

# Understanding the Celestial Sphere

## Materials Needed—

- Celestial sphere
- Pencil & paper

## Objectives—

- Define what is meant by celestial sphere and explain why it is commonly used even though it is not real.
- Define celestial equator, celestial pole, right ascension, declination, ecliptic, equinox, solstice, and find these on the celestial sphere.
- Explain how we can use the celestial sphere to model the yearly motion of the Sun and the daily motions of stars.
- Explain how we can use the celestial sphere to define the position of objects on the sky.



FIG. 1.— Your new best friend.

*Introduction*— The celestial sphere, while an antiquated and ultimately misleading representation of the visible universe, is extremely useful when we want to pinpoint the location of an object in the night sky or to follow the motions of the Sun, Moon, and planets. In this activity, you will become more familiar with just how astronomers use the celestial sphere<sup>1</sup>. You will also have a newfound appreciation for the power of a geocentric model of the universe!

*Procedure*— Your celestial sphere should look like the one in Figure 1. Note the position of the Earth dial and the Sun knob. The following steps/questions will help you navigate your way around your celestial sphere.

1. The place where the two halves of the sphere meet represents the celestial equator. What imaginary line on Earth is this a projection of?
2. The Earth has a rod running through its spin axis. What two points on Earth does this allow us to project onto the celestial sphere?

Find the ecliptic. It has days and months of the year marked on it and is tilted relative to the celestial equator. Twist the Sun knob (see Figure 1) to see how it moves relative to the ecliptic.

3. What do the dates along the ecliptic indicate? What do we call the constellations along the ecliptic?
4. How can an observer tell what constellation the Sun is in?
5. How much time passes while the Sun undergoes one complete sweep around the celestial sphere?
6. Look at your answers to the previous three questions. How would you rephrase them if you put the Sun at the center of the celestial sphere?

Now, find the places on the celestial sphere where the celestial equator and the ecliptic cross. These intersections are called the equinoxes. On these two dates, the Sun rises directly in the East and sets directly in the West, and there are 12 hours of light and 12 hours of dark.

7. Position the Sun at the fall or autumnal equinox. What is the approximate date? What is the name of the constellation that lies the closest to this intersection?
8. Position the Sun at the spring or vernal equinox and answer the same questions.

<sup>1</sup> This activity is adapted with permission from an activity developed by Ana Larson's students at the University of Washington. The original activity is here: <http://www.astro.washington.edu/larson/Astro101/CoursePak/>.

Next, position the Sun at its highest point on the ecliptic. This date is an important day for us as it has the greatest number of hours of daylight for the Northern Hemisphere.

9. What is the approximate date? What is this day called?
10. Describe what happens six months later. What is this day called?

Locate the celestial equator again. Follow the lines that start at the celestial equator and run vertically up to the North Celestial Pole and then down to the South Celestial Pole. These are the lines of constant right ascension (RA, sky longitude).

11. Where is the RA zero point?
12. What is the maximum RA?
13. What do the RA numbers along the celestial equator represent?

Some of the lines of right ascension have numbers running up them, marking the circles that run horizontally around the celestial sphere. These are lines of constant declination (DEC, sky latitude).

14. Where is the DEC zero point?
15. What is the maximum Dec? What is the corresponding point?
16. What do the DEC numbers along a given RA line represent?

The ecliptic is tilted  $23.5^\circ$  with respect to the celestial equator.

17. What does this angle represent?
18. What is the full angle in DEC that the Sun travels between the solstices?
19. How does this angle compare to the angle between the Sun's position when at its highest position in our summer sky and at its lowest position in our winter sky?
20. Would your answer to the last question be the same if you lived on the Equator? How about at the North Pole?

Now, twist the Earth dial and make the Earth go through one complete rotation.

21. What does this one complete turn represent to someone living on this Earth?
22. If looking down from above the North Pole, what direction do you need to rotate the Earth to replicate the actual day/night cycle?

Finally, hold the Earth dial still so that the Earth does not rotate at all. Now turn the celestial sphere completely around in the opposite direction, as viewed from above, from the direction you turned in question 22.

23. For someone on this Earth, what would the celestial sphere appear to do?
24. From the perspective of a person living on Earth, is it possible to distinguish between this scenario (the Earth standing still) and the one above (the Earth rotating)?

**Bonus:** Find your birthday on the ecliptic and note which constellation it coincides with. Surprised? Feel cheated?? Got an explanation??? [Hint: When was the zodiac defined? What has happened since?]