AST 301, Spring 2009 (Scalo)
Review sheet for Exam 6

This exam covers Chapters 23, 24, and 25. As on previous exams, emphasis is on understanding the basic ideas and their implications and connections, not on memorization of details or on numerical values.

Julie (our TA) will have office hours Tuesday 2-4 (unless I send you an email note telling you differently--I have not checked with her on this yet). I will have office hours on Tuesday from 10 to 12. I'll have to send you email if there is some meeting that day that I have forgotten to put on my calendar.

If you want to meet at another time, let me know—late afternoon is a possibility. After class is fine on Monday, outside the classroom.

I will be available for phone consultation from 9am to 9pm Mon. and Tues., if I am home—otherwise, leave a message, feel free to call back, etc.; you won't be disturbing me because I'll just be reading or working. But please don't call after 9 pm.

I strongly recommend that you try all the Review and Discussion, and True-False/Multiple Choice questions at the end of each chapter; they are nearly all good ones, at the level that will be typical on the exam. In fact I will, as usual, take a few of the exam questions from the end-of-chapter and online questions. Of course, don't try the questions that are numerical problems, or questions that have to do with the sections you didn't read.

You will have to be responsible for reading the few parts of the textbook that I don't cover: I think that is mainly material on evolution of galaxies in 24.2.

As with the last exam, a good way to review is to try to "tell the story" Each time you use some new terminology, e.g. "rotation curves of galaxies," try to explain what you mean, as if you were explaining this to someone with no background. What is it, what does it tell you, what are its implications for understanding the universe?

Chapter 23: Omit: The historical discussion of "Discovery 23-1" and Sec. 23.7, The Galactic Center). DO read 23.6, The Mass of the Milky Way Galaxy.

The two most important things: 1. How you can get distances for distant objects using variable stars (get used to the idea of "standard candles", which is just another way of saying that you are getting the distance to something by knowing (somehow—that's the hard part) its luminosity; 2. How estimates of the mass of our Milky Way led to the realization that there is "dark matter." The most important technical idea is that the rotation velocities give you the mass—this is because, unlike a star where pressure balances gravity, in disk galaxies rotation balances gravity. So the rotation of a galaxy at a certain distance from the center is related to the total gravitating mass inside of this distance. This is the "rotation curve."

Much of Chapter 23 is concerned with how difficult it was to discover what kind of structure we live in (a galaxy, with a disk and a bulge and a halo). You should be able to explain how finding the distances to certain types of objects were the key to being able to get a picture of the galaxy we live in. You should know (roughly) the size of our galaxy (in parsecs), how far the Sun is from the Galactic Center, and the thickness of the galactic disk. Try to explain how the ages of the halo objects are known, and the ages of disk objects; how does this lead to a picture for how our Galaxy formed? Explain how the metal abundances in globular clusters are a crucial key.

Chapter 24: Try reading More Precisely 24-1, but I won't test you directly on that material. Omit sections 24.4 (Active Galactic Nuclei), and 24.5 (The Central Engine of an Active Galaxy).

For the Hubble sequence of galaxy types (ellipticals, spirals, irregulars), you should be able to name each basic class and describe some of its properties—they all follow from knowing the main thing that varies is when they have formed stars: all in the past. Of course you should know what they look like, and that some galaxies don't fit into any of these classes.

There is a very basic theme running through all the material in Chapters 23 and 24: A lot of it is about learning to get distances to more and more distant objects so that we can map the structure of our own Galaxy (chapter 23) and the large-scale structure of the universe (starting with 24 and continuing in 25). In our Galaxy the use of these "standard candles" allows us to see the disk-halo structure and the presence of spiral arms; RR Lyrae variables give us the globular clusters in the halo and the resulting information about the evolution of our galaxy, Cepheid variables the distances to the nearest galaxies, then supernovae, the Tully-Fisher relation, and the Hubble relation to learn about the large-scale universe. The Hubble relation is especially important, since it tells us something very important about the history of the universe and allows us to map the most distant galaxies. Try to explain how each of these standard candles is used and what we learn from it—that would be a good way to review much of this material.

Chapter 25. Now we are bridging the gap between mapping the distant universe and the question of how it got to be the way it is, and whether we can know its origin and evolution (Chapters 26, 27, exam 6). You should read and study all this material except for sec. 25.4, Black Holes in Galaxies. You might find it interesting to look over that section, though, because it describes observations and theories about the supermassive black holes that lurk in the centers of galaxies; very interesting and important, but I will not include it on the test--it takes us too far from the general path we are taking (mapping more and more distant things to understand the large-scale structure of the universe).

