Astronomy 1141 Quiz 1 Review Answers

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Observational astronomy — the night sky

- What are constellations? They are collections of stars which are close together on the sky.
- What is special about the constellations called the zodiac"? They lie along the ecliptic, so that the Sun passes through them.
- What is the ecliptic plane? The plane of the Sun's path along the sky. Since all the planets have low inclination, it is also where they lie, as well as the zodiac.
- Why is the ecliptic tilted with respect to the celestial equator? How big is this tilt in degrees?

  1. Because the Earth's rotation is tilted with respect to its revolution around the Sun.

  2. 23.5 degrees.
- What are the primary coordinates for finding a place on Earth? What about the celestial sphere?

  1. Earth: latitude and longitude.

  2. Celestial sphere: declination and right ascension.
- Why did the ancients keep track of the planets? Because they move with respect to the background stars.
- What are the two main periods of a planet, and how are they defined?

  1. Synodic period: the apparent orbital period of a planet as viewed from Earth. This is the time from conjunction to conjunction, or opposition to opposition. The synodic periods of the outer planets are just over one year.

  2. Sidereal period: the time it takes an object to return to the same place with respect to the background stars; also the true orbital period of a planet around the Sun.
- What is the angular size of an object? What is it for the Moon? 1. It is the angle subtended in your

  eld of view by the object. 2. The Moon is about 30', or 0.5 degrees, in the sky. This is roughly the same size as the Sun.
- How big is an arcminute? An arcsecond? 1. 1' = 1/60th of a degree. 2. 1" = 1/60th of 1' = 1/3600th of a degree.

Greek Astronomy

- What is stellar parallax? Why is it useful? 1. Stellar parallax is the apparent change in the position of stars brought about by the motion of the Earth around the Sun. 2. It can be used to determine the absolute distance to stars.

- Why did the Greeks reject the heliocentric model? 1. They could not see stellar parallax. cWhy couldn't they see stellar parallax? 1. Even for the nearest star, the parallax is far too small to see with the naked eye.

The Heliocentric Model

- In simple terms, what are the geocentric and heliocentric models? 1. Geocentric - the planets and Sun all orbit around the Earth. 2. Heliocentric - the planets, Earth included, all orbit around the Sun.
- Who was the first major proponent of the heliocentric model? What were the key facets of his model? 1. Copernicus. 2. His model had a central Sun with the planets orbiting it.
- Explain the main observational problem that Mars presented for the geocentric and early heliocentric models. 1. Retrograde motion - Mars would abruptly change its direction of motion on the sky and then back periodically.
- What did Ptolemy add to the geocentric model to explain this problem? 1. By adding epicycles, i.e. circular orbits within circular orbits, to the planets' motion around the Earth.

Exoplanets and Life in the Universe

- What is necessary for life as we know it?

  Amino acids are required for all life forms that we know of, specifically in the production of DNA. Water, methane, ammonia, and electricity can combine to form amino acids.
- What was the experiment that showed a primitive atmosphere can produce amino acids?

  The Miller-Urey experiment combined some primitive chemicals like water, hydrogen, nitrogen, and carbon dioxide and ran an electric current through them. Amino acids, the building blocks of DNA, formed. We think this is how the necessary building blocks of life formed on our planet.
- What is necessary for reproduction of living organisms?

  DNA, which carries the genetic code that tells every living organism how to work, must be self-reproducing. This is a chemical process that is absolutely necessary for life to continue its existence.
- What is the Drake Equation, and which parameters in it can we actually observe? It gives the number of advanced civilizations that could exist at any given time for a galaxy. N = (star formation rate) x fraction of stars with planets) x average number of planets per star that can support life) x fraction of life-supporting planets that actually develop life) x fraction of planets with life that develop intelligent life) x (fraction of civilizations that develop technology that releases signals into space) x (length of time a civilization sends signals into space) We don't know most of these parameters. The only one we know for sure is the star formation rate of the Milky Way, and exoplanet searches can help us get a handle on the average number of planets per star and the average number of planets in the habitable zone for a star.
- In general, do astronomers think it's possible for there to be lifeform like those on Earth elsewhere in our galaxy? Why or why not?

  Absolutely! There are lots of stars similar to our Sun, and we know from recent planet searches that lots of stars have lots of planets. We can also see that new planetary systems are forming all the time, so even more planets are out there than we can find! The trouble is actually finding signs of life... we can find planets that are similar to the Earth that may have life, but we can't get to them and we can't tell much more about them, so we really can't know if there's life unless they send us a radio signal.

- What are the ways we determine a star might have a planet orbiting it?

