ENSC 470/894 Lab 2
V3.3 (Oct. 30, 2015)

Introduction:
Lab 2 is designed to give students basic experience in the use of spectrometers and the spectral width of regular light sources, LED's, white LED's, IR LED's and lasers. In addition you measure the transmission curve of an optical filter. Also this gives a first experience with lasers.

Optical Setup
In this lab the spectrometer is controlled by the computer

Computer Setup before the Experiments
1. Before beginning the experiments first turn on the computer for the experiments if it is not on. Do a Ctrl-Alt-Del to bring up the login. At the login use:
Login: ensc476
Password: Test@123

Fig. 1: SPM-002 spectrometer – note optical input port at the front

2. Check the spectrometer is in place on the optical breadboard. The spectrometer is a Photon Control SPM-002 sitting on a blue stage jack (or possible a pile of books). Note the optical input for the spectrometer (see Fig. 1) which is the small hole at the front of the spectrometer. You will be putting light (laser, incandescent light, or LED's into this port.)

3. Click on the SPECSOFT icon to start the program for spectrometer. You will see a display as shown in Fig. 2. Before inputting any light source, click the "Store" button then "Apply" on the "Dark Background" panel which located on the right-hand side. This provides a background noise subtraction to the measurements. You only need to do this once at the beginning of the lab.

4. Before starting create a sub directory for your group under the My Documents\e470-2015\Lab2 directory for your groups images. Please put these in the e470 directory with a directory name of your group (ie Group X). Save it to the hard drive so you do not lose the data. We cannot have you save to a USB drive as we have been infected with those before. We will be posting your images on the web so choose file names that make sense or record the file names in your notes.

