An Inexpensive Video Photospectrometer

for use in Pyrotechnics

By Tony Wilkinson
with help and encouragement from Ken Kosanke

Goal

To determine if a common camcorder can be used with a cheap diffraction grating to produce an inexpensive photospectrometer which would be of use to the pyrotechnic experimenter.

Potential benefits:

once set up, the camcorder is hands-free
a permanent record is made of whole 'burns'
an audio commentary can also be recorded
could record the spectra of the whole flame from core to flame tips
individual frames can be captured and manipulated on a PC

Equipment

Camcorder

These investigations were undertaken with a Panasonic NV-R33B VHS-C camcorder. Resolution of the 1/3-inch CCD image sensor is not given, although 'Video Horizontal Resolution' is stated as more than 230 lines in Standard Play (SP) mode.
Many modern camcorders are 'point and shoot' devices: focus, exposure (aperture and shutter speed) and white balance are fully automatic. Unfortunately, these features are a hindrance in this application, manual control of both focus and exposure would be desirable. The camcorder at hand did have manual focus, but not manual exposure.

Diffraction grating

Gratings of: 100 lines/mm, 300 lines/mm, 530 lines/mm and 600 lines/mm were tried. The best results were obtained with an inexpensive (10 UK pounds) 600 lines/mm grating mounted in a glass slide. These are often used in schools and colleges for teaching purposes and are readily available from laboratory suppliers. Professional optical component suppliers may also stock 'reproduction' gratings which are not costly (as opposed to optical gratings which may cost 50 UK pounds or more!).Investigations

Initial investigations

Exposure problems

The camcorder automatically adjusts exposure for the ambient light level, high brightness spots produced when viewing the spectra of a burning compound may cause the camera to adjust exposure and/or over-expose some spectral lines. Over-exposure results in 'whiteout' and blooming of the bright part(s) of the image.
Possible solutions:

- Narrowing of the slit
- Masking/filtering of the slit
- adjusting ambient illumination
- External 'iris'

Intensity 'Dynamic range'

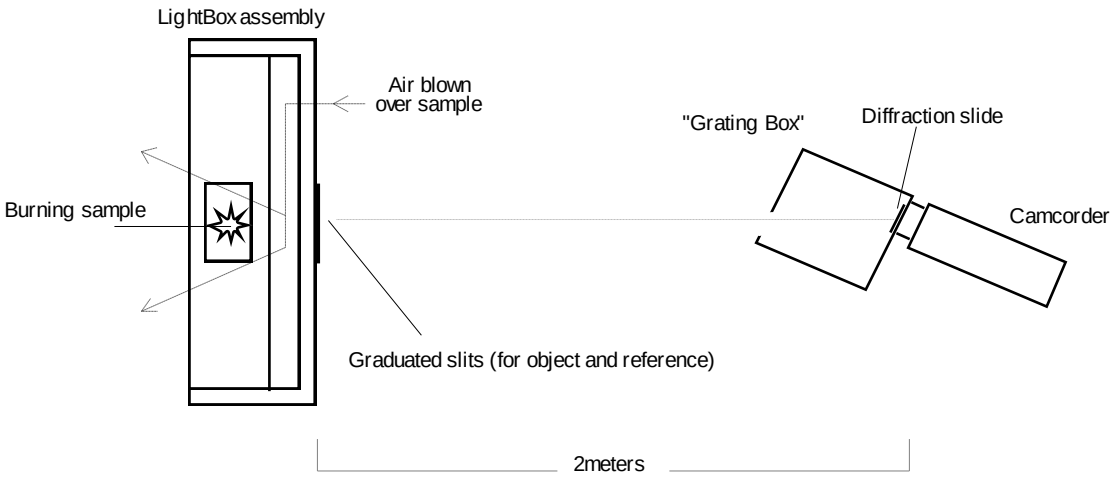
When the exposure is correct for strong emission lines, faint lines are no longer resolved.
Possible solutions:

- Use of neutral-density filters
- use a tapering slit (e.g. horizontal scale = wavelength, vertical scale = intensity)
- use a rotating slit to achieve 'width control' - (Ken Kosanke, 30th Sept. '96)
- record separate trials at different 'exposure' settings

Image resolution

…F5b card…. Awaiting software….

Constructing a Camcorder Spectrometer



The above diagram illustrates the main components of the setup as seen from above.

