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Systemtheremino

Theremino Spectrometer
Diffraction gratings

Diffraction gratings

You can use diffraction gratings taken from CDs or DVDs (which must be blank - not written), or you can use commercial gratings which are brighter.

Type of reticle	Lines per millimeter	Notes
CD	625	OK
DVD	1350	Only 300 nm of useful coverage
HD DVD	2500	Not usable
Blu-ray	3125	Not usable
Diffraction grating commercial	500 or 1000	OK OK

Number of grid rows

Here are some possible calibration ranges depending on the number of lines.

Better efficiency	Lines per millimeter	Spectral coverage (nm)
UV/NIR	600	200 - 850
UV/NIR	600	350 - 1050
Visible / NIR	800	550 - 1050
Visible	900	380 - 750
Visible	1000	380 - 700
NIR	1200	750 - 1050
Visible	1800	500 - 700

Some benches, for example the B&W ones that sell second hand for about 300 Euros, have a 1800 line grid. And with these grids you can't even see the red LEDs and the blue LEDs on the same scale.

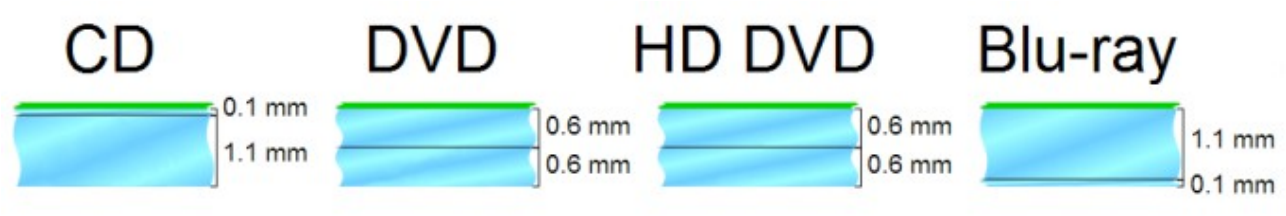
These 1800-line benches were used for analysis where only the fingerprints of some elements were needed. In these cases the lines were close to each other and were fine, but for a general use like ours they are unusable. So be careful when you buy an expensive bench and if they do not write the number of lines ask the seller to specify it.

Some might think that by broadening a part of the spectrum one could obtain a higher resolution, but this is not the case because focusing errors and inaccuracies still limit the achievable precision to about a nanometer.

And also with a 600-line grid the resolution is much greater than a nanometer, here is an example:

- 1304 3600 pixel sensor
- With 300 lines, for example, you go from 350 to 1050, therefore 700 nanometers.
- So 700 nanometers divided by 3600 pixels is 0.19 nanometers resolution

Preparing CDs and DVDs



Type of reticle	Notes
CD	To prepare them, they are not separated into two halves but the surface is peeled.superior (the one with the writing) by tearing it with adhesive tape
DVD	To prepare them, divide the two halves and then remove the aluminum foil. lifting it from one side and then peeling it.
Commercial diffraction grating	They are ready-made, they require no preparation.

Prepare the DVDs

Using a blank disc, separate the two halves of the disc with a small knife or razor blade.

Throw away the half of the disc with the writing and use the other one.

Tear off the thin silver layer with tape.

If you can't, try cutting the silver layer with a knife to make it easier to remove. Make a radial cut from the center outwards and start removing from the cut.

With some types of discs it may be easier to lift a corner of the film with the knife and peel from the lifted corner.

Once the disc is divided, it is easy to cut it with scissors. Cut a square from the outer area of the disc (where the lines are less curved). If the square is too large, you can trim it later.

Be careful not to scratch the surface or touch it with your fingers.

The scoring must be horizontal (outer edge of the DVD on the left)

Using a real diffraction grating

We bought the diffraction grating on eBay. These gratings are also cheap but may be difficult to find.

These “Highly efficient embossed Holographic Optical Elements (H.O.E.)” produce a brighter colored spectrum than DVDs. This makes it easier to measure even dim sources.

Features:

- This grating has 1000 lines/mm instead of the 1350 lines/mm of DVDs and the 625 of CDs, so it deflects a little less and a little more than the latter.
- There is also a 500 line version and it could be useful to have a larger visible area.
- The DVD fragment is more rigid and therefore easier to handle and fix, but you can make the grating just as robust by mounting it in a slide frame.

We recommend buying a sheet as soon as possible on eBay. It takes some time to ship from Israel so buying it now will arrive at the right time, at the end of the spectrometer construction.

Search Bay for phrases like:
“Diffraction Grating Roll Sheet Linear 1000 lines/mm Laser Holographic Spectrum”

Only buy the 1000 or 500 lines per millimeter types, the 13500 lines/inch one is no good.

