Name:_____

Astronomical image display and color composites

1. First, we're going to generate some synthetic images to get a feel for how bias, dark, and flat images can improve a reduction. To do so, let's work through a few web tutorials. Go to https://colab.research.google.com/github/skgrunblatt/ccd-reduction-and-photometry-guide/blob/main/notebooks/01-03-Construction-of-an-artificial-but-realistic-image.ipynb This file should now open a Google Colab scripting terminal in your browser. By clicking on what looks like a 'Play' button (a black triangle pointed to the right) on the left side of each individual cell, you can run the individual cells of code in the Jupyter notebook file.

   a) Read through the notebook and run all of the cells in order. Take a screenshot (or otherwise save) the blank image, the read noise image, the bias image, the dark noise image, the sky background image, and the realistic image of stars with noise. Report the range in counts for each image here. (12 pts.)

   What's a typical count value for a random pixel in the image? Which limiting case of the signal-to-noise regime is this pixel in (object limited, background limited, or read noise limited)? How can you tell? What is the signal-to-noise value of this pixel? Repeat this procedure for a pixel at the center of the brightest star in this image and report your answers below (8 pts).

b) Now open https://colab.research.google.com/github/skgrunblatt/ccd-reduction-and-photometry-guide/blob/main/notebooks/01-04-Nonuniform-sensitivity.ipynb and similarly run all of the cells in order. Take a screenshot of the flat image, final image and final image with high sky background and report the range in counts here (6 pts.).

What is the name of the effect that is visible around the edges of the final image with high sky background, but not in the final image with a standard sky background (2 pts.)?

c) Finally, open https://colab.research.google.com/github/skgrunblatt/ccd-reduction-and-photometry-guide/blob/main/notebooks/01-05-Calibration-overview.ipynb and similarly run all of the cells in order. Take a screenshot of the uncalibrated and calibrated images, and report their count ranges here (4 pts.).

What is **one** number that you can change in this notebook file that will result in a clearer image from this example? Describe which value you changed, and how this changed the range of counts in the modified calibrated image, and the visibility of individual stars in the image if at all (6 pts.).

2. Next, we're going to display some real images that were taken here at UA using the 16-inch telescope.

   I have loaded some sample FITS files to the class folder on Blackboard Learn.

   a) First load m16ham3.fits in JS9 (js9.si.edu). This is a nebula. Notice how dark the image appears until you change the scale setting or switch to log mapping. Experiment with these setting and brightness/contrast until you get a display that you feel captures as much of the detail as possible without parts of the nebula either saturating to white or dropping into the dark background. Next, use the orientation buttons in the Zoom menu to match its orientation on the sky (north up, east to the left) - for this camera system, you need to invert Y. Normally you could check this by, for example, entering the ID M16 into wikisky.org to see how it should look, but this nebula is saturated in the photographs used for that site**. Print or email me your final image (PNG or JPG)** (4 pts.)**. What is another name for this astronomical object?** (2 pts.)

   b) Now you will use JS9 to make a color composite from 3 FITS images of the same star cluster or nebula using different filters. Create a color frame with Frame→New RGB (and keep that little floating RGB panel where you can find it). Anything you do in the main JS9 window will happen to whichever frame you select by its color in the floating panel. Load the three images of one of the objects: star cluster M3 (m3b,v,r.fits), cluster M13 (avgm13b,v,r.fits), elliptical galaxy M87, spiral galaxy NGC 2535, or planetary nebula NGC 2392 (likewise) as follows: B→B, V→G, R→R (V stands for "Visual" and is in the green region of the spectrum, about the average wavelength of human visual sensitivity, while "ha" stands for Hydrogen alpha, an energy level transition in atoms of Hydrogen which occurs in between the green and red wavelengths). **Make a color version of these data by changing the brightness, contrast, and intensity scales of each until you get a neutral typical star color and dark gray background, with a few stars distinctly reddish or bluish.** In making color images, you may need to select Align→WCS to get the three color images to line up properly. **Take a screenshot and print or email it to me** (6 pts.)**.**

   Extra credit (5 pts.): Label all screenshots accurately (e.g. 'bias_image.png', 'dark_image.png', etc.) and send them all to me via email in a self-contained, zipped folder labeled 'lastname_AY203_week6.zip'.