Chapter 4: How to Use the Spectrometers

One of the most difficult pieces of equipment for this class are the spectrometers. They are easy to unalign and break.

For example, important: The Fiber optic cable coming out of the Spectrometers should never be bent with a radius less than 3 inches. This can destroy the cable. Remember it is a cable of glass, so try to be extra careful with it.

Specifications visible:

- Center wavelength: 532 nm
- Wavelength Range: 134.85 nm
- Pixels: 0.263 nm
- Approx Resolution: 0.49 nm
- Throughput: 50%

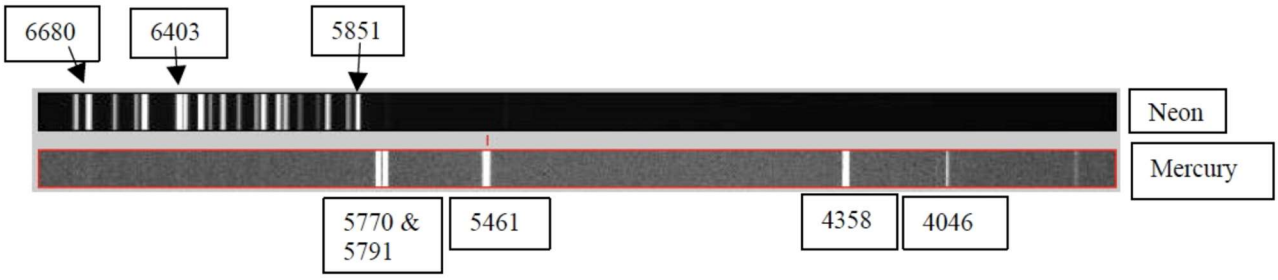
Specifications IR:

- Center wavelength: 830 nm
- Wavelength Range: 199.80 nm
- Approx Resolution: 0.72 nm
- Throughput: 50%

It is recommended that you do the initial step of the spectrometer in the lab:

1. Remove the aluminum plug on the side of the spectrometer. There is an hex socket set screw that holds it on. Slightly loosen the screw and remove the aluminum plug.
2. Attach the CCD camera with the long end of the camera perpendicular to the spectrometer length. Tighten the hex socket set screw.

3. Set up the laptop and start up the camera, making sure to follow the setup directions, such as first plugging up the USB cable, then the power, then turning on the camera etc.
4. With the focus mode of the CCD running, remove the end cap of the fiber and point it toward the fluorescent lights (for visible) or the neon lamp of the power strip (for IR). These are good reference spectra.
5. Verify that the spectrum is a) along the long length of the camera sensor and b) as as straight as possible. The latter may require you to slightly rotate the camera.
6. Reduce the light input and take a short exposure of your wavelength calibration source. Verify it is a good exposure and that the wavelength can be calibrated and then it is ready to move to the telescope.
7. Follow proper camera shutdown procedures.
8. Attach the fiber optic end to the optical splitter, being careful not to scratch the front of the cable.



Telescope Use:

1. Unlock and open dome to the North.
2. Do not power on the telescope.
3. Uncover the main mirror and the finder scope.
4. Screw on the fine focuser. (Do not plug it in yet, but secure the cord.) I find that the cord gets in my way if plugged in for this.
5. Before you use the spectrometer you MUST verify that everything is working with your eyepiece. So, we start the same as before.

6. Attach diagonal (90 degree component) to the fine focuser. Do not overtighten the finger screws.
7. Attach the 26 mm eyepiece to the diagonal. Do not overtighten the finger screws.
8. Make sure the telescope is balanced for this configuration. Someone could be using the camera before you and that changes the balance a lot!
   a. Unlock the RA and DEC locks.
   b. Then, point the telescope straight up (i.e. vertical) with the mirror and equipment at the bottom (see Figure 1).

Figure 1: Arrows show the two weights to screw on or off to correct for offsets of mass while pointing straight up.

   c. You want to balance it so that it stays in this position. You will do this by screwing on/off the weights pointed at by the arrows in Figure 1.
   d. Holding the telescope straight up, see what way the telescope wants to move and counteract with the counterweights.
   e. For example, if the telescope moves to the left in Figure 1, then first screw the left weight toward the telescope. When, screwed all the way in, screw out the weight on the right side until the telescope is balanced, i.e. when you let go of it, it stays pointing up.

f. Next, move the telescope so that it is pointing horizontal (Figure 2).

Figure 2: What a horizontally pointing telescope looks like. Now, we have to move the entire weight assembly along the rail shown in this image running along the top of the telescope (and along the bottom). Be careful, they can fall off the rail so loosen carefully while moving these, while a teammate holds the telescope.

g. Now, to balance in this direction, we need to move the entire weight assembly left or right to balance. Do not screw/unscrew the weight up or down since that will affect the balance of the vertical direction.
h. Holding the telescope carefully in the horizontal direction, see which way the telescope moves.
i. Unscrew (carefully) the weight assembly that moves left/right (horizontally) along the telescope tube. You can move either one, but it is best to move them together.
j. For example, if the telescope moves mirror down (counter clockwise), then you will need to shift the two weight assemblies to the right to counter.
k. Once you have the vertical and horizontal balanced, you should be able to move the telescope arbitrarily and when you let go, it should not move too much. If it moves fast, then you did not balance the telescope.
l. Remember the better balanced, the better the telescope will track and the easier it is to use the telescope overall. It is worth your time to balance it.

