Astronomy 102, Fall 2004

Homework Set 2 Solutions

1. *There are a range of laitudes where, on at least one day of the year, the Sun will pass directly overhead (i.e. at the Zenith). Which latitudes of the Earth meet this condition? Does this happen in Nashville?*

The declination at your zenith is the same as your latitude. For the Sun to be at your zenith, it would need to have a declination equal to your latitude. Over the course of the year, the Sun's declination varies from +23.5° (on June 21) to -23.5° (on December 21). Therefore, at least one day a year, the Sun will pass directly overhead for **latitudes between 23.5° S and 23.5° N**.

Nashville is at a latitude of 36° N, so the Sun never passes our zenith here.

2. *(a) Suppose you are standing on the moon, looking at the Earth. Would you see the Earth go through phases the way an Earthbound observer sees the moon go through phases? How long would it take for you to observe one cycle of Earth phases?*

(b) When an Earthbound observer sees a full moon, what Earth phase would you observe?

(c) Describe how you would see the Earth move across the Moon's sky over the course of a day, and over the course of a month.

(a) When the Earth is on the opposite side of the Moon as the Sun, an observer on the Moon will see a "full Earth". Two weeks later, the moon will be halfway around its orbit, and now observers on the Moon see a "new Earth". Two weeks after that, the Moon is back to its original position, and Lunar observers see a "full Earth" again. Observers on the Moon will see the Earth go through phases, and it will take one month for a complete cycle of phases.

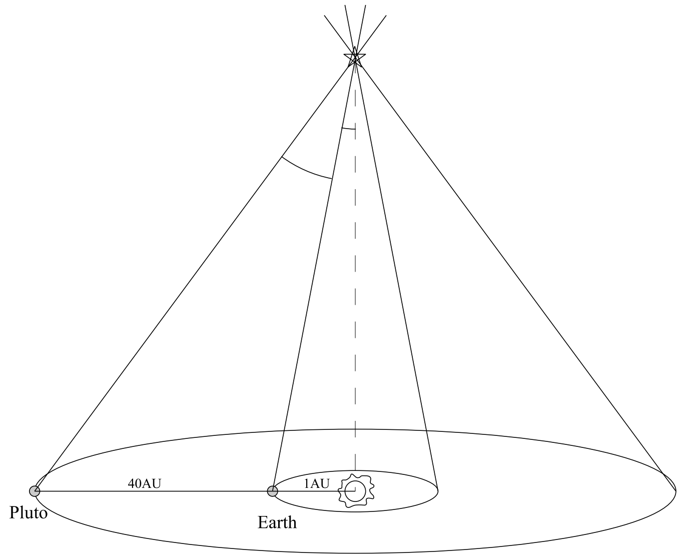
(b) If an Earthbound observer sees a full moon, it means that the moon is on the opposite side of the Earth from the Sun. To a Lunar observer, the Earth is in the same direction as the Sun, so the lit side of the Earth is facing away. Thus, the Lunar observer would see a "new Earth."

(c) We always see the same face of the Moon from Earth, because the Moon's rotation period is the same as its orbital period. Two weeks later, the Moon will have moved halfway through its orbit to the opposite side of the Earth, but it will also have rotated halfway around. If you are standing on the face of the moon that's pointing towards the Earth, the Earth will *always* be overhead in your sky. The Earth does not appear to move across the Moon's sky. Because the Earth rotates once every 24 hours, a Lunar observer *would* see the Earth spinning on its axis, but it would stay in the same place in the observer's sky.

3. *(a) The Earth is 1 AU from the Sun, and Pluto is on average 39.5 AU from the Sun. Would there be any advantage in measuring the distance to stars using parallax from Pluto? If so, why would it be easier to measure parallax from Pluto?*

(b) Ignoring the expense and trouble of getting to Pluto in the first place, and of surviving in such a hostile environment, would there be any disadvantage in measuring stellar distances using parallax from Pluto? If so, suggest a way to get around this disadvantage.

(a) From one side of the Earth's orbit to the other side is a distance of 2AU. This is the base of the triangle used in a parallax measurement. From one side of Pluto's orbit to the other is a distance of about 80AU. The distance to the star, however, is the same. (Remember that the *closest* star is nearly 10,000 farther away from the Sun than Pluto is, so the change in position going from Earth to Pluto is very small in comparison.) Thus, the parallax angle you would measure would increase by a factor of 40 (see diagram below). If you can measure angles down to a given precision, you'd be able to measure stars that were 40 times farther away.



(b) Pluto takes about 250 years to go around the Sun. Thus, you'd have to wait 120 years between the two opposite-orbit positions in order to get the crucial two perspectives necessary for a parallax measurement. A way around this would be to make one observation from Pluto, and one from Earth. That would give you a $\sim$ 40AU baseline, not as good as the 80AU baseline for a pure Pluto measurement, but still better than the 2AU measurement one gets from Earth.

4. *In the northern hemisphere, June 21 is the longest day of the year and December 21 is the shortest day of the year. How long is the day (in hours) at the equator on June 21? Can you identify the shortest day in the year on the equator?*

On the equator, a star anywhere on the Celestial Sphere, regardless of declination, spends half of its time up and half of its time down. This is true also of the Sun. Thus, the number of hours of daylight you have is 12 hours on June 21... and on any other day.

(In fact, there is a *slight* modification due to the ellipticity of the Earth's orbit. However, we haven't talked about that, so don't worry about it.)

5. *Pasachoff & Filippenko, Chap. 4, Ques. 17: Explain why for an observer at the north pole, the Sun changes its altitude in the sky over the year, but the stars do not.*

If you are an observer at the North Pole, all the stars in the sky appear to be moving around in a circle parallel to your horizon. The direction to your zenith (straight up) is parallel to the axis of rotation of the Earth's orbit, so the stars do not appear to rise and set as the go around the sky.

The Sun, likewise, over the course of the day, appears to travel in a circle around the sky at an approximately constant altitude off of the horizon. However, because over the course of the year the Sun changes in declination, it will appear to drift higher and lower in the sky. Indeed, for half of the year, the Sun will be below the Celestial Equator and therefore below your horizon.

6. *The moon and all of the planets appear to go through phases, meaning that most of the time we see only a part of their surface illuminated. The Sun never goes through such phases. Explain why the Sun is different from the Moon and the planets.*

The moon and planets go through phases because the light we see from them is reflected sunlight. Only the side of the planet facing the Sun is illuminated. If we aren't lined up with the moon/planet and the Sun, but looking at the moon/planet at a different angle, the face of the moon/planet towards us will be different from the face illuminated by the Sun. Therefore, we see phases.

The Sun is different because it is the *source* of the illumination. It's not reflecting light, but glowing itself. Any part of it we see will be glowing, so we won't see phases on the Sun.