Lab 2: Data Reduction using Astropy

Due: Friday, November 22 by 5pm to Dickinson 104

The purpose of this lab is to introduce you to the data reduction functions within the python packages *astropy* and *ccdproc*. The packages are designed to allow for efficient and organized processing of large amounts of CCD data. They have a number of very nice features that allow the user to completely reduce a batch of data with a minimum of interaction, if so desired. Chapter 9 of *To Measure the Sky* very nicely lays out the ideas of data reduction, while the practicalities are covered in the Astropy CCD Data Reduction Guide (linked in #2 below). But such power and efficiency in the reductions doesn't come without a price. For the first time user, Astropy and CCDProc can seem rather complicated So, plan to spend plenty of time reading over the documentation before going on to the last stages of the lab.

As with previous work, you are strongly urged not to put off starting this lab until the last minute. The amount of document reading involved, plus mastering the setup, etc. is large. You're best advised to start early.

Your write-up should consist of a lab report, detailing the steps you took at each point. The layout of your report should follow the numbering scheme of the exercise itself. You don't need to repeat the instructions given at each step or describe each keystroke. Just describe what you did when you did it. Of course, you should answer all questions posed in each section. Turn in the report along with all figures, plots, and tables requested.

Preparatory Reading

1. Read through the documentation on the python ccdproc package (https://ccdproc.readthedocs.io/en/latest/index.html**)**. You don't need to understand every detail here; the main goal is to familiarize you with the package and what it's capable of doing. What is an ImageFileCollection? How is it used to manage data while you're reducing data? What is the ccdproc procedure used for bias subtraction? Dark subtraction? Flat field correction?

2. Read through the Astropy CCD Data Reduction Guide (https://www.astropy.org/ccd-reduction-and-photometry-guide/). This is the primary source that was used in constructing the python notebook that will be used to reduce the data in this lab. You should read through the entire guide, but don't get bogged down in details of all parts. Do carefully read all of Section 1 and the introduction to sections 2 through 5.

Using Astropy and ccdproc on Real Data

3. The following part of the lab should be done only **after** reading all the documents above. Use the instructions below to reduce a set of data taken with a CCD on a "Telescope 32" from the iTelescope network. You can read about this telescope here:

   https://support.itelescope.net/support/solutions/articles/231919-telescope-32

   How big is this telescope? What kind of sensor does the camera use? What information can you find out about that sensor online? What are the relevant specs of the sensor like Quantum Efficiency, Read noise, dark level, etc.?

   The goal is to carry out the preliminary reductions on a set of images of the galaxy NGC 55. This means correcting for the bias level and flat fielding. Based on what you read above about the CCD, why did you not correct for the dark current?

4. Download the ipython notebook file from the link on the course webpage. This is a small (text) file that contains all of the python code you'll need for this lab.

5. You have two options for where you can reduce the data.

   a. The default option for most students is probably to use a python setup that I have provided for you. This is on the computer named speedy. Its url is http://speedy.bennington.edu. You should each have a login the same as your Bennington user name. The password you set when you first login will become your password. You can upload the .ipynb file that you downloaded in step #4 by dragging the file into the file browser in the left part of your window.

   b. Your second option is to set it up on your own computer. This is good practice if you want to be able to easily reduce data in the future, but will also provide additional complexity that you may not wish to deal with.

6. In addition to the data reduction you will be doing on speedy, you will also need to *look* at the images that you are analyzing. For this, you will use the tool ds9. It is available on the computers in the physics lab, but is also (relatively) easy to install on your own computer: https://sites.google.com/cfa.harvard.edu/saoimageds9

7. The data you will use for this lab is available in two places. The first is on the shared NAS ("Network Attached Storage") device called "scivault." You can find instructions for connecting to scivault in Appendix A. From there, you should find a directory called "mot", which contains the data for this lab. In addition to the data on scivault, it is also available on speedy. This means that you do **not** need to upload your own set of raw data to speedy.

8. Download **one** example of **each** of the data types (flat, bias, and object) to your own computer from the scivault archive. Open each image in ds9 and examine the header of the file (from within ds9, go to the "File" menu and select "Display Header…"). What information is included

in the header? How are the headers the same? How are they different? Include a print-out of **one** of the headers with your lab write-up.

9. Now, for each image, examine its appearance in ds9. You can change the "stretch" of the image by opening it in ds9, holding the right mouse button, and dragging the mouse around the ds9 window. Change the "stretch" with the mouse until you can see useful information in the image. Additionally, click on the "scale" button and select "log" scale ("linear" scale should be selected by default). Now change the stretch again by right-click-dragging within the ds9 window. How does "log" scale look different than "linear" scale? Include a hard copy of **one** of **each** of the file types (bias, flat, and object) in your write-up.

10. Next, run through the python code in the Jupyter notebook that has been provided to you. To run each block of code, simply click on it, hold down the "Shift" key, and press "Enter." *Take careful notes of what is done at each step and make sure to answer any questions provided within that notebook.*

11. After you have finished reducing the data, download the reduced, combined galaxy images. If you're doing this on speedy, go to the Jupyter notebook window, right-click on the reduced science files. If you've used the default names in the code, they will have names like "combined_science_filter_Blue.fit".

12. Open the fully reduced images in ds9. Examine their headers. How do the headers for the reduced images differ from the headers of the raw science images? For the hard copy of the science image that you created in Step #9, create a hard copy of the reduced image. How do the images themselves look different?

Appendix A: Using the Science File Server

Basic Information

Address: smb://scivault.bennington.edu

Note that you will only be able to access the file server from an **on-campus connection** – either a wired connection or through the *Bennington Community* wireless network. It ***will not work*** from off-campus or from the *Bennington Public* wireless network.

From a Mac

1. Click on an empty part of the Desktop to ensure you have access to the finder menu at the top of your screen.
2. Under the **Go** menu at the top of the screen, click on *Connect to Server…*
3. In the window that pops up, type the address of the file server. *Note: Most times, it is sufficient to simply type **scivault**, but if that doesn't work, try typing the full address: **smb://scivault.bennington.edu***
4. The first time you connect, a window will pop up confirming that you want to connect to the server. Click *Connect*.
5. Make sure "Registered User" is selected in the login window, then enter your Bennington user name (usually *firstnamelastname*) and password. *Note that you should **not** add the "@bennington.edu" part onto your username.*
6. You will be presented with a pop-up window of folders on the data server. The "home" folder is your own private data storage folder on the server. The other folders are shared folders that you should have access to. Note that some folders may be *read-only* for you, such that you can access files in them, but can't change the files in them or write new files.
7. Once you connect, a window should pop up with the directory you just opened. This window will also be accessible from any Finder window (along the left hand side under the "Locations" subheading) or as a shared drive link on your desktop.
8. Once you are done using the file server, disconnect from it by clicking the "Eject" button in any Finder window or by dragging the shared drive link on your desktop to the garbage can.

From a Windows Computer

Click on the Start button and find the **Run** command.

1. Type **scivault.bennington.edu** (or just **scivault**).
2. Click the OK button.
3. Log in with your Bennington user name and password (if you didn't already log in with that login info when you started Windows).

   A window will open up with all the folders you have access to. The "home" folder is your own private data storage folder on the server. You have the ability to save files there, but no one else can see anything you put there. The other folders are shared folders that you should have access to. Note that some folders may be *read-only* for you, such that you can access files in them, but can't change the files in them or write new files.