ASTR 5460, Fall 2004: Extragalactic Astronomy

due in class Wed., Sep. 8, 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.). The important thing is to learn the material involved with each problem.

1. On the course webpage, under "Homework 1," you will find gif or jpeg images of about 15 galaxies. Please examine them closely and classify them using the De Vaucouleur's system as best you can. E.g., 15_22.gif is an image of NGC 1300, which is a SB(s)bc galaxy according to his system. [FYI, De Vaucouleur used to teach the galaxies course at Texas before I started there. He used to make his students classify several THOUSAND galaxies and no one passed until they did it to his satisfaction, and this often meant taking incompletes for several semesters!]

2. More on Gerard...Show that if the surface brightness of an elliptical galaxy follows De Vaucouleur's $r^{1/4}$ law given on page 11 of the textbook, then the average surface brightness over the area of a circular disk of radius r_e is given by:

$$< I >= 3.607 I_e$$

[Hint: you'll want to do some transformations and get to a definite integral that you will likely need to look up in a table.]

3. The Dave Allen memorial question. Part a. Assuming an initial mass function $dN/dM = CM^{-1.8}$, where C is a constant and M is the mass, what is the ratio of the number of stars formed in the mass range between 2 and 3 solar masses to those formed with masses between 10 and 11 solar masses? Part b. Given the mass-luminosity relationship for main sequence stars, $L = M^4$ in solar units, what is the expression for the number of main-sequence stars formed per unit luminosity, dN/dL? Part c. Calculate the ratio of the number of stars with luminosities between 2 and 3 solar luminosities to the number with luminosities between 10 and 11 solar luminosities. Part d. Compare your answers and explain your results in terms of the properties of main-sequence stars. Basically, how does the mass-to-light ratio change?

4. Use NED to find the redshifts, broad-band colors ($U - B$, $B - V$), angular sizes, classifications, Galactic reddening, and apparent magnitude of the six galaxies in Fig. 1.3 of your texbook. Tabulate these. Plot angular size (major axis) vs. redshift. Does this behave the way you expect? Compare the colors of the galaxies to the color-color diagram of Fig. 1.10. Do your colors agree with those of the diagram?

5. Stellar synthesis population models as described in the textbook are used to help understand galaxy evolution. I have such a code, by Bruzual and Charlot, installed in my directory at /d/users/mbrother/bc01. We'll start simple, but feel encouraged to play around with different aspects of the code and experiment with lots of things. At a minimum, run the code /d/users/mbrother/bc01/src/galaxevpl using the solar metallicity models with the Salpeter initial mass function (/d/users/mbrother/bc01/models/ssp_salp_z02.ised) to produce the spectra of stellar populations with ages from 0 to 15 Gyrs. Make one or more plots showing in detail how the spectra change with time in the UV-optical-near-IR range. Please comment and discuss these changes in terms of broad band colors (as in the text book) and in terms of other spectral features you might notice.

Please write this problem up using LaTeX and the aastex style, and embed tables/figures inside as needed. [You could also do this with the entire problem set if you wish – learning to use TeX to write the equations of problem 2 would be very educational.]

You might also wish to explore how the spectra change with metallicity and the initial mass function. Other executable codes are present in src in addition to galaxevpl that permit more complex stellar populations to be assembled (e.g., the results of constant star formation rather than simple instantaneous burst models produced by galaxevpl). The bc95.ps and bc96.ps files in the src directory provide additional documentation.