29:52 Exploration of the Solar System
Class Notes for April 16, 2008
The Outer Solar System

We are finished with Jupiter and Saturn for the moment. Now we move out further.

All objects discussed in the course to date were known in antiquity. Even by 1000 BCE, a lot was known about the motions of these objects in the sky. The next 2 objects we discuss are the last two major planets in the solar system. They are Uranus and Neptune, and they were discovered after the invention of the telescope.

Uranus borders on being a naked eye object, and is easy in binoculars. Neptune is not easy to see in binoculars, but it is possible.

Look at the physical and orbital properties of Uranus and Neptune in Tables 13.1 and 13.2 of the book. The semimajor axes are 19.2 and 30.1 au for Uranus and Neptune, respectively. Don't get blase about these numbers. 30.1 au is 2.8 billion miles.

In appearance, both of them look like blue balls. We didn't have any decent pictures of them until Voyager 2 went there in 1986 and 1988. Look at Figures 13.3 and 13.9 for their appearances.

Tables 13.1 and 13.2 also tell you how big (diameter) and massive Uranus and Neptune are relative to the other planets. The basic result is that they are much bigger (both in diameter and mass) than the Earth, but are a lot smaller than the "Jovian" planets Jupiter and Saturn. They are sufficiently distinct that it probably makes sense to have three categories of planets; the terrestrial planets, Jupiter and Saturn, and a third class with Uranus and Neptune.

Uranus and Neptune are blue because their cold atmospheres contain methane. The light we see reflected from these planets goes through their atmospheres, reflects off the clouds, then travels through the atmospheres again before making its way to us. The gas methane absorbs red light more than blue light, so the light that makes it to us appears bluish.

We don't see prominent clouds (like we see for Jupiter and Saturn) mainly because the atmosphere is too cold for clouds. Substances like ammonia and methane freeze out in the bitterly cold outer atmospheres of these planets, and fall into the interior.

Look at Figure 13.6 for a plot of the atmospheric structure of Uranus and Neptune, together with those of Jupiter and Saturn. Notice the temperatures at the 1 atmosphere point for Uranus and Neptune, which are at or below the temperature of liquid nitrogen.

The **internal structures** of Uranus and Neptune are shown in Figure 13.10.

The centers of these planets are believed to be formed of rock and metal cores. It is not believed that the pressures in the interiors of these planets reach the point necessary for liquid metallic hydrogen.

An oddity about Uranus is that its *obliquity* (remember this term from earlier in the semester) is 98 degrees, meaning that on Uranus, the celestial pole is nearly in the plane of the ecliptic. This would make for extremely pronounced seasons.