Light from the burning sample passes through a specially-constructed ‘graduated slit’ to the diffraction slide in front of the camcorder lens. Beneath the sample platform, a compact fluorescent lamp provides a reference via a second ‘graduated slit’. The diffraction grating is held inside a ‘grating box’ whose main function is to exclude extraneous light from the camera.

The combination of a reference light source and the graduated slits help the camera to maintain a reasonable exposure level and allows strong and weak lines to be visible at the same time.

The LightBox assembly also has an electric blower fan which draws air from the front of the box, blowing into a cavity in the woodwork, expelling over the burning sample. This blows smoke away from the burning composition and may help better simulate conditions of a burning star travelling through the air. It must be noted however, that if the fan is too powerful, it tends to blow the sample away.

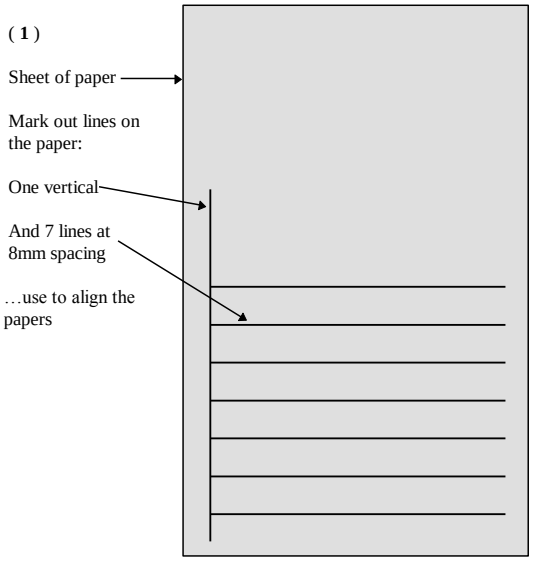
Constructing a graduated slit

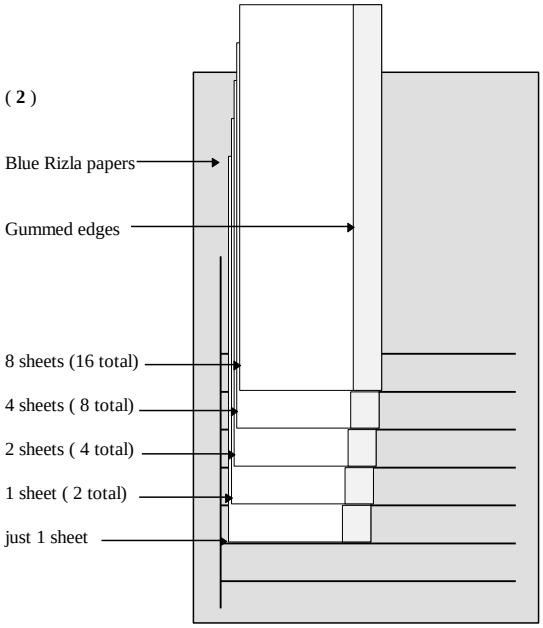
The graduated slit is a 1mm x 48mm slit which is graduated by a neutral density filter, the problem has been how to construct this from readily-available materials.

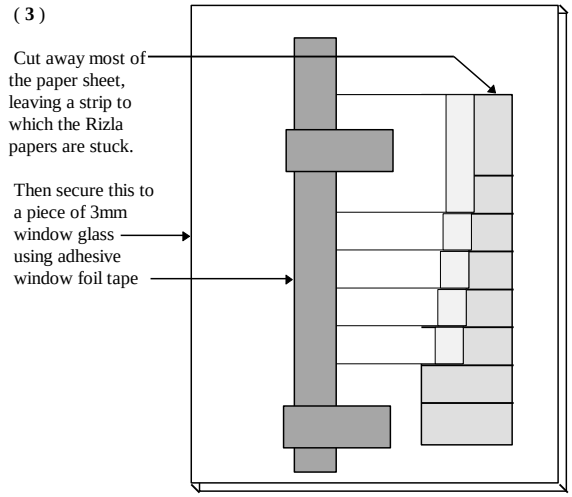
The method used here employs thin white paper as the 'neutral density filter' material to grade the slit optically, each 'graduation' being half the intensity of the preceding one.

