ASTR 257 - Homework 2

Due: April 25

1. Which instrument would you use for the following investigations? Instrument choices are: HST WFC3, HST COS, Keck DEIMOS, Keck NIRSPEC, Keck NIRC2, MegaCam on CFHT (for Keck you can consider using AO where appropriate).

a. searching for high-redshift galaxies in a deep observation
b. spectroscopy of a binary black hole candidate with a separation of 0.2"
c. measuring the large-scale distribution of galaxies in the universe
d. measuring OVI absorption (1032, 1038 $\AA$ doublet) in quasar sightlines

2. JWST will have a 6.5-m mirror. If your detector has 10 μm pixels and you want your pixel scale to be equal to the diffraction limit at 6000 $\AA$, what focal ratio do you need?

3. Download the files http://scipp.ucsc.edu/~tesla/ay257_hw2.tar and http://scipp.ucsc.edu/~tesla/ay257_hw2_extras.tar; unpack them (tar xvf ay257_hw2.tar). In the first .tar you will find a number of fits files. Examine the fits files. For each file identify what type of data it is, and describe what it would be used for.

4. Start CIAO and display the image file identified above in ds9. Find a good color scaling (as a starting point you can try color grey, scale minmax and log). This image has already been reduced and calibrated. There is a fairly isolated galaxy near RA=12:30:32, Dec =12:29:24.6; estimate its magnitude through aperture photometry.

a. First find the center of the galaxy and estimate where the galaxy emission goes below the background level. You can use fv to plot the light profile. You can also use ds9. In ds9, you can define regions of varying shapes using the region menu. To find the centroid of a region go to the "Analysis" menu, go to "CIAO", then "Statistics", and finally "centroid"; to plot a radial histogram first define a set of annuli and then under "Analysis", "CIAO", select "Histograms" and "Radial Profile".

b. In ds9, define a circular aperture for the galaxy and an annulus for the background. Are there any visible sources in your background region? If so, you will want to subtract their contribution. You can find the sum of all pixels in a region using the following CIAO command:

dmstat "image.fits[(#1,#2)=circle(xcenter,ycenter,radius)]" centroid=no

Here the center and radius are in image coordinates. In the output, 'sum' tells you the total counts in the region and 'good' the number of pixels. Find the counts in the background using the same command with an annulus region: annulus(xcenter, ycenter, r1, r2); you can exclude contaminating sources using annulus(xcenter, ycenter, r1, r2)-circle(xsource, ysource,

rsource). Make sure to normalize the background to the proper area to account for the amount of background in the source region. (See the CIAO help pages for more info.)

c. Convert counts to magnitude. The image is in nanomaggies (an SDSS unit); 1 nanomaggie has a magnitude of 22.5 in any band or a flux density of 3.631×10^{-6} Jansky

d. Print a copy of the image showing the regions you used and list the region centers and radii. In addition, note any instrumental/observational features you see in the image. What we have done provides a rough estimate of the galaxy's magnitude. List a few ways you might improve this estimate.

5. Run sextractor on the image using the parameter files provided in ay257_hw2_extras.tar (named config.sex and default.param). You will need to edit config.sex to use the path names for your sextractor distribution. You should get two output files, output_cat.cat which has the object catalog and check.fits which shows the sources found and their apertures.

a. The column MAG_AUTO lists the estimated magnitude of each detected source (Note: this is only one of several methods that one can use in sextractor to estimate magnitude). What is the magnitude listed for the galaxy in question 2?

b. Make a plot of source magnitude (y-axis) versus Flux_Radius (x-axis). In this case, Flux_Radius lists the estimated half-light radius (radius enclosing half of the light). Stars are point sources and should all have a similar small size (hint: except stars that are saturated which appear to be larger). Print out your plot and mark regions containing stars, saturated stars, and galaxies.

c. Using your plot derive a method for selecting galaxies based on magnitude and radius. Sextractor also outputs a column CLASS_STAR which gives an estimate of how star-like an object is based on a neural network output table, which you can use as a check of your criteria. Did your cuts select the galaxy from question 2?

d. What is the seeing for this image? You can estimate this using a few non-saturated stars and the FWHM output by sextractor. (You will need to figure out the pixel scale.)

6. Display the spectral file in ds9 and find a good color scaling (try color grey, scale zscale and log). This is a spectrum of a galaxy which has been reduced and wavelength calibrated (see the linear/WCS value).

a. Print a copy of the spectrum and label the galaxy continuum emission and examples of night sky lines. Note also any instrumental/observational features you see in the spectrum and speculate on their cause.

b. Using the line list included in the .tar file identify several emission and absorption features and label these on your print out. What is the redshift of this galaxy? Based on the spectrum what type of galaxy might this be?