ASTR 5460, Fall 2004: Extragalactic Astronomy

Homework 2: ***due in class Wed., Sep. 22, 2004***

Instructions: You may work together and discuss answers, but please write up your own solutions and do not simply delegate parts of problems. You should feel free to use any resources you need to (e.g., other people, the internet, computer programs, journal articles, etc., citing as appropriate). The important thing is to learn the material involved with each problem. Some of the problems are intentionally open-ended with minimal direction to encourage you to explore and develop new resources/skills. I am always available to you for additional guidance as needed. Please make efforts to be complete and professional in your write-ups; not only does this make my grading easier, it is what is expected of scientists in the "real" world. As usual, use of LaTeX is encouraged in support of this (and will be required for the end-of-term proposals).

1. Please estimate the mass of the spiral galaxy UGC 1013. Cite sources of information, assumptions made, etc. NASA's ADS and NASA's NED are good starting places. This problem is intended to sharpen your literature skills and scientific judgment as much as anything else.

2. The Coma cluster is a rich, regular cluster. Coma has an approximate radial size of 3 Mpc, and a line of sight velocity dispersion of about 980 km/s. What is a typical crossing time for Coma? What is the mass of Coma? If the visual luminosity of Coma is 5 x 10^{12} $L_\odot$, what is the mass-to-light ratio of Coma? Discuss this answer given the fact that typical elliptical galaxies appear to have mass-to-light ratios of $\sim$10 $M_\odot/L_\odot$.

3. Assume that the hot intercluster gas in Coma is isothermal at a temperature of about 88 million K, and of uniform density. The X-ray luminosity is about 5 x 10^{44} ergs/s. Calculate the average electron density in Coma's hot gas, and estimate the total mass of hot gas. Compare this to the numbers from problem 2. Explain any discrepancies and make an argument about what these two techniques tell us about the masses of galaxy clusters. Your discussion will be well informed by reading the relatively short paper by Henriksen & Mushotzky (1986, ApJ, 302, 287).

4. Galaxy observing preparation. Each of you should find galaxies to observe at WIRO Sep. 24-25, the planned dates for our observing run. Please find 2 elliptical galaxies, 2 lenticular galaxies, 4 spiral galaxies, and 1 irregular/interacting galaxy. Ideally these should span a range in properties (e.g., both edge-on and face-on spirals, both barred and unbarred spirals, both start of the night and end of the night targets). The ideal size for the galaxies is approximately 5-10 arcminutes across. Galaxies should be brighter than 15th magnitude. Construct a table listing the galaxies and their general properties. Print "finding charts" for each galaxy – hardcopy images of each galaxy (easy from NED). Finally, use an internet search engine to locate the program SKYCALC online (it can be downloaded or run from some websites). Use SKYCALC to produce an observing "almanac" for WIRO for Sep. 24th. Use SKYCALC to produce plots or tables of airmass vs. time for each target. Hints: Galaxies with large NGC numbers will have large right ascensions (RAs). SKYCALC can suggest RA ranges for the targets. NED is your friend!

5. Galaxy spectra and stellar synthesis population models. Please again use the Bruzual and Charlot code which can be found in my directory at /d/users/mbrother/bc01. I've placed fits spectra of several galaxies (from Storchi-Bergman, Calzetti, and Kinney) in the HW2 area of the course webpage. Use NED to look up the image/classification of each, the Galactic reddening (use the Schlegel et al. numbers on NED), and the redshift. Deredden the spectra. Measure and confirm the redshifts. Deredshift the spectra to the rest-frame. Try to reproduce the spectra as best you can using instantaneous starburst models of different ages, or simple linear combinations of different aged-starbursts (e.g., an old population, a younger population, and a very young population). Be sure to discuss your criteria for deciding which spectral models are better than others, and why. Illustrate your models with figures. Feel free to automate this any way you want to, but the goal here is for you to look at and learn what galaxy spectra look like and how they are related to different stellar populations. In what ways are the bc01 models successful in reproducing the spectra? In what ways are they not? How could you improve on these efforts?

I would use IRAF to accomplish these tasks, and can show you how, but other methods (e.g., IDL) are fine, too. You may find it useful to visit http://iraf.noao.edu which documents iraf and has tutorials. You will need to use several IRAF tasks in the onedspec package, particularly SPLOT for measuring redshifts, DEREDDEN for dereddening spectra, and DOPCOR for correcting for redshift. LISTPIX with coordinates set to "world" can be used to making data files to plot with sm. SINTERP can be used to turn bc01 text files into IRAF spectra. Remember, IRAF has help files! In your write-up, be complete and specific about what you did, how you did it, and in what order. Another person should be able to duplicate what you did from reading your write-up.