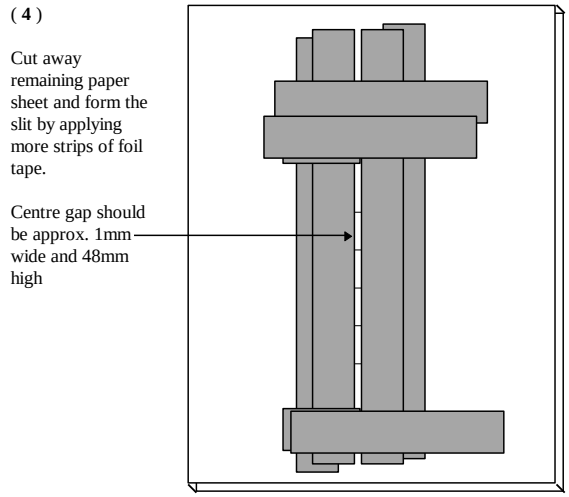
After some investigation, it was discovered that an ideal grade of paper is Blue Rizla+ cigarette paper - also having the advantage that this is available almost anywhere in the world!

Construction
Take a pack of Blue Rizla+ papers, mark out a sheet of paper and gum the papers down to form steps of 0, 1, 2, 4, 8 and 16 thicknesses of the papers onto a piece of window glass- as shown below:

