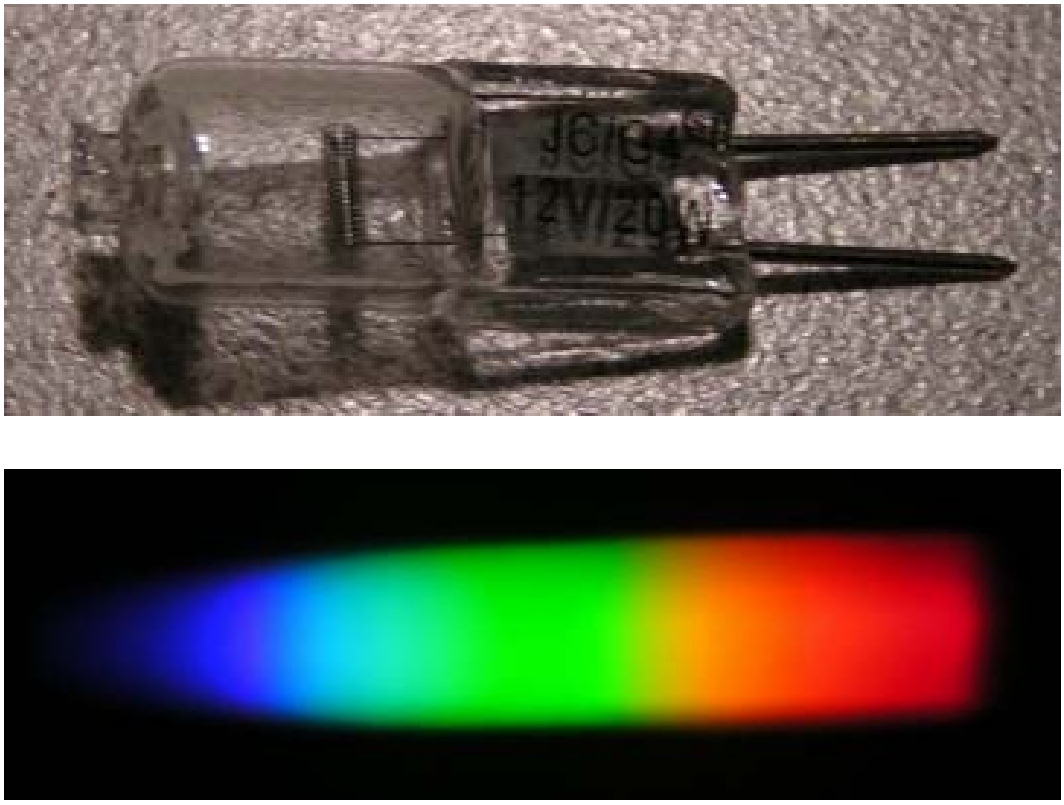


Fig. 10: Halogen bulb and its spectrum

energy-saving bulbs have clear spectrum lines:

Fig. 11: Spectrum of an energy-saving bulb

Old-fashoned **fluorescent lamp:**

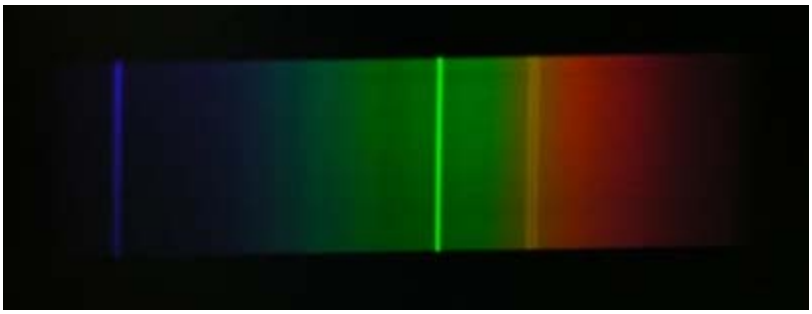


Fig. 12: Spectrum of an old-fashoned fluorescent lamp

Modern fluorescent lamp:

