ASTR 257 - Homework 3

For April 30: Bring to class two proposal ideas and be prepared to discuss them. Proposals may use either one of the imagers on Hubble (ACS or WFC3) or the Chandra CCD detectors (ACIS). Proposals may be for new observations or use archival data.

Due: May 2

1. Based on our class discussion, write-up a few sentence description of at least one of your potential proposal topics. In addition to general science topic, you should consider target choice, what instrument you might use, and whether there are existing observations.

2. Consider M31 (the Andromeda Galaxy). Take its B-band magnitude to be 3.4 and its distance to be 0.8 Mpc.

a. Using the central wavelength of the B-band filter (4400 Å), what wavelength does this correspond to at a redshift of 7? Which filter for NIRCam on JWST best matches this wavelength? (See: http://www.stsci.edu/jwst/instruments/nircam/instrumentdesign/filters and choose a wide-band filter)

b. Using the Cosmology Calculator at http://www.astro.ucla.edu/ wright/CosmoCalc.html, find the luminosity distance to a redshift of 7 for a flat universe with the default cosmology values. Assuming that the width and response curves of the B-band filter and the filter you chose in part (a) are the same (a big assumption!), what would be the JWST observed magnitude of a galaxy like M31 at z=7?

c. Could JWST detect M31 at a redshift of 7 for a reasonable observing time (the Hubble Ultra-Deep Field has a maximum exposure of about 4 days)? If the answer is no, what magnitude could you detect? For simplicity, you can assume the galaxy is a point source. Here you can use the exposure time calculator provided by the JWST team at http://jwstetc.stsci.edu/etc/input/nircam/imaging/.

Use the help files to make reasonable choices for the input parameters, and print out a sample of the output and what you input. Hint: Use a galaxy template and remember which magnitude system is appropriate for Johnson B-band.

d. Given the central wavelength of the reddest wide-band filter available for WFC3 on HST what photometric band (z=0 equivalent) would you be sensitive to at z=7? See http://www.stsci.edu/hst/wfc3/ins_performance/filters/ for WFC3 filters.

e. Given your answers to the previous questions what type of high-redshift galaxies can be studied with JWST and HST?

Some preparatory work for problem 3: Take the catalog you created from the SDSS image of M87 in HW2 and create a list of galaxies by making cuts on magnitude and radius. To limit the source list you can make a cut for fairly bright galaxies ($m_r < 17$). Since we

will only consider bright galaxies you can also be pretty strict in only considering sources that are significantly larger than the PSF (say a half-light radius greater than 5 pixels).

3. From the class website download the file http://scipp.ucsc.edu/~tesla/virgo_chandra.tar.gz. You will find two images: m87_0.5-2_long_crop.fits and m87_2-10_long_crop.fits which are unbinned ACIS-I images of the Virgo cluster in the 0.5-2 keV and 2-10 keV bands. These images were created from the level 2 event file using dmcopy to filter on the energy range and to slightly crop the image.

a. Take a look at the X-ray emission from M87 (and the Virgo cluster) in the images (In ds9, try log scaling and color=b). What astrophysical and instrumental features do you see?

b. Run the CIAO tool wavdetect on m87_0.5-2_long_crop.fits using the command:

wavdetect m87_0.5-2_long_crop.fits scales="2 4 8 16 32" regfile=m87_xsources.reg sigthresh=3e-7 outfile=m87_xsources.fits scellfile=m87_xsources_cell.fits imagefile=m87_xsources_img.fits defnbkgfile=m87_xsources_bkgd.fits

wavdetect is a wavelet source detection algorithm. It will create a number of files. In particular, m87_xsources.reg is a ds9 region file showing the detected sources, and m87_xsources.fits is fits table listing properties of the sources. The parameter "scales" gives a list of the size scale in pixels of sources for which the tool searches. Primarily this will detect point sources and mildly extended sources (i.e. it will not find the Virgo cluster). If you are interested understanding the other parameters, you can see the CIAO ahelp pages.

c. Which galaxies are detected in X-rays (you can use ds9 to overlay source regions or contours on the optical image)? Using your SDSS catalog, make a list of the optical sources which fall within the X-ray image (including position and magnitude) and note which ones are also X-ray sources. Of those not detected, are there any that are clearly not galaxies (this will tell you something about the purity of your optical catalog)?

d. For those galaxies which are detected in X-rays, are these sources point-like or extended? Look at the size of the sources as found by wavdetect compared to the Chandra PSF for the source position. You can use the distance from the center of M87 as an estimate of the off-axis source distance. The website http://cxc.harvard.edu/cgi-bin/prop_viewer/build_viewer.cgi?psf will plot the PSF as a function of off-axis distance; choose an energy of 1.5 keV.

e. Now run wavdetect on the 2-10 keV image (make sure to rename your output files). Which galaxies are detected in the hard band and are they extended?

f. For the X-ray detected galaxies, given the source size and which bands it is detected in, what source or sources may be contributing to the X-ray emission?