We covered Chapter 25 out of order, only in the sense that we began with sec.25.5, mapping a large part of the observable universe using different techniques, finding evidence for clustering up to extremely large scales. We started here because it was a continuation of the "standard candles give you a map of the universe" theme of ch. 24. We then returned to sec. 25.1, which presents still more evidence for even larger scale structure and "dark matter." You should be able to explain in simple words what this evidence is—generally it is all the same kind of evidence (except for using gravitational lensing), but using different objects. Don't worry if you don't quite understand gravitational lensing, as long as you are willing to accept that it happens.

A new theme in this chapter is looking back in time by observing very distant galaxies to learn something about how they have evolved as galaxies, and especially how the large-scale structures mapped out by galaxies has changed.

Notice the emphasis on starburst galaxies, and galaxy collisions when you go back to sections 25.2 and 25.3. You should be familiar with the role these may play in the formation and evolution of galaxies, as well as be able to describe the various lines of evidence we have now amassed for dark matter (sec. 25.1) and how its mass compares to the mass of "normal" ("baryonic") matter in the universe.

Sample questions

Here are some sample questions to see if you are prepared to take the exam. As usual, these tend to be a little more difficult than the average exam question.

1. What type of radiation is most useful in the mapping of our Galaxy's DISK structure?
a. dust emission b. visible light c. radio spectral lines d. infrared spectral lines

2. What type of radiation is most useful in the mapping of our Galaxy's HALO structure?
a. dust emission b. visible light c. radio spectral lines d. infrared spectral

3. The diameter of the disk of our galaxy is about ___________ parsecs.
a. 100 b. 1000 c. 8,000 d. 30,000
(What is the diameter of this disk? How big is the halo?)

4. What two observations of objects allow for a determination of the Milky Way's mass?
a) mass and velocity. b) age and distance from the galactic center.
c) mass and age. d) velocity and distance from the galactic center.
(Even if you think you know the correct answer, you should be able to explain It in words. Remember that it is no different than getting the mass of the Sun by observing the planets.)

5. What is one of the differences between Cepheid variables and RR Lyrae variables?
a) Cepheids are higher luminosity stars than RR Lyrae variables.
b) All Cepheids have the same luminosity.
c) Cepheid variables pulsate irregularly as compared to RR Lyrae variables which are very regular.
d) Cepheids vary because they pulsate; RR Lyrae variables vary because they are binaries
(This seems like a detail, but I want you to understand which can be used to locate the more distant galaxies. Remember that the answer to this question is the "candle" used to calibrate the next major standard candle, the Tully-Fisher relation.)

6. Which type of galaxy contains the largest percentage of its mass in the form of gas?
a. Elliptical galaxies b. Spiral galaxies c. Irregular galaxies
(Hint: Think of their colors. Relate this to how actively each type of galaxy is currently forming stars.)

7. Which type of galaxy is the most numerous in the Local Group?
a. giant elliptical b. spiral galaxies c. dwarf irregular and elliptical galaxies
(Can you name a satellite of the Milky Way?)

8. What observation is used in the Tully-Fisher relationship to determine distances?
a. the maximum brightness of supernovae b. Cepheid light curves
c. recessional velocity d. neutral hydrogen gas 21-cm line broadening
(Remember: Estimating DISTANCE usually means estimating LUMINOSITY. Explain in words why it makes sense that the Tully-Fisher relationship works.)

9. Using the Hubble relation, what single observation is needed of a galaxy in order to determine its distance?
a) color b) period c) mass d) spectrum

10. How are galaxies at large redshifts (means very distant—review the Hubble relation if this is not clear to you!) different from nearby galaxies?
a. They are more massive b. They contain redder stars
c. They contain more dark matter d. They are younger.

11. How large (roughly) is the largest structure that has been discovered during the course of mapping the positions of galaxies in the observable universe?
a. 1-3 Mpc b. 10-30 Mpc c. 100-300 Mpc d. 1000-3000 Mpc
(Think "wall." Explain in words how such a structure would be found. It is no different from how other structure, like clusters of galaxies, are found. If you don't know how to do this, try drawing the positions of galaxies as dots on a piece of paper, with you (us) at the center.)