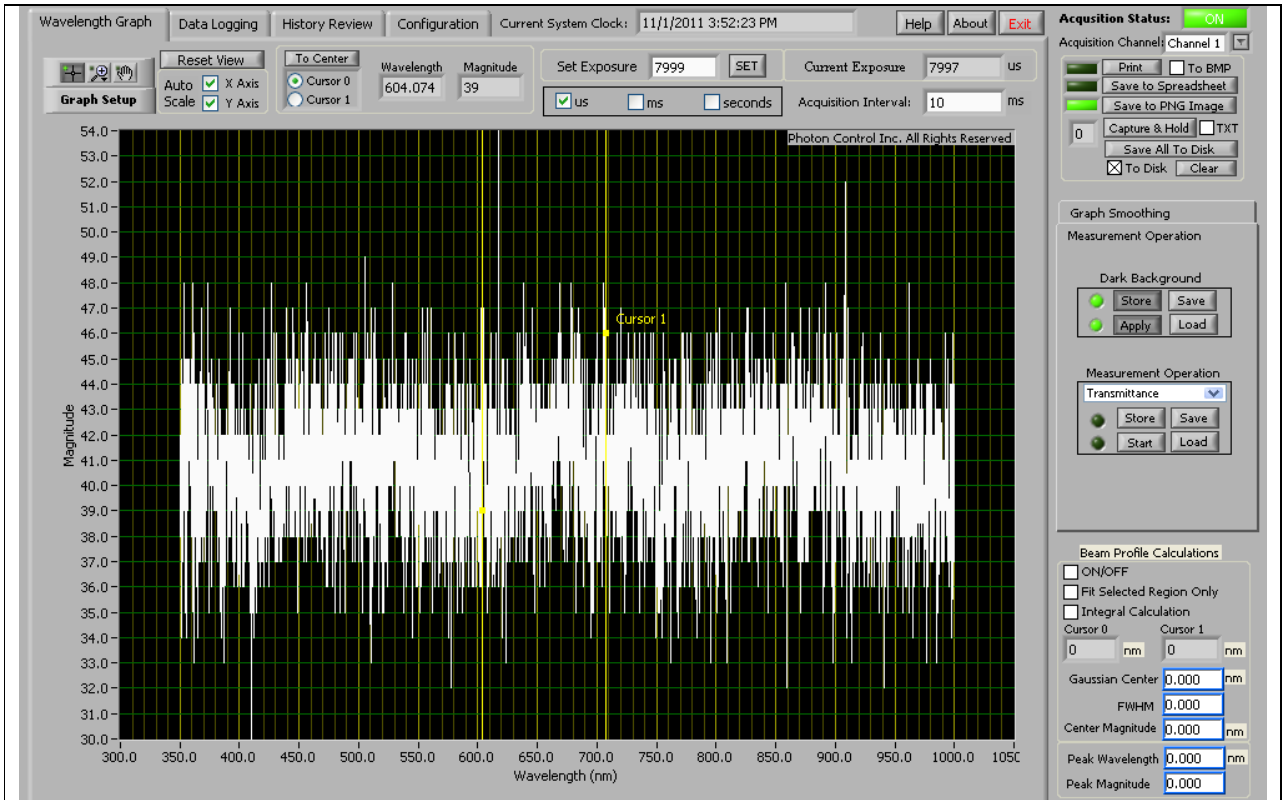

Fig. 2: specsoft program as it initially starts up.

1. Regular light Bulbs Spectrum.

First you will test an incandescent light source, compact fluorescent and Halogen light bulbs. For the incandescent is to be put in the desk lamp but you may need to change bulbs if two lamps are not available.

(a) Apply the light almost directly to the spectrometer optical port. You will see a live image of the spectrum. If the image is saturated it is too bright. Saturated images have a flat top as in Fig. 3. To correct this you can either

(i) adjust the exposure number (centre of the control panel in Fig 3 showing the 7999 to a lower number then set or

(ii) Move the source away from the optical port to reduce the signal.
Note if you do if you do adjust the exposure number be sure to return it to the original value before proceeding to other test.

(b) To take the images click on the "save to PNG Image" button on the top right (3rd button down).

(c) Immediately also click on the "Save to Spreadsheet" button. You will be doing the analysis from the spreadsheet but the PNG image will show what you have obtained. Note the file numbers for both from the folder. Note at the end you want to move all these files into a directory for your group.

(d) Repeat these for the Fluorescent light bulb.

