Astronomy 330 / Galaxies

Term Project
Due: Friday 10 December 2010

Build the spectrum of a disk galaxy like the Milky Way (MW), at various stages (t) in its lifetime, viewed externally from an edge-on perspective at various heights (z) above the disk mid-plane and radii (R) from the center.

Phase 0. Come up with a *realistic* schedule to conclude each of these milestones. Pace yourselves.

Phase I. This phase involves understanding components of a population synthesis model.

1. Identify your favorite globular cluster.
2. Pick 3-5 "template" stars (spectral types) that you will use to make an integrated spectrum of the cluster.
3. Find examples of these template stars (spectral libraries exist on the web).
4. Calculate the ratio with which you will need to combine your template stars in order to make the integrated spectrum.
5. Estimate how many supernovae went off in the cluster over its lifetime.

Phase II. A globular cluster is only a "simple" (single-aged) stellar population (SSP) observed at one moment in time, so there are relatively few stellar components. What we want to build here is the spectrum of a disk galaxy, like the Milky Way, at various stages in its lifetime and with on-going star-formation. For starters, let's work out the integrated spectrum as a function of time:

1. 11 Gyr ago the disk started forming stars with a Salpeter IMF. Star formation continued at a rate constant in time and radius in the disk.
2. Neglect the effects of gas, so you don't need to figure out extinction and the spectrum of ionized gas.
3. Determine what time-steps you want to simulate. Three to four time-steps should suffice.
4. For each time-step you simulate, again pick a number (5-7) template stars with which you will make your spectrum. If your group chooses, you can use more stars. Determine the ratio with which you should combine the template stars so simulate the integrated spectrum of the galaxy at each time.
5. Pick your time-steps wisely, and explain your reasoning. First think about the time-steps you will need to track one SSP. Then think about what happens as you keep adding younger SSPs as time moves forward. Remember, at each time, what we care about is the integral of the SSPs.
6. Keep things as simple as you can – there's another step coming. Think ahead.

You should all put together an optical spectrum (350 nm to 850 nm). The software we'll be dealing with is something called specview which is from the Space Telescope Science Institute (www.stsci.edu/resources/software_hardware/specview). Go to that web page to get an introduction, examples etc. The software has been installed on the departmental Linux machines. Each group will have at least one member with access to the 3rd floor computers (let me know if this isn't true), so there won't be any problems with getting on a computer. Feel free to download it onto your own computer if you want (its freeware). The spectra you end up using will very likely be in "FITS" format, which specview can handle. If you prefer to do this using some other software, feel free (just let me know what you use). For starters, you can find template spectra at http://vizier.u-strasbg.fr/viz-bin/Cat?J/PASP/110/863. You may find other useful stellar libraries as well.

Phase III. Now we get to the core part of the project. For each of the time-steps you chose in Part-II, here you will generate spectra for the integrated stellar population at 4 locations: 1 and 3 radial scale-lengths, and at 100 and 300 pc above the mid-plane for each of these radial locations. Here are the assumptions to make and the boundary-conditions to achieve:

1. The disk has (and has always had) an exponential *radial* light distribution of constant scale-length (h_R).
2. The size and rotation of the disk is like that of the MW.
3. The vertical structure is a superposition of exponential distributions of stars of varying scale heights (h_z) and velocity dispersions (σ_z), which vary as a function of age. At any given time the stars of a given age can be considered in equilibrium. All stars respond to the same disk potential at a given radius.
4. The vertical velocity dispersion and scale-height of stars start with typical values for the atomic and molecular gas out of which the stars are born. Assume the gas values are constant with radius and time.
5. The stars are heated over time such that σ_z *today* agrees with observations of the Solar Neighborhood.
6. The disk *today* has a vertical thickness that is *constant* with radius.

Remember to keep things as simple as you can, and build on what you have done in Part II. Extra credit: Expand our heating model to include a thick component realistic for the MW.

Phase IV. Now you have to compare your integrated spectrum to some reality. Go back to the sdss.org (http://cas.sdss.org/dr7/en/proj/advanced/galaxies/spectra.asps). Click on the spectra of the galaxies you classified in HW-1. Compare and contrast your spectrum with the observed spectra of real galaxies. Ignoring the emission lines, what are the major differences between your spectra and the spectra of real galaxies? How would you classify your spectra relative to a Hubble-like classification based on spectra (i.e., E,S0,Sa,Sb,Sc,Sd,Im)? What inferences can you make about distant galaxies given the the appearance of the MW as seen edge-on earlier in time?

Grading and What to Turn In.

Everyone in the group will get the same grade. You should turn in everything! I'll need to see spectra and a written document telling me what you did and why. For example, justify the template stars you picked and the ratios by which you combined them (i.e., your stellar-synthesis model). Describe the salient features of your spectra. What heating model did you adopt and how did you go from the heating model to altering the stellar-synthesis model? What are the salient physical properties of your galaxy disk? Please use Word or LaTex or something similar for the written part. Format it so that it looks like a scientific paper with an abstract, introduction, discussion, conclusion, and references.

Final Words

Pace yourselves (don't wake up on Nov 1 and realize you haven't started) and have fun!