Study Guide for Exam 4

Chapter 22

- We know that there is gas and dust in interstellar space, because Supernovae create them and they turn into nebulae.
- We know the size and shape of the Milky way by measuring the different frequencies of light of our galaxy (X-Ray, IR, Radio (21cm).
- The 21cm radio waves show us the size of the galaxy. They form a map that is invisible to visible telelscopes.
- The Milky way is a spiral galaxy with four arms and a supermassive black hole in the middle. It is more dense, the closer you get to the supermassive black hole at the center. There are over 100 billion stars and the galaxy is about 150 thousand light years across.
- The sun is located on the Perseus-Orion arm of the Milky Way, approximately 30 thousand light years from the galactic center.
- Astronomers believe that most of the milky way is made of dark matter because the outermost stars have the same angular velocity around the galactic center as stars closer to the galactic center. Dark matter is the hand that pushes our sun as quickly around the galactic center as star closer to the galactic center.
- The galaxy has spiral arms because they condensed over billions of years into arms.
- There is a supermassive black hole at the center of the galaxy.
- An HII region is a large cloud of partially ionized gas (mostly hydrogen) where a star was recently formed.
- HII regions only last a few million years because solar wind blows them away when a star is formed within them.
- The 21cm line comes from hyperfine splitting at the ground state of the hydrogen atom. Spins of electrons determine this energy. Antiparallel have energy and parallel have energy. This is the principle behind MRI
- We utilize it in astronomy because it can penetrate large clouds of interstellar dust.

Chapter 23

- Spiral- the distribution of stars follow spiral arms
- Bar Spiral- the stars emanate from the ends of a bar
- Elliptical- a football shaped galaxy that is extremely dense
- We determine the distance by how fast they are moving away from us.
- Astronomers think that galaxies contain large amounts of dark matter because there is a large amount of gravitational lensing.
- We think galaxies formed from large clouds of interstellar gas by density fluctuations.
- They nearly all have red-shifted spectra because they are moving away from us at great speeds.
- The red-shifts increase with distance because of Hubble's Law.
- If a galaxy is moving away from us at 200000 km/s, we can find the distance the galaxy is away from us by Hubble's Law $V=Hd$, solving for d with V being the velocity, and H being a given value (be careful of units)

Chapters 24,25

- Galaxies are almost always found in clusters.
- Gravitational lensing is another evidence for dark matter
- They are in clusters but there may be large voids of empty space between the clusters.
- There are enormous voids because of dark energy and because galaxies tend to form in groups.

Chapter 26

- Hubble's Law tells us that the universe was in one point in the past.
- We can tell how old the universe is by using Hubble's law.
- Space can be curved.
- Positive curvature would mean that the universe will end in a big crunch.
- Negative curvature would mean that the universe will end in a big freeze.
- We can tell because there is no center of the universe because any point in the universe can be seen as the center of the universe.
- An important event that happened in the early universe was the changing of pure energy into matter and antimatter, then the formation of hydrogen atoms and Helium.
- Matter is created when two photons interact to make a particle/ anti-particle pair.
- The recombination period began when the universe cooled down to 3000K.
- The Cosmic Microwave background is what we see the beginning of the recombination period
- It was discovered by a radio telescope
- The meaning of anisotropies in the angular distribution of the CMBR is slight variations of temperature from the protons and electrons combining sooner or later during recombination
- The future universe may be a big freeze, in which the universe keeps expanding and the temperature goes down, all the stars die, and the universe fizzles out.(this would happen if the escape velocity is less than the speed at which the universe exploded in the big bang. It may also result in a big crunch, in which the universe would expand to a maximum point and contract back into a single point (this would be when the escape velocity is greater than the velocity at which the universe exploded in the big bang.
- To find the age of the universe be able to convert megaparsecs to kilometers and use division to make the units cancel