Time: 4:21 pm, 15 October, 2010
Test 1, 22 October, 2010
Astronomy 123
Fall 2010

Material: Topic 1 (drawn from parts of Chapters 23-27), Topic 2 (Chapter 23 and part of 24)), Topic 3 (Chapter 24), and as far as I get in Topic 4.

INTRODUCTION

- Cosmology: What is it? Contrast Universe and universe. Why does the fact that we have observations of only 1 universe hinder theory?
- What makes a *model* scientific? Contrast science and philosophy. Is cosmology a science or is it philosophy? Defend your position.
- Basic Observations of cosmology (which drive the Big Bang Theory):
    - The Universe is expanding as implied by Hubble's Law (24.3). Who initially discovered Hubble's Law? . What is the *naive* interpretation of Hubble's Law? What is the Principle of Mediocrity and did it contribute to our interpretation of Hubble's Law?
- Cosmic Microwave Background Radiation (CMBR), What is it? When did it arise? What are we observing when we see the CMBR? What are the properties of the CMBR? (26.7) What is horizon problem? (27.4)
- Chemical composition of the normal matter in the Universe is roughly 90 % hydrogen and ~ 10 % helium (everyting else heavier than helium is referred to as a *metal* and makes-up only a small part of the Universe). This is not question, but is noted that the chemical composition is one of the strong supporting pieces of evidence for the Big Bang theory.
- What is the make-up of the overall Universe? What is dark matter? What is dark energy? Who first proposed the idea of some sort of dark energy and why. What fraction of the Universe is normal matter?
  Cosmological Principles:
    - What is the Principle of Mediocrity?
- What is the Copernican Revolution? What is the significance of annual trigonometric parallax for the Copernican Revolution?(pp 27-28). Explain how Hubble's Law may be explained through uniform expansion of the Universe,
- Are we at the Center of the Galaxy? Describe how Herschel and Kapteyn, and Shapley (23.2) attempted to find our location in the Galaxy and the size of the Galaxy. What did Herschel, Kapteyn, and Shapley conclude about the location of the Sun in the Milky Way galaxy? Who was correct? Why did the ones who were in error reach their erroneous conclusions (talk about dust, what is dust?)? How do we currently study the structure of the Galaxy? What is the location of the Sun and the true shape of the Milky Way galaxy?
- Cosmological Principle (26.1), what is it? What is meant by homogeneity and isotropy? (The Universe is clearly not bland and uniform on all scales, so why can homogeneity and isotropy of the Universe be useful assumptions?) In the Cosmological Principle is the Universe allowed to evolve in time? Could it be unchanging in time under the Cosmological Principle? What is a nice example that our Universe is homogeneous and isotropic?

- Perfect Cosmological Principle, what is it? It is not currently used by astronomers when they model the Universe. What are some reasons why the Perfect Cosmological Principle is not in favor? What is the Cosmological Constant? Einstern proposed the Cosmological Constant, why? Why did Einstein withdraw his suggestion?
- Anthropic Principle, What is the Anthropic Principle? Does Jim like the Anthropic Principle? Why does Jim like (or dislike) the Anthropic Principle?
- Describe the *Big Bang Theory*. Upon what observations is the Big Bang Theory based? Is the Big Bang on firm observational footing?

Milky Way Galaxy (Chapter 23 and Chapter 24, Hubble galaxy types, and Hubble Tuning Fork diagram.

- Milky Way Galaxy:
    - What is the Hubble classification of the Milky Way galaxy?
- Briefly describe the apparance of the Milky Way galaxy. What are the three primary regions of the Milky Way galaxy? What are the properties of these regions? What are the overall properties of the Milky Way galaxy?
- A black hole lives in the center of the Milky Way galaxy. What is a black hole? What are the properties of nonrotating black holes (Schwarzschild black holes) and rotating black holes (Kerr black holes). What is the Penrose mechanism? What is Cosmic Censorship?
- What are the properties of the black hole in the center of the Milky Way galaxy? What are Event Horizon, singularity, Schwarzschild radius, static limit, ergosphere? What is the escape speed from a black hole?
- What are the properties of the black hole at the center of our Galaxy? What are S2 and S6? What is Sgr A? Where is Sgr A? What are tidal forces?
- What are Population I stars? What are Population II stars? Where are each found?
- How is the structure of the Milky Way galaxy determined? What objects are used to study the structure of the Milky Way galaxy? Why are OB stars, H I regions, H II regions, Giant Molecular Clouds used to study the spiral arms of our Galaxy? What is meant by H I? by H II?
- What are galactic rotation curves (what kinds of rotation curves did I discuss in class)? How are rotation curves found in the region outside of the visible disk of our Galaxy, that is, outside of where we find stars and star forming regions (OB star, H II regions, Giant Molecular Clouds)? How far do rotation curves extend beyond the visible disk of our Galaxy? Describe how rotation curves are used to deduce the masses of spiral galaxies. (Note--how fast does the Sun move in its orbit about the center of the Milky Way galaxy? How large is the orbit of the Sun about the center of the Milky Way galaxy?)
- What is the significance of the fact that most rotation curves are nearly flat at large distances from the centers of the gaalxies (the galaxy spins at nearly the same speed at large distances as at small distances from its center)?
- How do the mass estimates from rotation curve affect the question of the amount of Dark Matter in our Galaxy?
- What are MACHOs? Where are MACHOs found? How are MACHOs detected? (What is gravitational lensing?) What fraction of the Dark Matter is contained in MACHOs?
    - Sketch the Hubble Tuning Fork diagram, be sure to include schematic representations of ellipticals, spirals, barred spirals, S0s & SB0s (lenticulars), and Irregulars, By schmeatic, I

