29:52 Exploration of the Solar System
Notes for February 18, 2008
The Astronomical Basis of Eclipses

There are two important concepts to keep in mind when thinking about eclipses.

(1) **The Orbit of the Moon.** The Moon orbits the Earth, or more exactly the center of mass of the Earth-Moon system. The orbit is an ellipse with a semimajor axis of 384,400 km. At closest approach of the Moon to the Earth, it is only 356,400 km, and at its most distant, is 406,700km. The eccentricity of the Moon's orbit is 0.072.

A very important aspect of the Moon's orbit is its 5 degree inclination to the plane of the ecliptic.

(2) **Shadows.** Eclipses are caused by a shadow of one astronomical object falling on another. As you can see in Figure 9.9, a shadow consists of two parts; the *umbra* which is the darkest part of a shadow, in which the light of the Sun is completely blocked by the object causing the shadow, and the *penumbra* in which the light of the Sun is partially blocked.

Types of Eclipses

1. A lunar eclipse occurs when the Moon moves into the shadow cast by the Earth.
2. A solar eclipse occurs when the Earth moves into the shadow cast by the Moon.

Look at Figure 9.12 to see illustrations of what happens in an eclipse.

Lunar eclipses occur only at times of full moon, and solar eclipses occur only at times of new moon. Think about why this must be the case.

Frequency of Occurrence of Eclipses

If the phase of the Moon were the only thing determining whether eclipses occurred or not, we would two eclipses every month, a solar eclipse at new moon and a lunar eclipse every full moon. However, this does not happen. Eclipses are much rarer. The reason for this is that another condition must be fulfilled. The Moon must be in or near the plane of the ecliptic, or equivalently, it must be close to one of the nodes of its orbit. If this does not happen, the shadows of the Moon and Earth miss the Earth and Moon, respectively, and no eclipse occurs. This is illustrated in Figure 9.14 of your textbook.

Darkness of Lunar Eclipses

The darkness of lunar eclipses varies significantly. Some are so dark that the Moon is invisible during totality. In others, the totally eclipsed Moon appears as a dusky red color. The reason lunar eclipses are often not totally dark is that some light is scattered

by the Earth's atmosphere into the umbra of the Earth's shadow, thus shedding some light there. This is illustrated in Figure 9.11 of the textbook.

This scattered light is ineffective, and lunar eclipses are extremely dark, at times when a large volcanic eruption has occurred in the last couple of years. Volcanoes blast ash high into the atmosphere and render it much less transparent. Since there have been no major eruptions in many years, the February 20 eclipse will be fairly bright.

Duration and Darkness of Lunar Eclipses

The length of a lunar eclipse, and how dark it is, depends on how deep in the umbra of the Earth's shadow it passes. If the Moon passes through the center of the circular umbra, the eclipse will last a long time and the eclipse will be dark. If it passes near the edge (as will be the case on February 20), the time of totality will not be as long, and the eclipse will be lighter.