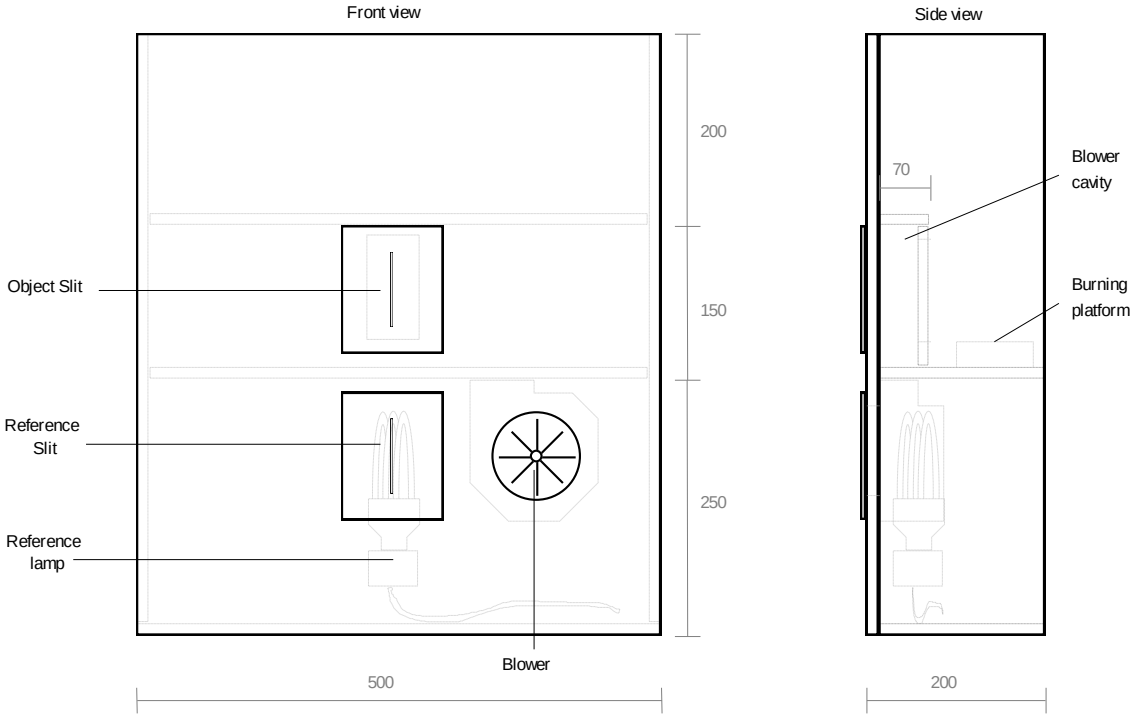


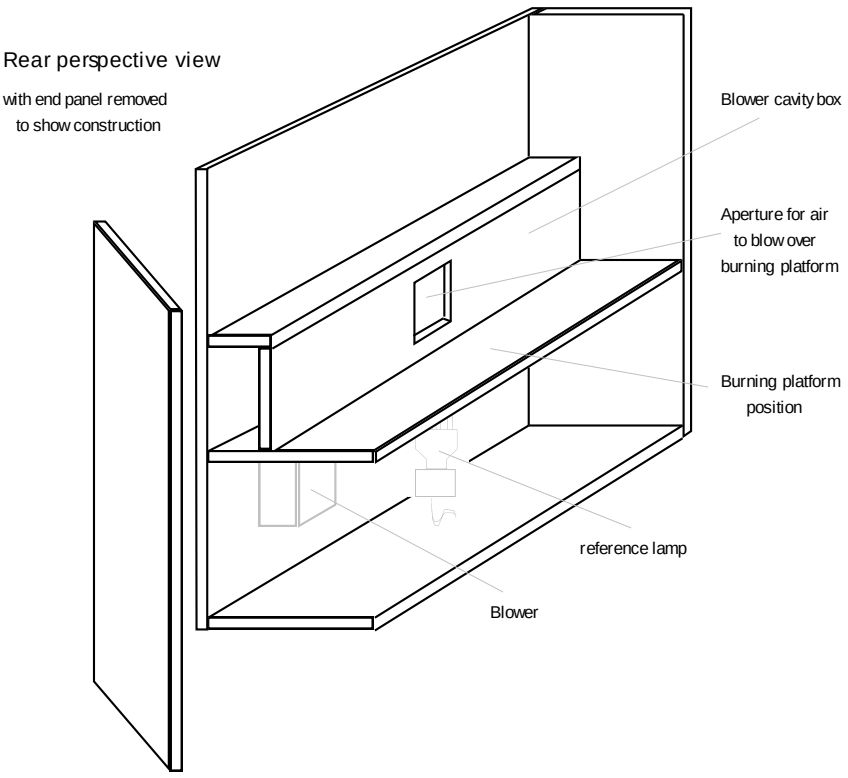




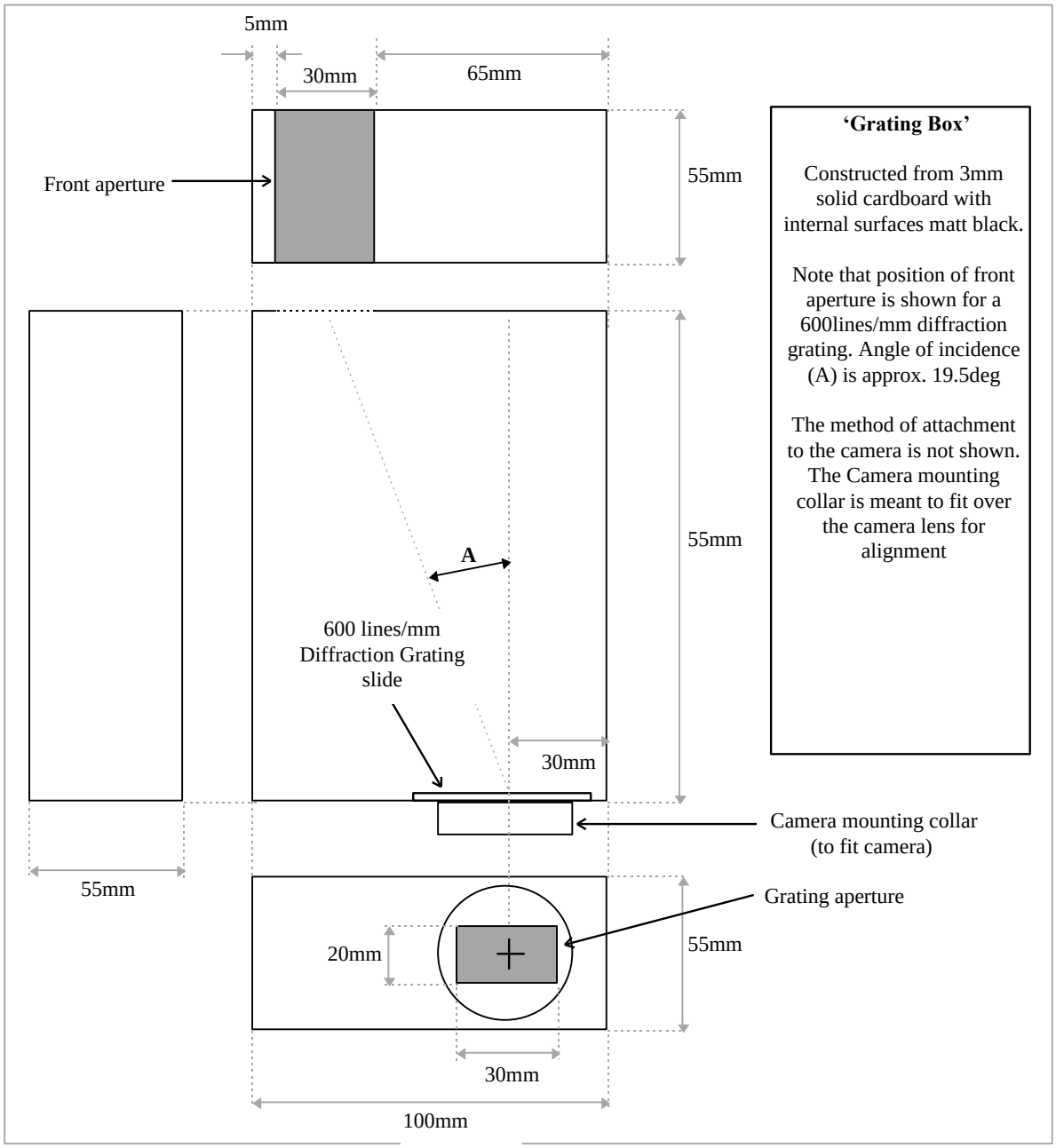


LightBox Assembly





The camera ‘Grating Box’



Test star mixtures

The following mixtures were made into 10mm stars for test burning. The compositions were based on Veline's colour system; adjusted according to my lab. stock at the time.

The Na/Li 'calibrator' was intended to produce good Sodium and Lithium spectral lines for calibration purposes.

	Na/Li 'calibrator'	Red	Green	Blue
Potassium perchlorate	55	52	28	52
Red Gum	10	8	4	8
Magnesium	15	8	13	8
Lithium chloride	10			
Sodium chloride	5			
Strontium nitrate		10		
Strontium chloride		4		
Copper (II) oxide				14
Barium nitrate			23	
Barium carbonate			14	
PVC (powder)		14	14	14
Dextrin	5	4	4	4

