General Astronomy (29:61)
Fall 2012
Lecture 12 Notes, September 24, 2012

1 The Month and the Orbit of the Moon

See Section 4.4 of the textbook. From night to night we see the Moon moving against the background stars, approximately on ecliptic (except for the 5.1° offset due to the inclination of the Moon's orbit). This has been noted since prehistory. We now know that is due to the Moon's orbital motion around the CM of our system.

Associated with this motion against the background stars, there is a change in the phases of the Moon from *New Moon* to *First Quarter Moon*, to *Full Moon*, to *Third Quarter Moon*, and then back to New Moon. This is explained in Figure 4.10 of your textbook, or in the accompanying diagrams.

The period for this orbital motion of the Moon is the basis for probably the oldest unit of time, the month. The time for the Moon to complete an orbit with respect to the stars is called the *Sidereal Month*, and has a duration of 27.32 days.

The other definition of the month is the time to go through all of the phases and end up with the same phase. This is called the *Synodic Month* and is equal to 29.53 days. Ask yourself why these two values for the month would be different. You should be able to figure it out.

1.1 Synchronous rotation of the Moon

One of the most striking features of the Moon is that we only see one side of, that facing the Earth. Until the Space Age, no one had seen the back side of the Moon. That is because it is our closest example of the important astrophysical process of *synchronous rotation*. The rotation period of the Moon equals its orbital sidereal period. This is a consequence of the tides raised by the Earth on the Moon. Synchronous rotation occurs throughout the solar system, and astrophysics in general.

1.2 Librations

Even though one hemisphere is always pointed towards the Earth, we nonetheless see more than 50 % of the Moon's surface. This is due to the phenomenon of *librations*.

An illustration of librations is shown for the September 2, 2007 Astronomy Picture of the Day under "lunations". There are three types of librations, clearly described on p100 and 101 and illustrated in Figures 4.11, 4.12, and 4.13. These librations can be summarized as follows.

- Diurnal libration .... a parallax effect
- Libration in longitude ... a consequence of Kepler's 2nd Law
- Libration in latitude ... a consequence of the fact that the Moon's rotation axis is not perpendicular to its orbital plane, but is closer to being perpendicular to the plane of the ecliptic.

2 Geology of the Moon

It would be better described as planetary science. The study of the Moon, particularly the rock forms present there, and the analysis of those rock samples, has provided us with important clues about everywhere in the solar system. Particularly interesting is what we have learned about the history of the solar system.

2.1 "Geography" of the Moon

Before discussing the geology of the Moon, we need to discuss its "geography", features of the lunar surface that have been known for several centuries. The next few items in the lecture could certainly have been presented in 1850.

There are a number of important features of the lunar surface that are visible in a small telescope. It is good to look at a picture of the Moon while discussing these.

- Maria – plural of Mare. Dark, smooth areas on the surface of the Moon. There are several of these on the Moon, and they have Latin names like *Mare Tranquillitatis* where the first Apollo spacecraft landing was.
- Terrae – these are the brighter areas on the Moon, that are higher than the Maria.
- Craters – these are big holes on the surface of the Moon. They are the most distinctive lunar feature. Before the space program in the 1960s, it is almost the case that the Moon was the only object known to possess them. They are now known as a major feature of the solar system. More below.
- Crater rays–a small telescope will show rays coming out of some of the prominent craters, such as Tycho and Kepler (see picture in online diagrams).

- Rilles, Graben, etc – There are features on the Moon that look like old river beds, or straight walls. The most famous example is the Hadley Rille, and another (geologically unrelated) feature is the Aridaeus Rille, that we can see with our telescopes from the roof.

2.2 Craters of the Moon

Amazingly, the debate as to what these are continued until the early 1960s. They range in size from a few feet in diameter to the many tens of kilometers in diameter. There are 5 with diameters greater than 200 km. The diameters of some of the best known (and easiest to find in a small telescope) are: Tycho, 102 km, Copernicus, 107 km, Kepler, 31 km.

By contrast, a prominent terrestrial example, the Barringer crater in Arizona, is only 1.1 kilometer in diameter. Look at some pictures of them in the online notes.

2.3 Craters as impact craters

In the early 1960s, it was finally accepted that the craters of the Moon are *impact craters*, caused by the collisions of objects from outer space with the Moon. The kinetic energy of the moving impactor was converted to, essentially, explosive energy that excavated the hole in the lunar surface. Empirical studies show that at the speeds expected for interplanetary projectiles, the impactor would be 1/3 to 1/5 the diameter of the crater it produces.

In looking at the Moon, the question arises as to when these impacts occurred. We will see the answer to that next time.

3 The Apollo Moon Landings

No discussion of the Moon would be complete without a description of the Apollo program landings that took place between July, 1969 and December 1972. To this day, it represents the only time that human beings traveled to another astronomical object. See the online pictures.