ASTR-1010: Astronomy I
Course Notes
Section XI

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Abstract

These class notes are designed for use of the instructor and students of the course ASTR-1010: Astronomy I taught by Dr. Donald G. Luttermoser at East Tennessee State University.

XI. Lesser Bodies of the Solar System

A. Pluto and Charon

1. Observations of Neptune in the 1800's suggested that a 9th planet may exist beyond Neptune.

2. Early in this century, a large search was made to find this planet. In 1930, Clyde Tombaugh discovered the 9th planet of the solar system $\Longrightarrow$ **Pluto**.

3. Although there was a lot of uncertainty, its brightness suggested that it was very small (current values are $M = 0.002\, M_{\oplus}$ and $D = 0.18\, D_{\oplus}$), too small to account for Neptune's perturbations.

a) This lead many to believe that there is a 10th planet beyond Pluto.

b) This "10th" planet has never been found and IR surveys of the sky would have picked up such a planet very rapidly.

c) It turns out that the original calculations of Neptune's perturbations were inaccurate. All of Uranus' and Neptune's perturbations can be accounted for by the known outer planets $\Longrightarrow$ there is no 10th planet in the solar system!

d) Due to Pluto's small size, it's debatable as to whether Pluto should be called a planet $\Longrightarrow$ it's closer in size to a large asteroid or comet!

4. Pluto's orbit is highly inclined and very eccentric, which for a time, brings the planet closer to the Sun than Neptune. (Pluto was closer to the Sun than Neptune from 1979 through 1999.)

5. In 1978 (11 years before Pluto's perihelion), James Christy discovered that Pluto has a moon, and a large one relative to the size of Pluto. The **Pluto-Charon** system is actually closer to a *double planet* than the Earth-Moon system.

a) Since we now have 2 bodies in orbit around each other, it became possible to measure accurate sizes and masses for these 2 bodies $\Longrightarrow$ they are both very small!

b) The sizes and densities of Pluto and Charon suggest that they are similar to Triton in the Neptunian system — it's possible that Pluto and Charon once orbited Neptune as moons as were later ejected (perhaps by an interaction with Nereid, which revolves backwards around Neptune).

B. The Asteroids

1. **Bode's Law** is an empirical relation of the distances that the planets are from the Sun. When following this law, the distance that a planet is from the Sun in AU is retrieved.

a) Write down the sequence of numbers 0, 3, 6, 12, 24, 48, 96, ... (each number past 3 is just double the previous number).

b) Add 4 to each number in the sequence.

c) Divide each resulting number by 10.

Bode's Law	**Planet**	**Distance (AU)**
(0+4)/10 = 0.4	Mercury	0.39
(3+4)/10 = 0.7	Venus	0.72
(6+4)/10 = 1.0	Earth	1.00
(12+4)/10 = 1.6	Mars	1.52
(24+4)/10 = 2.8	?	—
(48+4)/10 = 5.2	Jupiter	5.20
(96+4)/10 = 10.0	Saturn	9.54
(192+4)/10 = 19.6	Uranus	19.18
(384+4)/10 = 38.8	Neptune	30.06
(768+4)/10 = 77.2	Pluto	39.44

2. Note that Neptune and Pluto had not been discovered yet when Bode developed this law. This law is not really a law, but just a coincidence. However at the time, it was thought that a planet had to exist around 2.8 AU away from the Sun — in between the orbits of Mars and Jupiter.

3. Many astronomers started searching for this unseen planet and in 1801, Piazzi discovered **Ceres** (the largest asteroid) at a distance of 2.77 AU from the Sun. It was very small however (600 km in diameter).

4. Shortly thereafter, more and more small planets were discovered in between the orbits of Mars and Jupiter. These small planets are now called **asteroids** — the majority of them reside in between the orbits of Mars and Jupiter. As such, this zone is coined the **asteroid belt**.

5. Recently, spacecrafts have flown past some asteroids and found that they are covered with craters and some of them even have small moons in attendance $\Longrightarrow$ asteroid interactions and impacts seem to be common.

6. Asteroid impacts knock loose small particles called **meteoroids**. Many meteoroids exist in the solar system and collide with Earth every day.

a) When these small particles (most range in size between sand grains up to small pebbles) are in interplanetary space, they are called **meteoroids**.

b) If they encounter the Earth, they streak through the atmosphere and heat up from the friction, so much so that they vaporize and ionize producing bright streaks in the sky. These streaks are called **meteors**.

c) If a meteoroid is large enough (pebble to rock size), it survives passage through the atmosphere and impacts on the Earth. At this point, it is called a **meteorite**.

C. Comets

1. Asteroid orbits reside fairly close to the ecliptic (*i.e.*, the plane of the solar system) and many have fairly circular orbit. Comets, on the other hand, have a large range of eccentricities and inclinations.

2. When a comet comes close to the Sun, it develops a fuzzy cloud around the **nucleus** called the **coma**, and a long **tail** $\Longrightarrow$ **comets** are nothing more than dirty snowballs.

3. Most comets come into the inner solar system unexpectedly and have very large semimajor axes. In the 1950's, Jan Oort proposed that comets originate in a large spherical shell on the outskirts of the solar system $\Longrightarrow$ the **Oort Cloud**.

4. More recently, a zone of comets has been proposed to exist in the ecliptic plane just outside Neptune's orbit. This zone of comets has been coined the **Kuiper belt**. Comets and any asteroids that may exist in the Kuiper belt are called **trans-Neptunian objects**. There has been a relatively large number of trans-Neptunian objects discovered. Pluto is the largest of the trans-Neptunian objects.

5. As a comet comes into the inner solar system, some interact with the planets (the Jovian planets mostly) and their orbits get adjusted such that their semimajor axis reflects the semimajor axis of the planet that they have encountered $\Longrightarrow$ they become **short-period comets** (*e.g.*, Halley's comet orbit was adjusted by Uranus many centuries ago).

6. When a comet starts to **sublimate** (*i.e.*, solid into a gas) as it gets close to the Sun, dust particles that were trapped in the ice are liberated.

- **a)** The comet forms an **ion tail** from the sublimating gas which gets pushed away from the nucleus by the solar wind (charged particles blowing out from the Sun).

- **b)** The comet also forms a **dust tail** that gets blown away from the nucleus by sunlight itself!

- **c)** Note that the tail(s) always points away from the Sun whether the comet is approaching or receding from the Sun $\Longrightarrow$ the tail is <u>not</u> an exhaust jet — it does not push the comet along!

7. The dust that is liberated continues to orbit the Sun in the same orbit as the comet. If the Earth's orbit happens to intersect a comet's orbit, these dust particles collide with the Earth producing **meteor showers**.

8. This now concludes our study of the Earth, Sky, and Solar System (*i.e.*, *Astronomy I*). The course titled *Astronomy II* involves the study of stars, interstellar gas and dust, star clusters, our home galaxy the Milky Way, other galaxies in the Universe, cosmology (*i.e.*, the study of the Universe as a whole), and life in the Universe. We hope to see you there too!