9. Go to a bright star with the scope still powered off.

10. Verify the finder scope is aligned with the eyepiece, i.e., pointing at the same place. This will be essential later!
11. With a balanced telescope and an aligned finderscope, move the telescope back to the approximate location where you found it. Leave the motors unlocked (i.e. loose).
12. Turn on the telescope. Tell it to go to a bright star that you are aware of.
13. Let the motors go where they think it is located.
14. Once the drive settles, move the telescope to that location manually. Manually align the eyepiece to point at that star. Do NOT use the hand-paddle. If you use the hand-paddle you are moving where the telescope thinks it is. We want to move to that star where the drive thinks it is pointing to regain our alignment and not move the drive. This is an important point.
15. Lock the motors, and tell it to go to another nearby star. It should move there or else you wrapped the RA/DEC too many times and it is at a hard stop. To fix that, unwrap the motion.
16. When you have the star centered (it better be the right star), then press and hold the ENTER button on the hand-paddle until it beeps and request you to press ENTER again. Now, you are re-aligned.
17. Test this by going back to the first star. It better be aligned in the eyepiece or something wrong happened. If not, then you will likely need to redo the polar alignment procedure or Lab 1. But that is very unlikely. First, try to start alignment at Step #24 in Chapter 2. If that does not work, then you likely have to redo the fulll alignments-- again very unlikely.
18. Assuming everything is okay. Go to a very bright star and prepare for the CCD camera installation. Press and hold the ENTER button on the hand-paddle until it beeps and request you to press ENTER again. You are perfectly aligned with the star. We are about to remove the eyepiece and replace it with the camera, you better make sure your finderscope is aligned or at least where the star has to go back to once you no longer have an eyepiece.

19. Unlock the RA and Dec.
20. Replace the eyepiece with the optical splitter.
21. Attach the webcam to the optical splitter. Now both the CCD camera and the webcam are attached to the splitter.
22. Since you removed the eyepiece, you need to re-balance the telescope.
    a. Unlock the RA and DEC locks.
    b. Then, point the telescope straight up (i.e. vertical) with the mirror and equipment at the bottom (see Figure 1).
    c. You want to balance it so that it stays in this position. You will do this by screwing on/off the weights pointed at by the arrows in Figure 1.
    d. Holding the telescope straight up, see what way the telescope wants to move and counteract with the counterweights.
    e. For example, if the telescope moves to the left in Figure 1, then first screw the left weight toward the telescope. When, screwed all the way in, screw out the weight on the right side until the telescope is balanced, i.e. when you let go of it, it stays pointing up.
    f. Next, move the telescope so that it is pointing horizontal (Figure 2).
    g. Now, to balance in this direction, we need to move the entire weight assembly left or right to balance. Do not screw/unscrew the weight up or down since that will affect the balance of the vertical direction.
    h. Holding the telescope carefully in the horizontal direction, see which way the telescope moves.
    i. Unscrew (carefully) the weight assembly that moves left/right (horizontally) along the telescope tube. You can move either one, but it is best to move them together.
    j. For example, if the telescope moves mirror down (counter clockwise), then you will need to shift the two weight assemblies to the right to counter.

k. Once you have the vertical and horizontal balanced, you should be able to move the telescope arbitrarily and when you let go, it should not move too much. If it moves fast, then you did not balance the telescope.

l. Remember the better balanced, the better the telescope will track.

23. Use your finderscope to move the telescope back to the bright star that your drive thinks it is still tracking. Lock the RA/DEC.
24. Run the IC software for the webcam. Now both cameras have software running.
25. Focus the webcam using the telescope focus. Likely you don't want it perfectly focused for the spectrometer, so don't worry about the fine focuser.
26. Using the webcam bootstrap your way to your target. This will be hard as we are splitting the light, the secondary image is weak.
27. Align source on webcam and integrate the SBIG camera to reach the signal to noise you need.
28. Note that depending on your science goals, you may also need to calibrate the amplitude of the spectrometer. Try using a standard star.

Software Use:

1. We do not yet have a solid software plan for these spectrometers. As long as you save the observations as fit files, then you can use whatever software to reduce it, from python, IDL, IRAF, or whatever.
2. The main issues will be to extract the spectra from the CCD image: choose the pixels you want to average, straighten the spectra, etc.
3. A free software package to extract data is visualspec (recommended by Nick Glumac, but I have never tried it. http://www.astrosurf.com/vdesnoux/index.html), but it assumes you will give it a straight spectrum already. On the other hand, it has a lot of nice tools and features with included spectral line library, which can be useful for identifying lines.

Notes:

To gain experience with the device and the software, I recommend you start out measuring some bright stars. With the stars you will find that red stars, such as Betelgeuse, Arcturus, and Antares have copious spectral lines. Easily identified lines are the magnesium triplet at 5167.328, 5172.698, and 5183.619 A, and the sodium doublet at 5889.973 and 5895.940 A. Bright blue stars, such as Sirius, Vega and such have much less distinct lines, but have broad absorption features around H-beta (4861.342 A). Note that the breadth of these features is different between stars of different temperatures. Stars with hotter coronas have broader features (Doppler broadening). With nebular data, you should have no problem finding H-beta and atomic oxygen (5007 A) lines. Faint diffuse objects are easy if the spectrum is composed of emission lines. Note that these spectrometers can not image H-alpha (6562.808 A) or H-gamma (4340.475 A)