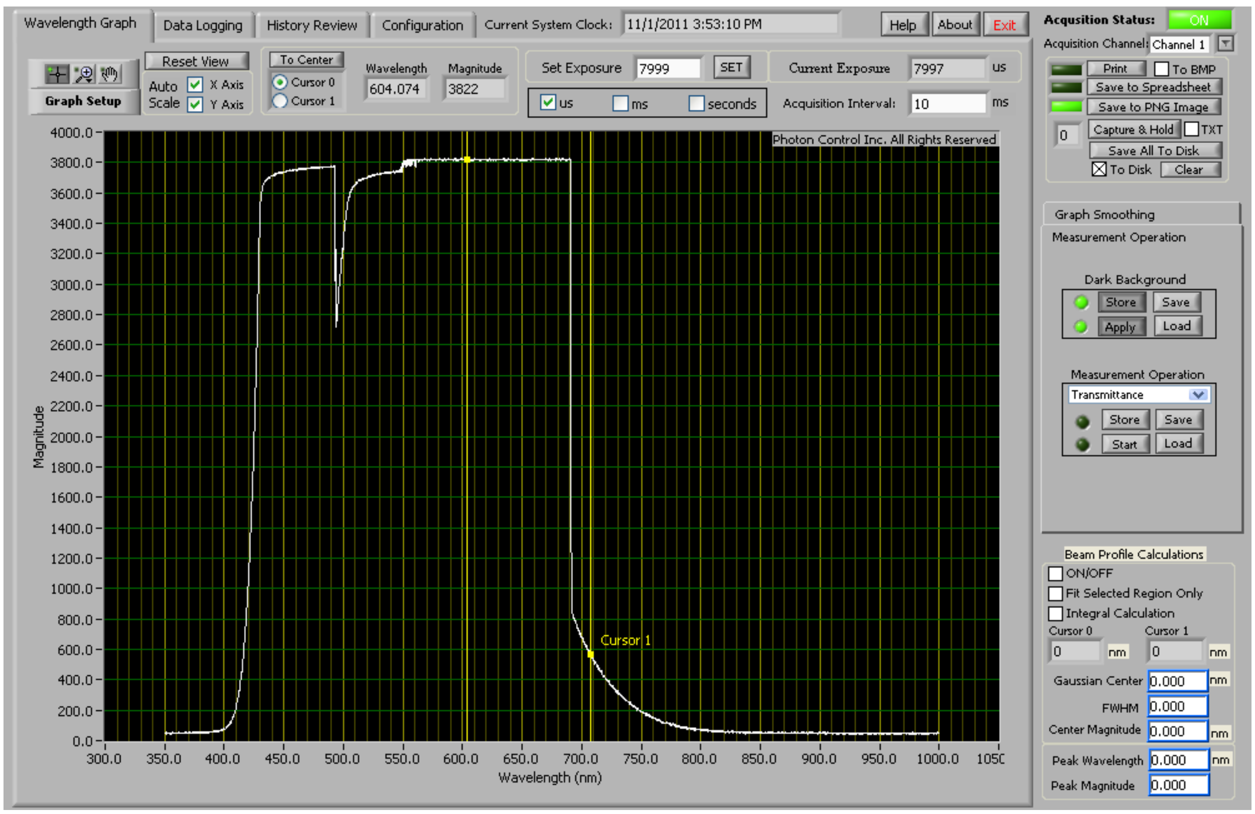

Fig. 3: spectrum generated by a saturated image.

(e) Now we test a quartz halogen light source (often used for high intensity lighting). We use a old slide projector for the source which is on the movable table (Fig. 4). Move the wheeled table so the light from the projector output (Fig 4 left) enters the spectrometer. You may need to adjust the spectrometer to get the light in. On the side of the projector (Fig 5) move the power slider (top center left) to the fan symbol then to the half light symbol. Take the spectrum and save as before. When turning off first move the slider to the fan and allow it to cool for a couple of min before turning it off.