The sheet that is usually sold (for only 2.88 Euro + 4 shipping) is 6 x 12 inches, which makes 15 x 30 cm. There are enough spectrometers to make for all the friends and there is still enough left to make some nice glasses to give to the children.

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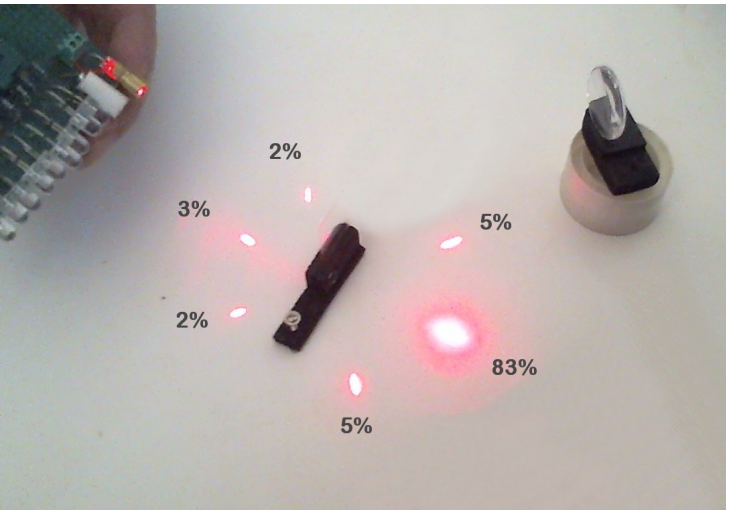
If you can't find them, ask Lello who can be found as MAXTHEREMINO on Ebay.

Reflection diffraction gratings

The optical benches of very expensive spectrometers use reflection gratings and collimating mirrors. These benches get a two or threefold increase in brightness, thanks to the reflection grating and a five or tenfold increase, thanks to the collimating mirror.

Unfortunately, they then use linear sensors, designed in the last century, which have a sensitivity one hundred times lower than the best current WebCams.

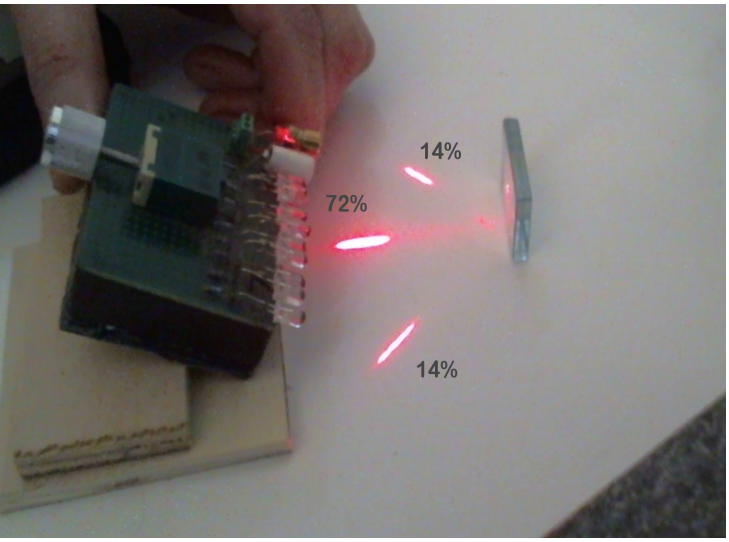
So in the end a bench with a transmission grating and WebCam is brighter and also significantly easier to adjust.



These images show the results of the tests we did with gratings using them in transmission or positioning them in front of a mirror.

For the measurements we used a 5 mW red laser, a lux meter and a surface mirror recovered from a laser printer.

If you use the grating in transmission, the light that is deflected and that we can use is about 5%.



In this second image you can see that adding a mirror increases the brightness by almost three times.

We measured about 14% but it could be an inaccurate measurement because a real reflection grating is not a transmission grating with a mirror behind it but a surface mirror shaped with lines.

