Homework 2 - Areas on the Sphere

Don't forget to `svn up` *before you issue any other commands in SVN—this is to guard against you changing a document that someone else is working on in the same directory*[1].

Don't forget to `svn ci` *(with* `-m` *comments) frequently as you work. This allows others to see how your work progressed, and it automatically backs your work up as you produce it so that you're less likely to lose any of your work and/or so that you can revert to earlier versions of your work.*

Remember to comment your code carefully with your initials before every comment (as in `;ADM I just wrote a Python comment`*). Remember to provide an informative header for* **every** *function that you write. Also provide a README file to inform people how to run your code.*

1. Astronomers often survey "square" fields in the sky that have corners (vertices) in Right Ascension and declination of $(\alpha_{\rm min}, \delta_{\rm min})$, $(\alpha_{\rm max}, \delta_{\rm min})$, $(\alpha_{\rm max}, \delta_{\rm max})$, $(\alpha_{\rm min}, \delta_{\rm max})$. Write a function to determine the area of such a general field in square degrees. Plot 4 areas that are progressively higher in declination for the same $\alpha_{\rm min}$ and $\alpha_{\rm max}$ and label the regions with their areas. Confirm that your function returns the correct area for a spherical cap as well as for a "square" field by inputting $(\alpha_{\rm min}, \alpha_{\rm max}, \delta_{\rm min}, \delta_{\rm max}) = (0°, 360°, 0°, 90°)$.

2. Write a function to randomly populate a "square" field drawn on the surface of the sphere. The procedure should take $\alpha_{\rm min}$, $\alpha_{\rm max}$, $\delta_{\rm min}$, $\delta_{\rm max}$ and return a set of (α, δ) coordinates that correctly populate that "square" field randomly in area. Use your function from the first item, above, to confirm that the areas you are populating contain the correct number of random points relative to populating the entire sphere (*hint: remember that the area of the entire sphere is 4*np.pi*180.*180./np.pi/np.pi and refer to my equations for randomly populating the sphere from lectures*).

In my `week2` directory in SVN, there is a list of quasars called *HW1quasarfile.dat*[2]. This is a list of 1,111 $g = 18$ ("18th magnitude") quasars that I've drawn from the Sloan Digital Sky Survey. Provided in the file are the coordinates of the quasars in base-60 ($hms.ss \circ \prime \prime\prime$) format.

3. Write a procedure that determines the pixel number at `Nside=4`, `Nside=8` and `Nside=16` of the HEALpix (ring) hierarchy for these quasars[3]. Create a *recarray* with the tags `ra`, `dec`, and `pixnum` to store this information, where `pixnum` is a 3-array. Write your structure out to a *fits* file.

4. Write a procedure that reads in the recarray from the *fits* file created in the previous step, plots the location of all the quasars in (α, δ), and over plots those quasars that lie in the 5 most over-dense[4] pixels at `Nside=4` of the HEALpix (ring) hierarchy in a different color and using a different symbol.

[1]this shouldn't be a big deal unless we're working collaboratively, but you should get into the habit *now*

[2]In general, it is **not** a good idea to store large data files in SVN as it slows down updates for all users, but this particular data file is very small

[3]At `Nside=4` there are 192 total pixels in the sky and each pixel has an area of 214.86 $\rm deg^2$, at `Nside=8` there are 768 total pixels in the sky and each pixel has an area of 53.71 $\rm deg^2$ and at `Nside=16` there are 3072 total pixels in the sky and each pixel has an area of 13.43 $\rm deg^2$

[4]i.e. the 5 pixels that have the largest number of quasars per square degree