  Radial velocity: We use Doppler shifts of absorption or emission lines of the star to see how the star "wobbles" due to the gravitational pull of a planet.

  Transits: Planets block out light from the star when they pass between the star and us.

  Microlensing: Gravitational lensing (thanks to Einstein's general relativity) of a star as it passes behind another star.

  Direct Imaging: Once we know that a star has a planet around it using one of the other detection methods, we can carefully block the light from the star from reaching the telescope and take a picture of just the planets around it. This is really hard to do because the star is always significantly brighter than the planets, and exactly blocking out the star without blocking out the planets is hard.

- What is the easiest kind of planet to find with all of the detection methods?

  Very large planets will either cause the star to wobble more with their large mass, thus producing a greater radial velocity, or will block out more light from the star during a transit with their large size. Therefore, big planets are easier to detect.

  Planets that are very close to their stars will transit more often (sometimes once every few days!), which increases the probability of seeing it at any time that you happen to be looking at the star. This is also true for radial velocity detections. Therefore, planets with very short periods are easier to detect.

- How do planets form?

  Not all of the giant gas and dust cloud that forms a star will go into the star itself. Some of it goes into the protoplanetary disk, which is a disk of material surrounding a star. If there are enough metals in the disk, planets will start to form out of it. Bigger and bigger rocks stick together until eventually they build up to the size of planets.

- How is our Solar System dient from other planetary systems we've found? Why is this a problem for planetary formation theory?

  Most of the systems we've found have very massive gas planets, like Jupiter in size and composi- tion, in very, very close to their host star. These are called "hot Jupiters." Our Solar System obviously doesn't have any of these. All our planets are pretty far away from the Sun, and even the closest ones are pretty small and rocky, not gas giants. This poses a problem to the theory of planetary formation, because it is generally thought that gas giant planets, like Jupiter, need ice to form, and ice just can't survive that close to the star. Maybe the planets migrated there after forming? We're not sure.

- What is a star's "habitable zone"?

  The distance from the star at which a planet would have temperatures we believe are conducive to life, such as ripe for liquid water formation.

- Are exoplanets common? Yes! The Kepler space mission has discovered thousands

Matter, Atoms, Radioactivity

- The Periodic Table consists of 92 known natural elements, as well as heavier laboratory-made elements such as plutonium (94).

- What subatomic particles make up the atom? What is radioactivity?

  Protons and neutrons in the nucleus, electrons in orbits around them. Neutrons have no charge but are as heavy as protons; electrons are about 1854 times lighter.

- How many protons, electrons, and neutrons does a hydrogen atom have? One proton and one electron, no neutrons. A neutral atom (an atom without any charge) always has equal numbers of protons and electrons. The number of protons in the nucleus, known as the "atomic number", separates atoms identifying each element. Hydrogen has one proton. Helium, the second element, has 2 protons.

- Nuclei of some elements contain more neutrons than protons. Those elements are said to have different "isotopes" of the same element depending on the number of protons+neutrons, called the "atomic weight". U235 and U238 are isotopes of Uranium with 92+143 and 92+146 protons+neutrons respectively.

- Atoms may spontaneously break up into ligher ones, a phenomenon called Radioactivity, emitting high energy radiation and small "alpha particles" consisting of two protons and two neutrons (Helium nucleus). For example, Uranium breaks up into lighter elements until it reaches the stable element lead (Pb) with atomic number 82.

- Radioactive decay occurs on a timescale given by "half-life", which is the amount of time when half the original number of atoms in a given sample decays to the lighter element. Uranium decays to lead with half-life of about 4.5Gyr. Radiactive decay can therefore be used for chronological dating of rocks by measureing the amount of heavier and lighter species at the present epoch. That's how we know the oldest rocks on the Earth are about that age, which agrees with the age of the solar system.

The Big Bang

- What is the Big Bang Model?

- It is the idea that the universe began in a hot, dense state that was the same everywhere.

- How old do we think the universe is? How about the Sun? The Earth?

- The universe is about 14 billion years old (roughtly $1/H_0$).

- The Sun is about 10 billion years old.

- The Earth is about 4.5 billion years old, same as the Sun.

- The Hubble Law: We observe galaxies that are far away are moving away from us faster than galaxies that are close by (distance-redshift relation). It measures the expansion of the galaxy.

- The Hubble Law states $v = H_0 d$, where v is the velocity, d is the distance, and H_0 is the Hubble Constant.

- The Hubble Constant, H_0 is the slope of this relationship and is determined by measuring the distance other galaxies. As it is difficult to measure distance to far away galaxies, it is hard to measure H_0. Presently, we measure $H_0 = 70$ km/s/Mpc.