Results with this equipment

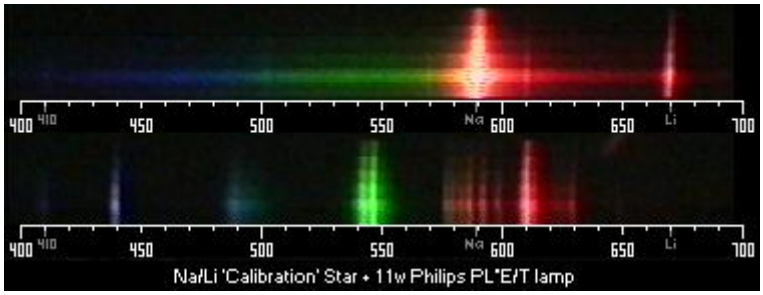


Image 1

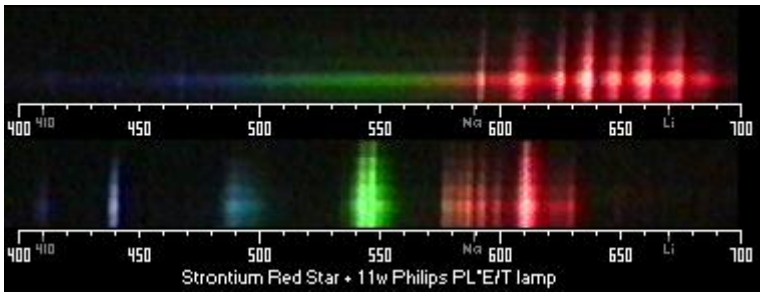


Image 2

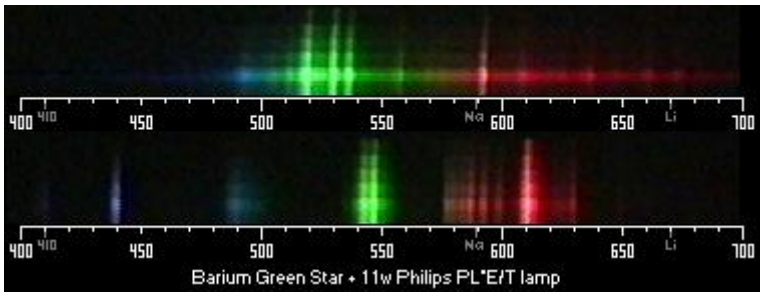


Image 3

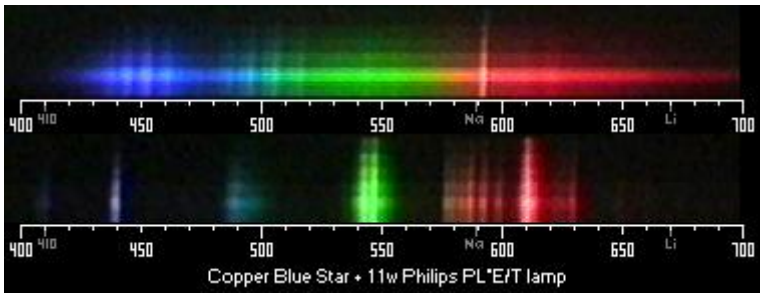


Image 4

Copies of the above colour images, rendered as inverse grayscale are shown below. This form is much better suited to printing:

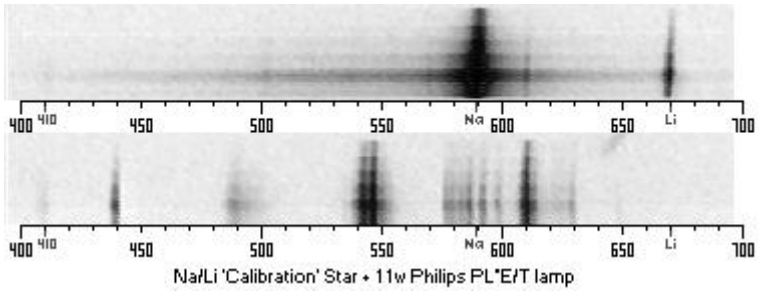


Image 5

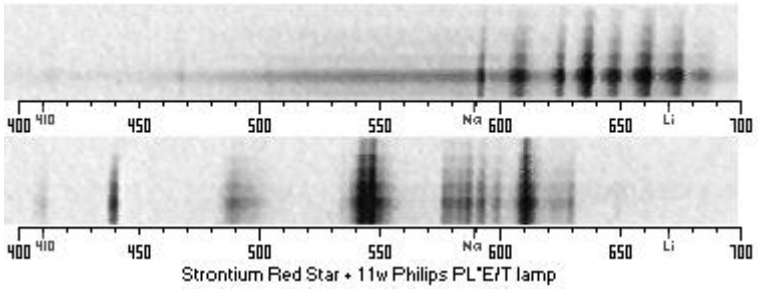


Image 6

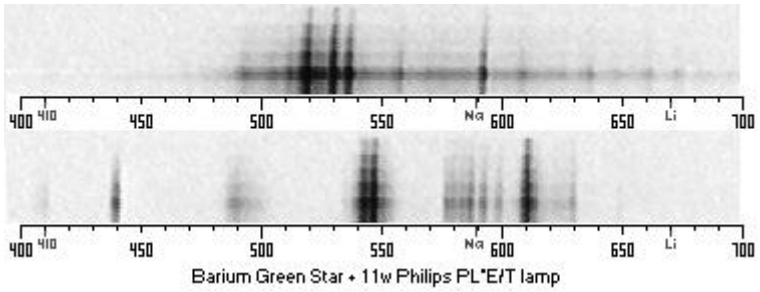


Image 7

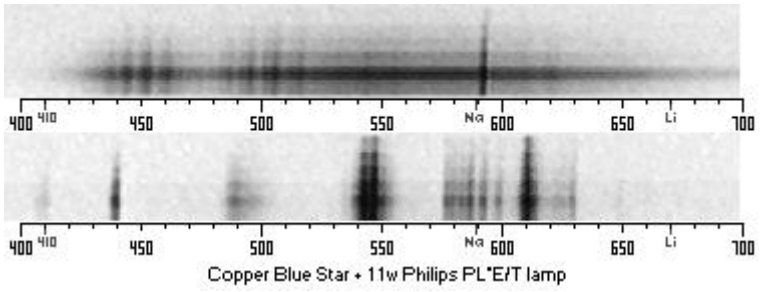


Image 8

Conclusions…

Hum… looks pretty good so far to me !