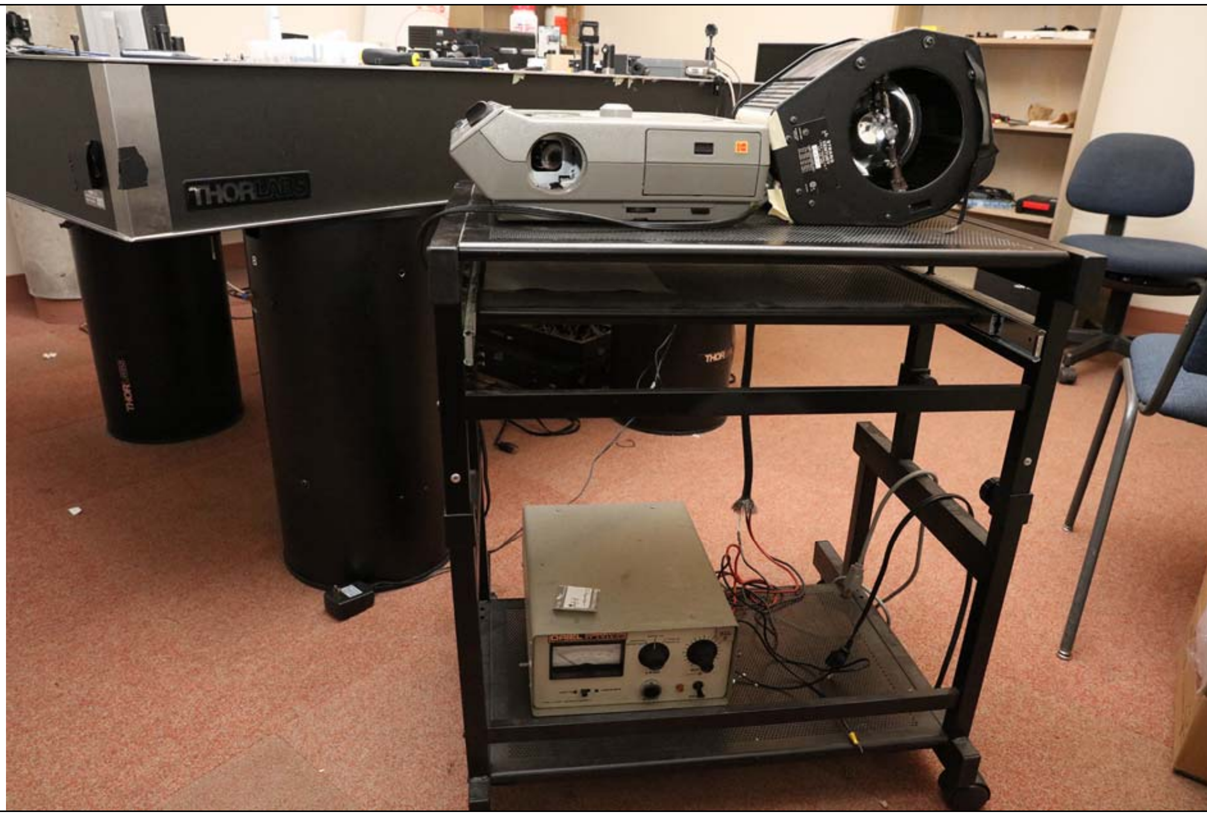

Figure 4: Table with quartz halogen slide projector (left) and mercury vapour (right) with power supply below

Figure 5: Slide project controls for quartz halogen source.

