General Astronomy (29:61)
Fall 2012
Lecture 32 Notes, November 14, 2012

1 The Sky this Month

There are some interesting sights to be seen in the sky this month.

- This Saturday morning, from midnight to dawn, will be the peak of the Leonid meteor shower. Look towards the east in the first after-midnight hours. If you can identify the constellation of Leo, look for the "question mark". That is the radiant of the meteor shower. There should also be Leonids Sunday morning.

- From now until the end of the month is your chance to see the planets we are talking about. Look east just before dawn. You can't miss brilliant Venus. Lower, close to the horizon is another light. That is the planet Saturn that we saw right at the beginning of the semester. Over the next couple of weeks they will be getting closer together. On November 26, they will only be 0.8 degrees apart. Lower in the sky will be Mercury, that we will be discussing today.

2 The Planets

Now we will start with the basics of solar system astronomy: the science of the planets. There are two ways you can approach the study of the objects in the solar system.

- The classical astronomy approach, which is to discuss the planets in order of their distance from the Sun. This makes sense if you think in terms of orbits and locations of objects in the sky.

- The geological approach. Much of the study of solar system objects nowadays relies heavily on geology, particularly the study of the Moon and the terrestrial planets. Geologists tend to organize their thinking around geological principles, such as vulcanism and sedimentation.

We will take the classic astronomy approach, but remain mindful of the geological perspective.

3 The Terrestrial Planets

Let's start with the terrestrial planets. A family picture of them is in Color Plate 7 of the book. Also $\longrightarrow$ also see pictures in online figures and diagrams. Look at Table A.3 for data on these planets.

3.1 Mercury and Venus

Let's start with Mercury and Venus. I always like to show early astronomical observations of objects. Check out the Mayan glyphs on Venus in the $\longrightarrow$ online figures and diagrams.

3.1.1 Just the facts, Ma'am

. Here are the fundamental numbers on these planets (also available in Table A.3.

- Mercury, radius = 0.383 $R_{\oplus}$, mass = 0.0553 $M_{\oplus}$; orbital properties: a = 0.387 AU, $\epsilon = 0.2056$
- Venus, radius = 0.950 $R_{\oplus}$, mass = 0.815 $M_{\oplus}$; orbital properties: a = 0.723 AU, $\epsilon = 0.0068$

3.2 The Orbit and Rotation of Mercury

The orbital period of Mercury is 87.97 days (pretty close to 88 days). Look at the accurate plot of its orbit in $\longrightarrow$ online figures and diagrams. It is neat to look at, and will be used in some of the arguments we will be making.

Well into the modern era in astronomy (1967) it was assumed that Mercury would be a synchronous rotator, like the Moon (review what this means if you have forgotten). In 1967 that was found to be wrong. Instead, the rotation and revolution period are related by a 3/2 resonance. Since that time, we have found that these resonances are very common in the solar system, and are super-important.

The rotation period is $P_{rot} = 58.65$ days, and $P_{orb} = 87.97$ days. The dynamics of this arrangement are shown in Figure 10.1 of the book. Also $\longrightarrow$ online figures and diagrams.

3.3 The weird day on Mercury

As we saw when talking about the Earth, on a planet that rotates and revolves around the Sun, there is a difference between the rotation period in an inertial reference frame and the length of the day. This is what causes the difference between the sidereal day and solar day. The formula relating this is (see also p232, 233 of book).

$$P_{sol} = \left[\frac{1}{P_{rot}} - \frac{1}{P_{orb}}\right]^{-1} \tag{1}$$

In the case of the Sun, the orbital period is much longer than the rotational period, so the period of the solar day is not much different than the sideral day.

However, in the case of Mercury, the periods are quite comparable, so the length of the solar day is much longer than the rotation period. If we plug in the numbers, we get that the length of the day is 175.9 days....2 years!

The high eccentricity of Mercury's orbit makes the whole situation even weirder. By Kepler's 2nd Law, the angular velocity of Mercury in its orbit is much larger at perihelion than aphelion. That means the *effective* P_{orb} is smaller at perihelion and larger at aphelion. This means the angular rate at which the Sun crosses the sky on Mercury changes dramatically, and can even change sign!