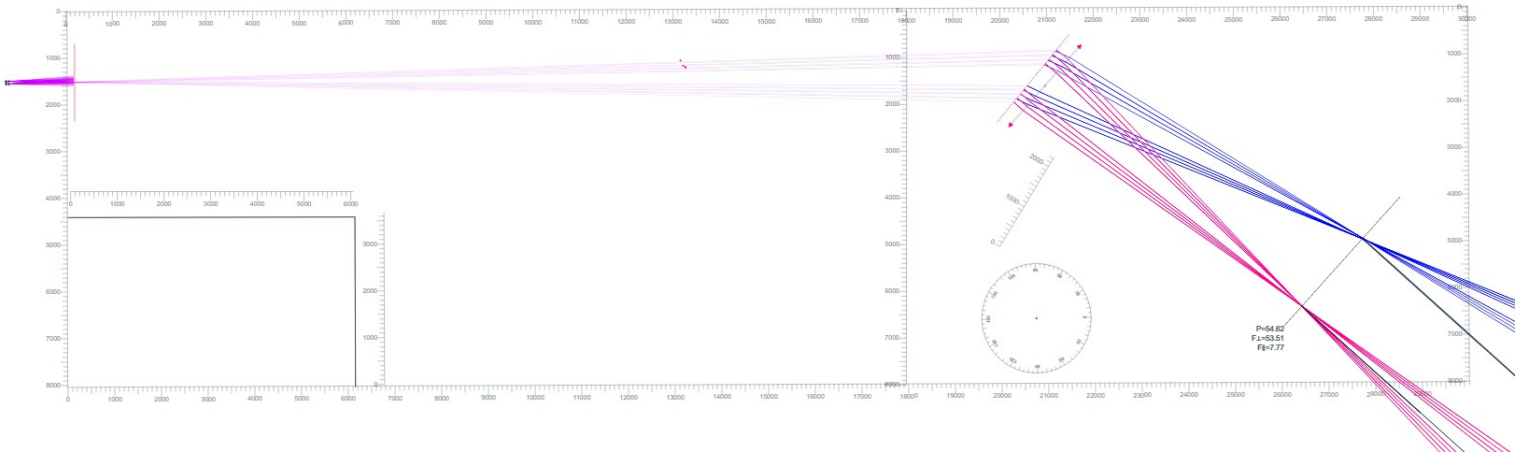
Anyway, the order of magnitude is that, with a reflection grating you increase the brightness by about 3 times, and it is not much.

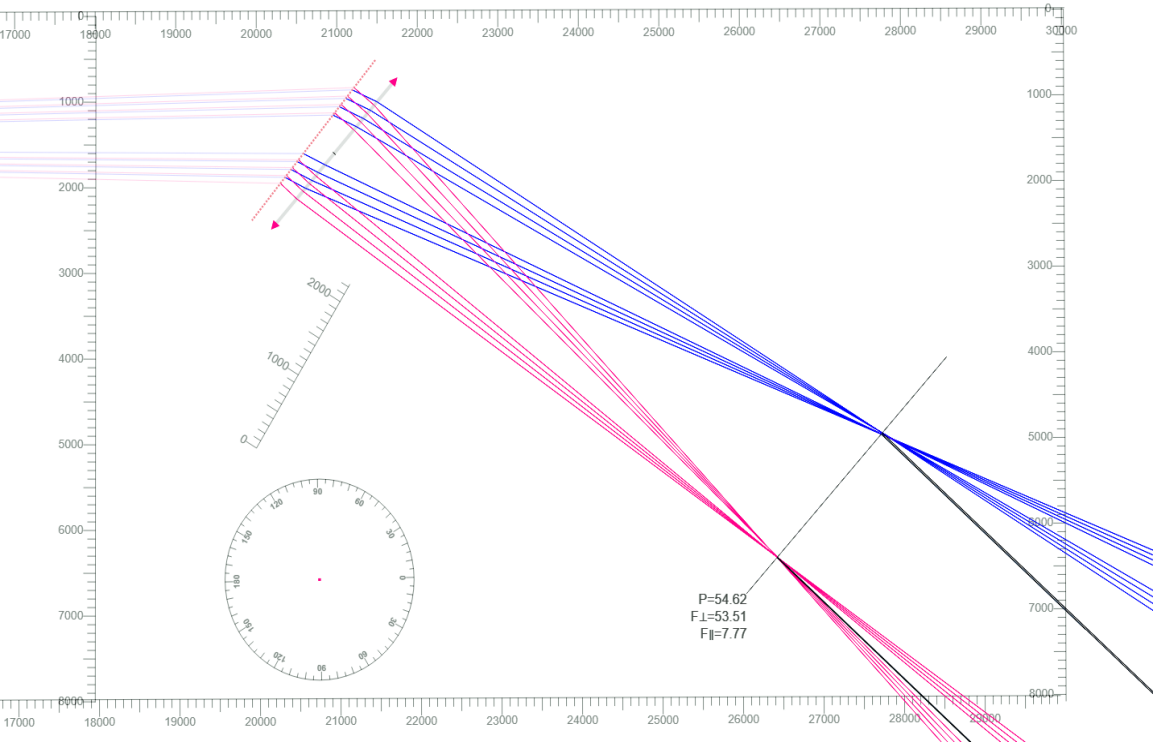
They get the bulk of the brightness gain with the collimating mirror.

Optical simulations

To calculate distances, angles and even focal lengths of lenses we used this excellent online simulator: ***https://phydemo.app/ray-optics/simulator***

To use the simulator you need to gain some experience but it is worth it, it is excellent and can be useful in many occasions.





Using these links you can upload some of our tests to the simulator:
LINK1, LINK2, LINK3, LINK4