General Astronomy (29:61)
Fall 2013
Lecture 1 Notes , August 26, 2013

1 Overview of the Solar System

The scale of the Solar System

The *astronomical unit* AU is the average distance between the Earth and the Sun, and is 1.496×10^{11} meters, $= 1.496 \times 10^{8}$ kilometers.

Instead of the term *average distance* between a planet and the Sun, we will use (an apparently hopelessly more complicated) term *semimajor axis* of the orbit of a planet. The reason for this choice will become clear later. The two concepts are equivalent.

2 Astronomical Coordinate Systems

Astronomical coordinate systems allow us to express, in numbers, one of the most basic things about an astronomical object: where it is. We will start with two of the main coordinates systems.

1. the *Horizon Coordinate System*, fixed with respect to you.
2. the *Equatorial Coordinate System*, fixed with respect to the stars.

Think of the sky as a big hemisphere over us at a given time. The full interior of this imaginary sphere is called the *celestial sphere*.

2.1 The Horizon Coordinate System

We use two angles to specify the location of an astronomical object, the *azimuth* angle and the *altitude* angle. Look at Figure 1.3 for a definition of these angles.

An important concept in the horizon coordinate system is the *meridian* . It is an imaginary line on the sky starting due north, going through the *zenith*, and ending up due south. The meridian divides the sky into two halves. An astronomical object *transits* when it moves through the meridian from east to west.

2.2 Motion of Celestial Objects in the Horizon System

The following basic astronomical facts were known to all human beings from the mists of prehistory until a couple of generations ago when most people began living in suburbs with high levels of artificial light.

1. The Sun, Moon, and planets rise in the east, reach highest altitude angle when they cross the meridian (transit), and set in the west.

2. In the horizon coordinate system, all objects in the sky move on big circles, called *diurnal circles*, centered on the *celestial pole*. In the northern hemisphere, we look at the *North Celestial Pole*. This concept is very nicely illustrated in Figure 1.4 of the book.

3. Some stars near the North Celestial Pole (NCP) never set, but move on circles around and around the North Celestial Pole. The ancient Egyptians called these stars "the immortals".

4. The diurnal circle that starts out due east, passes the meridian, and sets due west, is called the *Celestial Equator*. This is a super-important concept.

2.3 Different Appearance of the Sky in Different Regions

In antiquity, it was realized that the sky appears different at different locations on Earth. For example, in central Iowa the bright star Antares (check for it low in the southwest when it gets dark) transits at an altitude angle of 21.8°. In San Diego, it transits about 10 degrees higher. We can see why this is so by looking at Figure 1.1, and also a **Demo**.

If the latitude of a point on Earth is l, then the altitude angle of the celestial equator on the meridian is $Al = \bar{l}$, where $\bar{l}$ is the complement of l, $l + \bar{l} = 90°$. The same diagram can be used to show that the altitude angle of the NCP above the northern horizon is l. This is one of the most important results for practical navigation.

2.4 The Equatorial Coordinate System

The most basic astronomical observation is that the stars "hang together" as they move across the sky in the diurnal motion. This indicates that we should define a coordinate system fixed with respect to the stars. Just like we can specify the latitude and longitude of a place on Earth, we can specify the coordinates of a star relative to a coordinate system fixed with respect to the stars. Look at Figure 1.5 of the textbook for a definition of this coordinate system.

The Equatorial Coordinate System is similar in concept to longitude and latitude.

- Right Ascension $\rightarrow$ longitude. The symbol for Right Ascension is α. The units of Right Ascension are hours, minutes, and seconds, just like time
- Declination $\rightarrow$ latitude. The symbol for Declination is δ. Declination $= 0°$ corresponds to the Celestial Equator, $\delta = 90°$ corresponds to the North Celestial Pole.

2.5 The Origin of Right Ascension

. It is not obvious where to set $\alpha = 0^h$. By convention, this is the *vernal equinox*, the location of the Sun on the first day of spring.

3 Star Charts

The first lab experiment is to become familiar with star charts. Today you will get a sneak preview of the SC1 star charts. $\rightarrow$ SC1 charts.

3.1 Further Remarks on the Equatorial Coordinate System

The Equatorial Coordinate System is fundamentally established by the rotation axis of the Earth. See Figure 1.10.

With the definition of the Equatorial Coordinate System, we can figure out the altitude at transit of any star. This is

$$Al = \bar{l} + \delta \qquad (1)$$

Wake-up question: What is the azimuth angle of a star at transit?

3.2 The Equatorial Coordinates of Different Astronomical Objects

For stars, the Right Ascension and Declination are constant [1]. For the Sun, Moon, and planets, (α, δ) change with time. We will clearly see this during the course of the semester.

[1] This isn't completely true; wait for later in the semester

3.3 Why do the Right Ascension and Declination of the Sun Change?

3.4 The Celestial Equator and the Ecliptic

The Celestial Equator is the intersection of the Earth's equatorial plane with the celestial sphere, and it is a great circle on the celestial sphere. The ecliptic is the intersection of the plane of the ecliptic with the celestial sphere, and it is a great circle on the celestial sphere. They are not the same great circle, but are inclined with respect to each other at $23.5°$.

Why is this so? What is it telling us about the solar system?

3.5 Seasonal Changes in the Night Sky

A very fundamental fact of astronomy, known to all human societies, is that the location of the constellations in the night sky changes through the year. We will clearly see this during the course of the semester.

This results from the revolution of the Earth around the Sun. You can clearly figure this out from the SC1 charts. A particularly striking illustration of this is provided by the movies from the C3 coronagraph on the SOHO spacecraft (see the spacecraft web page on the course web page).