W4260: Problem Set #5

Due: Tuesday, March 10

To read the astronomical data files discussed in this problem set, you will need to find some way to read FITS files (FITS is the standard format for astronomical images). The recommended way to do this is to install `astropy`, a python package for astronomy which can be obtained from www.astropy.org. Note that if you used the Anaconda package, this should already be installed – you can test it with:

`from astropy.io import fits`.

Alternately you may install pyFITS directly, a python package for reading FITS files, from www.stsci.edu/resources/software_hardware/pyfits (see the download instructions).

Problem 1

Find two FITS images, one of an elliptical galaxy and one of a spiral galaxy.

One excellent source is from skyview (see skyview.gsfc.nasa.gov/cgi-bin/query.pl). For example, to get a FITS image of M87, go to this website, type `M87` into the *Coordinates or Source* parameter space, and then select `SDSSg` from the list of *Optical Surveys*. Then click submit request and you should get an image of M87 along with an option to download a FITS file. Note that you can change lots of options on this page – for example in *Common Options* you might want to increase the image size to 500 pixels, from the default of 300 pixels.

In addition to sky view, there is a list of astronomical image sources at the following site: tdc-www.harvard.edu/astro.image.html. A few particularly useful sites includes the archive of space telescope images at MAST archive.stsci.edu. Also good is the Aladin Sky Atlas (aladin.u-strasbg.fr).

Once you download the images (in FITS format), read them[1] and calculate the center of the image in two ways:

(1) Find the brightest pixel $S_{i,j}$,

(2) find the "center-of-luminosity" by calculating the brightness-weighted mean i and j indexes:

$$\bar{i} = \frac{\sum_{i,j} i S_{i,j}}{\sum_{i,j} S_{i,j}}$$

(and similarly for $\bar{j}$). Which way do you think works better, and why? You can use matplotlib's *imshow()* function to plot an image.

[1] Documentation for doing this with `astropy` is available at astropy.readthedocs.org/en/stable/io/fits/index.html.

Problem 2

For each of the images from problem 1, compute the cylindrically-averaged brightness profile (i.e. $\overline{S}(r)$ as a function of distance r from the center). Compare this against an exponential profile:

$$S(r) = S_0 \exp(-r/r_0),$$

which is, traditionally, the radial profiles used to model spiral galaxies. You will have to guess approximate values for S_0 and r_0, the two free parameters. Note that I'm not looking for precise fitting, just as try a few guesses and see if you can come up with anything close (hint: S_0 should be approximate $S(r = 0)$).

Problem 3

Extract a relatively small section (but at least 20x20 pixels) of the image near the edge, where the sky is mostly blank. Generate a histogram of the distribution of brightness values in this region, computing the mean and standard deviation of the distribution. Does the histogram look more like a Gaussian or a Poisson (plus constant) distribution? Again, a detailed comparison is required here – also, feel free to use numpy functions to help here.