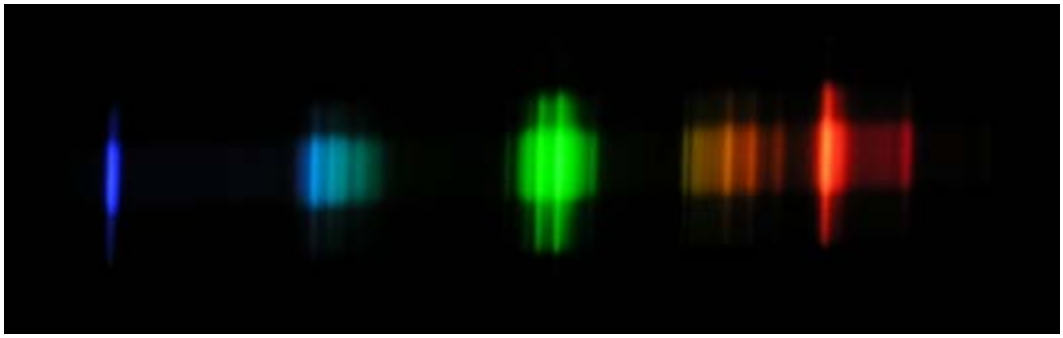
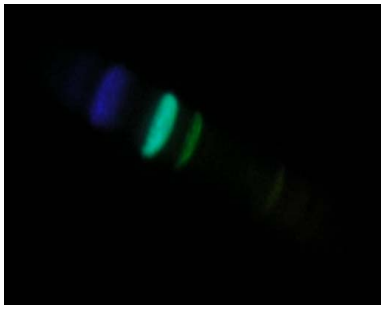
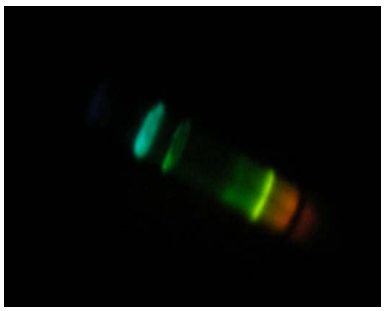


Fig. 13: Spectrum of a modern fluorescent lamp

the same applies to street **sodium-vapour lamps:**





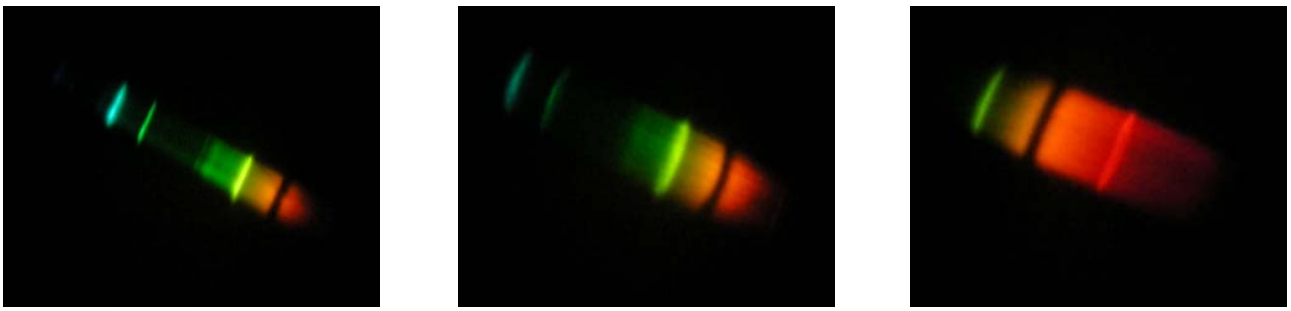


Fig. 14: Spectrum of a street sodium-vapour lamp

and **mercury-vapour lamps:**

Fig. 15: Spectrum of a street mercury-vapour lamp

If you act with due caution, you can also look at the Sun – due to the fact that spectrum is visible at certain angle from the source, so you never look directly at the source. Besides, we look through a narrow slit, which reduces amount of coming light. **Be cautious – looking in direction of the Sun can always be dangerous to your eye!** Fraunhofer lines are clearly visible in a lux-version of the spectroscope.

If you take precautions to prevent your spectroscope from burning, you can try to see spectrum of earth gas in a gas cooker, candle or a bonfire at a holiday trip.

Have fun!!