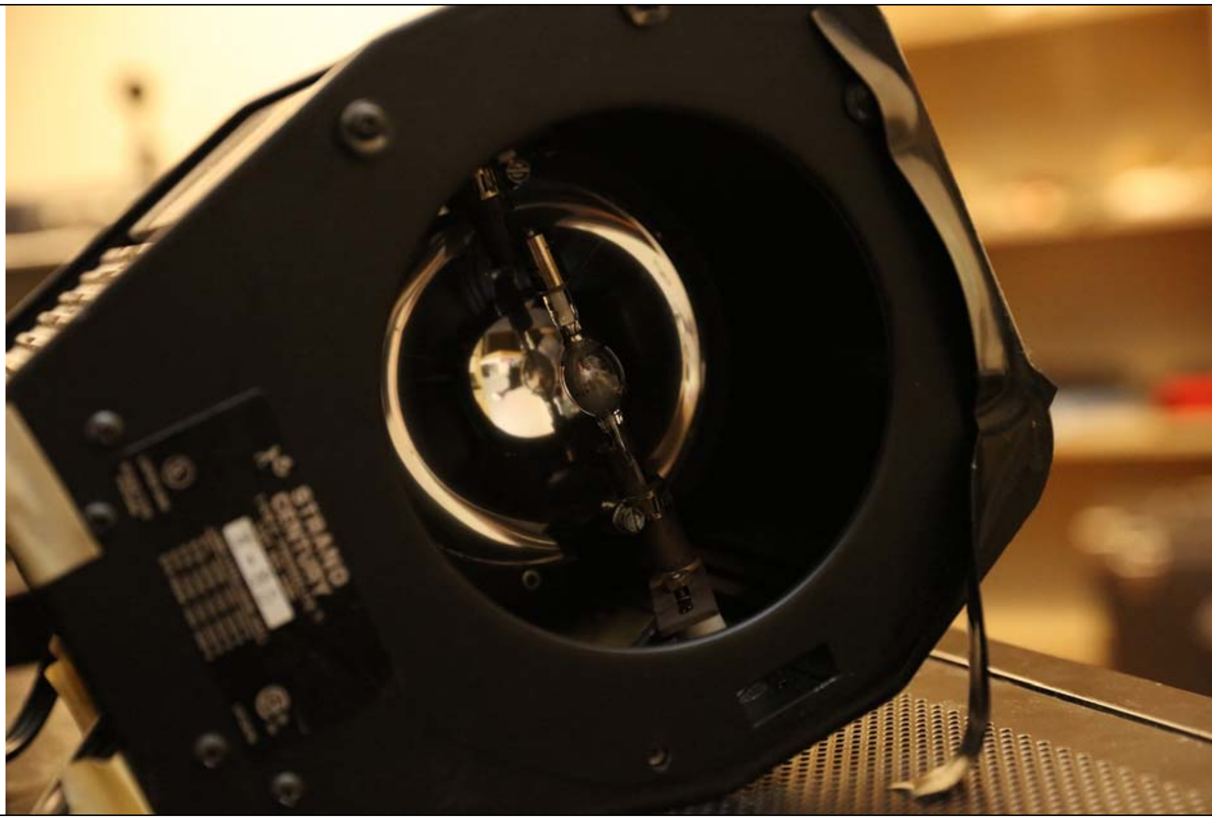

Figure 6: Mercury Vapour lamp source

Figure 7: Mercury vapour power supply

(f) Now we do a mercury vapour source which is a spot light used in stage performances. Warning this is very bright. Position the mercury vapour source (black case with lamp and mirror behind it (Fig. 6)) and the spectrometer to accept the light. The power supply is on the bottom of the movable table bottom (Fig. 4, 7) – plug it in. To start the lamp flip the power supply switch on (Fig 7) on the lower right and see the supply light come on. After a waiting a minute then press and release the start button (lower centre). Warning : the light comes on with a sharp sound. Save the files as usual. Make certain you have the files before turning off the lamp. When you turn off the lamp you need to give it several minutes to cool before moving it or restarting the lamp.

2. White LED Spectrum

Next test uses a white LED light source and compares its results to the Incandescent light

(a) Using the 3 prong source mount place the LED flashlight in the mount. Adjust the 3 holder arms so that the LED flashlight is stable and turn on the light. (see Fig 4/5 for and example with another LED source).

(b) Position the source and the spectrometer to get a strong signal without saturation. This may require adjusting the height of the mount, or moving the spectrometer away from the mount to reduce the signal.

(c) Again To take the images click on the "save to PNG Image" button on the top right (3rd button down). Immediately also click on the "Save to Spreadsheet" button.

3 Colour LED spectrum

Next test uses a colour LED light source and compares its results to White LED. Do the red LED and the colours specified for your group.

(a) Plug in the string of Christmas LED light sources. Using the 3 prong source mount place the correct coloured LED in the mount with the point of the LED towards the spectrometer. Adjust the 3 holder arms so that the LED is stable. (see Fig 8/9 for and example with the Red LED source).

(b) Position the LED source and the spectrometer to get a strong signal without saturation. It is probably best to get the point of the LED directly in line with the spectrometer optical input (see Fig. 9). This may require adjusting the height of the mount, or moving the spectrometer away form the mount to reduce the signal.

(c) Again take the images by clicking on the "save to PNG Image" button. Immediately also click on the "Save to Spreadsheet" button. Again record the file numbers for the future – especially if you take more than one files