mean indicate the flattening of ellipticals, bulge sizes, and the tightness of the winding of spiral arms. Hubble Galaxy Classification scheme (24.1)

- Describe Elliptical, Spiral, Barred Spiral, SBO, S0, and Irregulars. What are Lenticulars? What the differences between Sa, Sb, and Sc galaxies, E0 to E7 galaxies, Irr I and Irr II galaxies.
- Sketch the Hubble Tuning fork diagram. Describe how the general properties of galaxies vary along the diagram (consider gas and dust, stellar populations, Pop I and Pop II stars, star formation, ...)
- Is the Hubble Tuning Fork diagram an evolutionary sequence? (Do galaxies evolve from one Hubble class to another?)
- What kinds of galactic collisions occur? What are the results of collisions between similar disk galaxies, galaxies of greatly differing masses? Are collisions between aglaxies rare? What role do galactic colliions play in galaxy evolution? What are Supergiant Ellipticals? Where do they arise? Describe the interactions suffered (and to be suffered) by the Milky Way Galaxy. Describe the evolution and apperance of the Antennae, Cartwheel, and Mice galaxies.
- What is the extragalacitc distance ladder? What is the Tully-Fisher method (how does it work)? How do Cepheid variables fit into the extragalctic distance ladder? What are the most important ways to determine distances to distant objects?
- Describe how objects cluster in the Universe. Describe the properties of clusters of galaxies (such as Virgo and Coma). Why are there no spirals found near the centers of rich clusters of galaxies? What are cD galaxies? Why are supergiant Elliptical galaxies often times found near the centers of rich clusters of galaxies? How were observations of galaxy clusters used to detect Dark Matter? Who was the first astronomer to suggest the existence of Dark Matter? (What is meant by Dark Matter?)
- What is the look-back time?`The look-back time, distances to objects can be misleading, why? What is a more well-defined way to describe the *location* of distant objects in the Universe?
- What are voids, filaments, and the Sloan Great Wall? How were these features detected? Do these observed structures obviate the Cosmological Principle as a viable asuumption for the nature of the Universe? Why or why not.

Active Galactic Nuclei (AGNs)

- What is the major difference between the way normal galaxies and active galactic nuclei produce their emission (How do their spectra differ)? What is meant by thermal emission? nonthermal emission?
- Describe the different families of bright AGNs. Which class is the most luminous? Which classes are found in normal galaxies (or are all AGNs found in normal galaxies)?
- What observed features of AGNs make them difficult to understand? Are AGNs such bizarre objects that are considered to be completely outside the realm of normal galaxies or are they considered to extreme examples of normal galactic evolution? Upon what evidence is the answer to the preceding question based?
- How is rapid variability used to determine the maximum size of a emitting region?
- How was the Hubble Law used to find distances to QSOs?
- What are the models used to explain the nonthermal spectra of AGNs, the efficient energy production of AGNs, and the small size of AGNs? What evidence supports our picture of the energy engines of AGNs?
- What are supermassive Black Holes? Describe the evidence that the Universe contains supermassive Black Holes. Describe the supermassive Black Hole in the nucleus of our Galaxy. How are supermassive Black Holes thought to be produced? How efficient are black holes as energy engines?

What fuels the black holes found in AGNs? What is the radius of 1 billion Solar mass black hole? Desribe the relationship between supermassive black holes and the bulges of the galaxies in which they are found. What is the significance of this relationship?