Department of Physics and Astronomy
University of Iowa
29:137 Astronomical Laboratory
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Lab 4: Stellar Spectroscopy

1 Introduction

Throughout your astronomy education, you have read about stellar spectra. Now is your chance to actually take some and compare them with the spectra presented in textbooks. We will mount the DSS-7 spectrograph on a Celestron 8 and take spectra of a few bright stars.

1.1 Reading Material

Once again, the manual for the DSS-7 spectrograph (on the course web page under "Textbooks") will be indispensible for this project. Among other things, it describes how to get a star on the slit so we can do spectroscopy. Once the data are taken, you will need to refer to your introductory astronomy book for information on stellar spectral classification.

2 Equipment to be used

We have equipment for one setup of telescope and functioning spectrograph. Working groups will have to take their turn with the equipment. Assume the wavelength calibration you determined in the laboratory is valid, although it may well have shifted as the camera and spectrograph have been disassembled and reassembled. We will check it during the nighttime observing session by taking spectra of streetlights.

The following pieces of equipment will be used in this lab.

- A "nosepiece" that connects the DSS-7 spectrograph to an adapter ring which fits a Celestron 8 telescope. The nosepiece screws into the slit aperture of the DSS-7.
- The ST-402XME CCD camera

- Power unit and USB cable for the ST-402XME
- The DSS-7 Deep Space Spectrograph
- A 7 inch phoneline connecting the spectrograph and the camera
- Adapter ring to connect the DSS-7 and ST-402XME
- A set of Allen wrenches, including little ones
- A laptop computer which has the program CCDOPS installed, and had drivers activated. This computer will control the spectrograph and take data.

3 System Setup

The spectrograph was assembled in the previous class period. Assume that this was done right and that the wavelength calibration is still valid. Carry all the equipment to the roof, and set up the Celestron 8 telescopes. This should be done while there is still daylight. The whole system should be assembled and turned on while there is still light to work by. We can then wait until it gets dark to take spectra.

Follow these steps.

1. Screw the nosepiece into the DSS-7, then connect the nosepiece to the adapter ring for the Celestron 8. Attach the adapter ring to the C-8. There may be real problems with the weight distribution on the Celestron 8. The combined camera and spectrograph are sufficiently heavy to possibly cause problems in pointing and tracking. The situation was tolerable the last time we had this class, but there is the potential for problems.
2. When installing the spectrograph, try and place it so you have free access to the finder telescope and the focus knob. Both will be necessary.
3. Connect the phone line between the DSS-7 and ST-402XME, and turn on the DSS-7 with its own switch.
4. Connect the USB cable from the ST-402XME to the control computer.

5. Connect the power unit for the ST-402XME.

6. Bring up CCDOPS and establish a link between the computer and the spectrograph. Listen for the contented clicking noises of the ST-402XME.

4 Putting the Star on the Slit and Taking Spectra

We will start by practicing with Altair (Alpha Aquilae). Taking stellar spectra consists of closely spaced operations of manoevering the star onto the slit, then quickly taking a spectra ("Grab Spectrum") before the star drifts out of the slit. This will probably be a difficult and exasperating operation in view of the coarse position controls on the Celestron 8 telescopes. Be prepared to take a lot of time doing this. Be patient. Curses, blood-curdling oaths, and weeping outbursts of self-pity will not be tolerated in the laboratory. Follow this procedure.

1. Go to the section of the DSS-7 manual entitled "Operation at the Telescope". Follow the instructions, as summarized below.

2. A crucial task is to place a marker in the field of view that indicates the slit location. This will permit you to guide the star onto the slit. First, be sure the box "DSS-7 Enabled" is checked in the DSS-7 menu box. Then choose VIEW SLIT, then click POSITION MARKER. This will place a white rectangle on the screen. Change the size and reposition it so it fits right over the narrowest slit.

3. You are now ready to position your star on the slit, in preparation for measuring its spectrum. Click on the DSS-7 dialog box, and select "POSITION MODE". Choose a short integration time and take an image. As described in the manual, this is like an image frame, except for the little white box which indicates the position of the slit. While observing the image of the star, move the RA and DEC controls to get the star onto the white box[1].

[1] Curses, blood-curdling oaths, and weeping outbursts of self-pity will not be tolerated in the laboratory.