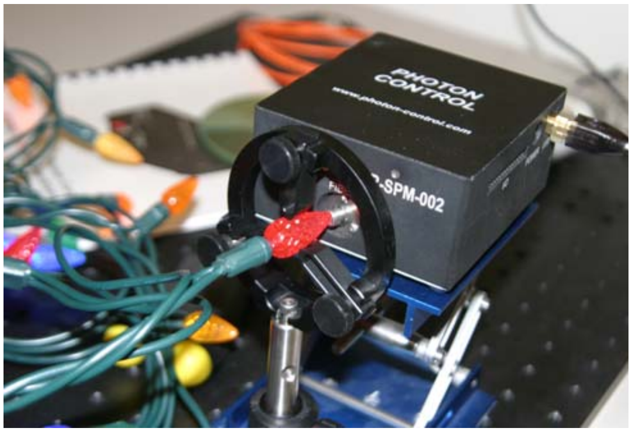

Fig. 8: LED source in mount


Fig. 9 closeup showing LED at optical port

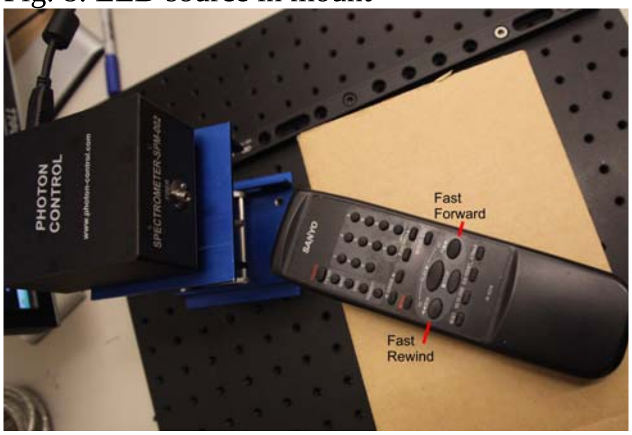

Fig. 10 Remote IR control

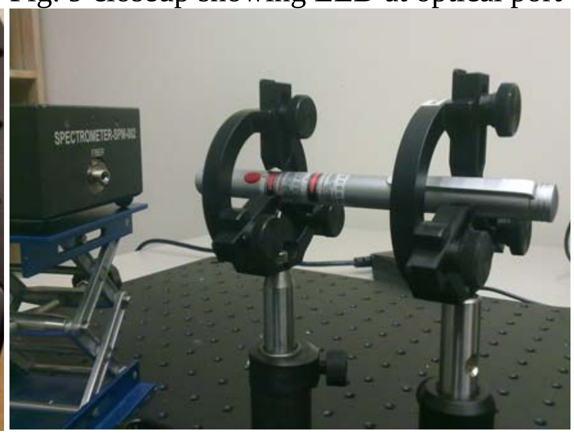

Fig. 11: Nd:Yag laser pointer in mount

4. IR remote control spectrum

Most TV, VCR or DVD remote controls use an IR diode which produces an encoded signal. In this test we compare the remote spectrum to the White and coloured LED's.

(a) Place the VCR remote control on a box so its LED emitter points to the spectrometer input. To operate it use the fast forward (>>) or fast rewind (<<) buttons (see Fig. 10). These controls produce a continuous encoded signal.

(b) The IR remote produces a pulsed beam so you need to set the exposure time to a long duration – typically ~200000 to 50000 to get a steady image. You may need to move the controller away from the spectrometer to get a steady image that does not saturate. Record your values.

(c) Again take the images by clicking on the "save to PNG Image" button. Immediately also click on the "Save to Spreadsheet" button. Again record the file numbers for the future – especially if you take more than one file of this image. Be sure to return the exposure to the 7999 before finishing this section.

5. Laser source spectrum

In this section you will take the spectrum of two laser sources. There are four: a HeNe laser (Fig. 12) and 3 laser pointers: a red, Nd:Yag 2nd harmonic green, and blue laser pointer (Fig. 11). The laser pointers are mounted using the 3 point supports (see Fig. 11). Everyone will do the HeNe but the laser pointers you will use will be specified for your group. Use the supplied tape to hold down the laser on button before the final alignment. Adjust the lab jack to be at the level of the sources (see Fig. 8,9). In both cases make certain enough laser signal reaches the sensor – you really do not need to directly get the beam into the spectrometer entrance hole – just near the hole.

(a) Both lasers are mounted on posts. Put the laser's post in the post holder and lock in place. Adjust height to the spectrometer height. Orient the laser and the spectrometer to get the laser beam directly into the spectrometer optical port. For laser pointers see Fig. 11, for the HeNe see Fig12. . If this produces a saturated spectrum (flat top) move the beam slightly to the side.

Fig. 12 HeNe laser in mount

Fig. 13: Coloured camera filters

(b) Again take the images by clicking on the "save to PNG Image" button. Immediately also click on the "Save to Spreadsheet" button. Record the file numbers for the future – especially if you take more than one files

6. Coloured Filter transmission spectrum

In this section you will be given a coloured optical filter (these are classic camera filters – see Fig. 13) and the Nd:Yag laser googles to measure the transmission curve for. You need to select a light source to give you the full spectral range for the filter. (To some extent the quality of your result will depend on the choice of source you make for this experiment).

