29:52 Exploration of the Solar System
Class Notes for April 9, 2008
Exploring Jupiter

Last time, discussed that Jupiter and Saturn are *almost entirely composed of hydrogen and helium*. There are three arguments for this.

1. Basic laws of physics indicate that objects with those masses, radii, and mean densities must be composed of the lightest elements in the periodic table of the elements.

2. In the spectrum of Jupiter, we see absorption lines of hydrogen-rich molecules like ammonia, methane, and water.

3. The Galileo spacecraft probe actually descended into the atmosphere of Jupiter and made measurements there.

The chemical composition of Jupiter and Saturn are essentially identical to the Sun. It is the terrestrial planets which are unusual as regards composition.

The Clouds of Jupiter

Clouds on Earth are water clouds, either liquid water drops or ice crystals make up the clouds. Based on physical chemistry and physics considerations, we conclude that there are three levels of clouds on Jupiter, consisting of ice crystals of different compounds.

The compounds that form clouds on Jupiter, at different altitudes in the atmosphere, are

- ammonia (NH3, highest in the atmosphere)
- ammonium hydrosulfide (NH4SH, middle layer)
- water (lowest layer)

Look at Figure 12.18 of textbook for location of these clouds in the atmosphere of Jupiter. This figure also shows that at an altitude of "0 kilometers", the temperature is about room temperature and the atmospheric pressure is a few times sea level pressure. However, these habitable conditions only exist in a very narrow layer in Jupiter's atmosphere.

The band structure of Jupiter's clouds is due to convection of gas from the hot interior, producing high, bright clouds. This gas cools and sinks back into the interior, producing the darker bands. Look at Figure 12.17 for a diagram of the band structure at Jupiter.

The Interior of Jupiter

Known properties of hydrogen indicate that a few hundred kilometers below the cloud tops, the hydrogen in Jupiter must make a transition to *liquid hydrogen*. This transition occurs for both Jupiter and Saturn. It is illustrated in Figure 12.21. At even deeper levels, the pressure is so great that the liquid hydrogen changes into a state (a so-called "phase transition" in physics) called *liquid metallic hydrogen*, in which the hydrogen is a superdense, electrically-conducting liquid. It is a liquid metal like Mercury. Until about 10 years ago, liquid metallic hydrogen had never been produced in science laboratories. In the past 8 years or so, high pressure experiments have produced it for less than a millisecond. It requires pressures of millions of atmospheres.

The Magnetospheres of Jupiter and Saturn

The fact that the interior of Jupiter is a liquid metal means that electrical currents can flow there. An electrically conducting liquid that is undergoing rotation and convection (an in-and-out boiling motion) acts like a *dynamo* that build up a strong magnetic field.

Both Jupiter and Saturn have strong magnetic fields, stronger than that of the Earth. Look at the comparison of the magnetic fields of Jupiter and Saturn to the Earth on p281 of the textbook. The basic statement of the strength of a magnetic field generated by a dynamo is something called the "magnetic moment". The magnetic moment of Jupiter is 20,000 times that of the Earth.

The fact that the Earth (and even more so) Jupiter and Saturn have strong magnetic fields , in contrast to the other three terrestrial planets, means that they also possess *magnetospheres*, or regions of space which are dominated by the planetary magnetic field, and which hold off the flow of gas from the Sun called the *solar wind*.