4. When you have the star on the slit, bring up the dialog box, choose "GRAB SPECTRA", and take a spectrum. Start with an integration time of 10 seconds. Check the resultant spectrum to see if it is usable (i.e. not saturated, but with an adequate signal-to-noise ratio). Take a number of spectra with different exposure times. If the ST-402XME is satisfactorily aligned with the DSS-7 so that the spectra are parallel to the horizontal axis, you could turn on the "vertical binning" at 4 pixels to increase the signal-to-noise ratio.

5. When saving your data file, you should also save a copy of the spectrum that is "cropped". That makes it look like the spectra in your physics and astronomy textbooks, and makes the spectra easier to analyse. We cropped our spectra in the lab exercise, but here are the details again. There is a utility in CCDOPS that cuts out a 20 pixel-high ribbon that can be read by the analysis program DSS7 (referred to as SCP in the manual). In CCDOPS, go to the UTILITY menu, the select CROP, then select SPECTROSCOPY. The program will pop a wide, white band on your set of spectra. Position it so it fits right on the spectrum you want to save (usually the one with the narrowest slit, and thus the highest spectral resolution). When you have positioned the CROP mask, go back to the UTILITY menu, select CROP, and under the choices, pick CROP IMAGE. Pick a name for the file that identifies it as a cropped spectrum, then save to your folder of spectra for the night.

6. Save your spectra to a folder for later processing. Choose file names that tell you what star and exposure time was used. If further notes are necessary, one member of the Working Team can act as scribe, and share notes with other Team members later.

5 Observations

If the observations work properly, take spectra of the following stars. The instructor may alter the selection of stars, depending on sky conditions, time of night, and degree to which the equipment is functioning.

1. Altair (Alpha Aquilae)

2. Arcturus (Alpha Bootes). This is the bright star in the western sky.

3. Vega (Alpha Lyrae)

4. η Cassiopeiae (Eta Cassiopeiae). This is a G3V star at a distance of 5.94 parsecs. As you will recognize from its spectral type, it is nearly the same type of star as the Sun. It is easy to find in the sky, but it is several magnitudes fainter than the other stars we have observed, so a longer integration time will be necessary.

5. The final measurement is taking of a calibration spectrum, so we can check the wavelength scale for these observations. This is an important step, since the wavelength calibration has probably changed due to remounting the spectrograph to the camera. Pick a street light for observations. Be sure and choose a mercury or sodium vapor light rather than an incandescent one. The lights that appear bluish-green are mercury, and those that are yellow are sodium. Pick a a sodium light that has a purer yellow light, rather than the pale light. The former class are low pressure sodium lights, and they have a less pressure-broadened spectrum. Save the calibration spectra files in both fits and cropped format.

6 Analysis and Results

Analysis of the spectra is most straightforwardly done with Maxim DL. A slice can be made along the horizontal axis of the image corresponding to a spectrum, which gives a plot of intensity versus pixel position. This can be converted to wavelength with the calibration curve developed in Lab 3. there are five slits on the DSS-7, giving different spectral resolutions. Use the narrowest slit (best spectral resolution) if possible, but move up to coarser spectral resolution if you need more signal.

Working groups who are ambitious can try out the program RSPEC which is on the machines in room 707 for analysis and display of spectral data.

The following items should be addressed in your report for this project.

1. Make plots of the spectra for each of the stars for which you have results. Include these with the worksheets that you hand in.

2. For each star, measure the wavelength of the spectral maximum, and use Wien's Law to estimate the photospheric temperature of the star. In some cases, this may be difficult, or you may only be able to provide an upper limit or lower limit. Clearly indicate this. **Be organized!** Set up your measurements and data in clearly labeled tables.

3. Identify absorption (or emission) lines in the spectrum of each star. Using the measured wavelengths, identify these spectral lines. This will probably involve consulting an astronomy book which contains information on stellar spectra.

4. In your report, you should be alert to the presence of "telluric" lines, which rise in the spectrum of the Earth's atmosphere. Think about how you would recognize such lines. Comment on them. Say something intelligent.

5. On the basis of item # 2 and # 3, determine the spectral class of each star. Look up the "real" spectral class and note that down, too.

6. Estimate the wavelength resolution in your spectra. This may differ from one star to another.

7. Save your spectra files. After I have had a chance to examine them, I may propose additional analysis tasks that you could undertake in future lab sessions.