(a) Set up your light source as before. Leave enough space that the filter can be inserted in before the spectrometer. Take a calibration spectrum of this source in the PNG and spreadsheet files as before

(b) Now put the filter close to the spectrometer input and take another spectrum. You may need to adjust the exposure to get the correct unsaturated spectrum. Note it is extremely important not to saturate the image in order to get the best results. Now take the filtered spectrum of this source in the PNG and spreadsheet files as before.

Writeup
The aim of the writeup (one writeup per group) will be to see what you have learned in the lab. You give a brief description of the experiment. Note in particular things that you needed to do differently from the description (e.g. how you aligned the laser). Note which LED and laser sources you used. In the observations section note all the results, and changes, e.g. changing the exposure values. Be sure and show the spectrum for each measurement section.

In the analysis section do the following the following. Note use the spreadsheet not the plots to extract the values. This is where you will also establish the errors on the numbers from the recorded values. Do not forget to do error analysis when comparing spectral widths etc. Errors here are how accurately you can tell the peak, and spectral width.

(1) For the incandescent source find the peak wavelength. From the peak wavelength estimate the black body temperature (called the colour temperature)
(2) Find the Full Width Half Maximum spectral range (give wavelengths). How asymmetric is this (ie from the peak to short wavelength difference, and similarly the peak to long wavelength value).

(3) On a plot use the estimated colour temperature and compare the measured curve to what you expect in a black body curve of that temperature. In particular scale the black body curve to have the same peak intensity value and plot both on the same curve. Separately plot the difference between the measured spectrum and the BB curve. Use the spreadsheet values for the plots

(4) For the Fluorescent and Halogen compare the plot to the regular incandescent. What is the peak colour temperature and repeat parts 1-3.

(5) For the white LED also measure the peak wavelengths (there will be two). From the peak wavelength estimate the colour temperature for each peak. Note does it have more than one peak?

(6) Compare the incandescent, fluorescent, halogen and white LED sources on a single plot. What can you say about the light colour cast (appearance) by each of these sources? How do these compare to sunlight?

(7) For the white LED find the Full Width Half Maximum spectral range for each of the peaks (give wavelengths). Again do a Black Body curve for each peak based on the colour temperature and compare the BB curve to the spectrum for that part of the curve. To give the error on the fit plot the fitted curve, and separately plot the residuals, that is the difference between the fitted and actual data.

(8) For the coloured LED and IR remote also measure the peak wavelength. From the peak wavelength estimate the colour temperature of the peak. Find the LED Full Width Half Maximum spectral range for each of the peaks (give wavelengths). How asymmetric is this (ie from the peak what is peak to short wavelength number, and similarly the peak to long

wavelength value). How does the spectral width of the colour LED compare to that of the peaks in the white LED.

(9) For the laser sources and the mercury vapour also measure the peak wavelengths Find the laser Full Width Half Maximum spectral range for each of the peaks (give wavelengths). How asymmetric is this (ie from the peak what is peak to short wavelength number, and similarly the peak to long wavelength value). How does the spectral width of the colour laser compare to that of the peaks in the white and coloured LEDs . In particular how does the red LED, laser diode and HeNe laser spectral widths compare. Compare the width of the mercury vapour lines to that of the lasers.

(10) For the optical filters you have two spectrums, the source and the filtered spectrum. To obtain transmission filter you must calculate the transmission at each wavelength relative to the expected value from the source spectrum. Scale this curve to give 100% transmission at the brightest part of that curve. This first curve is just the linear light transmission. Now recalculate this curve to plot the transmission in OD (Optical Density). For the Nd:Yag safety googles also give the unscaled curves of both.

(11) Calculate the coherence time for the emission in each spectrum. For spectrums with multiple spikes (eg fluorescent light) choose the most powerful peak. See the coherence notes (lesson 15) so see how to calculate the coherence time from the width of the spectral peaks.

In this lab the discussion is the comparison of the various sources as described above.

Conclusion is where you summarize the results. Did the results fit the expected theories (eg the black body curve, relative widths of the sources of LED, lasers and mercury vapour). What worked and did not work in this lab. What was the hardest source to align?