SPASH ASTRONOMY
CHAPTER 12: THE OUTERMOST PLANETS AND THEIR MOONS
OVERHEAD LECTURE NOTES

1. How do U. (Ur'-a-nus) and N. compare to J. & S. when you view them through a large telescope?

Instead of displaying the tan colors of Jupiter's and Saturn's clouds, they are strikingly blue.

2. Who discovered U., when was U. discovered and why was its discovery such a big deal?

The discovery of U. came in 1781, when the German-English musician-turned-astronomer William Herschel accidentally detected the planet during an ambitious star-mapping project. Thus he became the first known human being to recognize a new planet. THINK: Who discovered Mercury, Venus, Mars, Jupiter, and Saturn?

3. Who named U. and why U. of all names? When was the last time NASA probed U.?

The planet's name was suggested by J. Bode (of Bode's law) because in mythology U. was the father of Saturn, and Saturn was the father of Jupiter. Because of U.'s long 84 year period of revolution around the Sun, it will complete its third revolution since its discovery in 2033A.D.

4. Who discovered N., when was N. discovered, and why was its discovery considered an international scandal?

In 1846 J.C. Adams an English astronomer spent two years figuring out where N. should be but couldn't convince his senior professors at Cambridge to let him search for it because they were putting all their efforts into a way to determine longitude at sea. The French mathematician Leverrier had also predicted the planets whereabouts soon after Adams but he interested two young German astronomers into searching for it and they found it within a half hour.

Galle, Johann Gottfried 1812-1910

German astronomer who, with Heinrich Louis d'Arrest, made the first observation of Neptune Sept. 23, 1846 based on calculations by Le Verrier. Though Galle was the first to observe Neptune, its discovery is usually credited to Adams (who made an earlier calculation) and Le Verrier.

Side Note: More than two centuries earlier, in 1613, Galileo observed Neptune when it happened to be very near Jupiter, but he thought it was just a star. On two successive nights he actually noticed that it moved slightly with respect to another nearby star. But on the subsequent nights it was out of his field of view. Had he seen it on the previous few nights Neptune's motion would have been obvious to him. But, alas, cloudy skies prevented obsevations on those few critical days.

Neptune is smaller in diameter but larger in mass than Uranus. In Roman mythology Neptune (Greek: Poseidon) was the god of the Sea.

5. What probe was sent to U. and N.?

Neptune has been visited by only one spacecraft, Voyager 2 on Aug 25 1989. Much of we know about Neptune comes from this single encounter. But fortunately, recent ground-based and HST observations have added a great deal, too.

6. What did Voyager 2 find? List at least the two you find most interesting.

Voyager 2, thanks to heroic engineering and programming efforts, continued the mission to Uranus and Neptune. Uranus itself was highly monochromatic in appearance. One oddity was that its magnetic axis was found to be highly skewed from the already completely skewed rotational axis, giving Uranus a peculiar magnetosphere. Icy channels were found on Ariel, and Miranda was a bizarre patchwork of different terrains. 10 satellites and one more ring were discovered. *In contrast to Uranus, Neptune was found to have rather active weather, including numerous cloud features. The ring arcs turned out to be bright patches on one ring. Two other rings, and 6 other satellites, were discovered. Neptune's magnetic axis was also skewed. Triton had a canteloupe appearance and geysers.* **(What's liquid at 38K?)**

At Earth sea level pressures in the cloudtops, temperatures compare as follows E.(63° F), J.(-153° F), S. (-189° F), U.(-319°F), N. (-335° F).

N. turns out to have more pronounced cloud structures than U., including dark belts and a dark oval cloud system, called the Great Dark Spot. The G.D.S. is an Earth-sized storm system, reminiscent of Jupiter's Great Red Spot, circulating in an anticyclonic direction. H.S.T. has more recently found that the G.D.S. has disappeared and another smaller dark spot has shown up in a new location.

7. List at least two more facts about one or both of the Voyager spacecraft:

Most Distant Spacecraft

The Voyager spacecraft will be the third and fourth human spacecraft to fly beyond all the planets in our solar system. Pioneers 10 and 11 preceded Voyager in outstripping the gravitational attraction of the Sun but on February 17, 1998, Voyager 1 passed Pioneer 10 to become the most distant human-made object in space.

The Golden Record

Both Voyager spacecrafts carry a greeting to any form of life, should that be encountered. The message is carried by a phonograph record - -a 12-inch gold-plated copper disk containing sounds and images selected to portray the diversity of life and culture on Earth. The contents of the record were selected for NASA by a committee chaired by Carl Sagan of Cornell University. Dr. Sagan and his associates assembled 115 images and a variety of natural sounds. To this the added musical selections from different cultures and eras, and spoken greetings from Earth-people in fifty-five languages.

The Present Status

As of March 2002, Voyager 1 was at a distance of 12.4 billion kilometers (84 Astronomical) from the Sun. Voyager 2 was at a distance of 9.8 billion kilometers (65 AU). Voyager 1 is escaping the solar system at a speed of about 3.6 AU per year. Voyager 2 is escaping the solar system at a speed of about 3.3 AU per year. **If no unforeseen failures occur, we will be able to maintain communications with both spacecraft until at least the year 2030. Both Voyagers have plent of hydrazine fuel -- Voyager 1 is expected to have enough propellant until 2040 and Voyager 2 until 2034.**

8. Why is U. nearly featureless and yet N. has strong cloud features?

The main reason is a lack of heat from the interior. U. radiates only about the same internal heat as it gets from the sun but N. radiates 2.7 times more energy than it receives from the Sun.

9. How do U. & N.'s internal structures compare to J.&S.?
U.&N. lack the deep mantle of metallic hydrogen. Neptune's composition is probably similar to Uranus': various "ices" and rock with about 15% hydrogen and a little helium. Like Uranus, but unlike Jupiter and Saturn, it may not have a distinct internal layering but rather to be more or less uniform in composition. But there is most likely a small core (about the mass of the Earth) of rocky material. Its atmosphere is mostly hydrogen and helium with a small amount of methane.

10. Name three peculiarities U. has?
1). U.'s axis of rotation is highly tilted to the plane of the solar system, thus its name as the sideways planet.
2). U. has an east to west rotation like Venus thus retrograde rotation.
3). Due to high obliquity, its poles can point nearly at the Sun at different times during its 84 year trip around the Sun. After 21 years of one pole having complete darkness and the other pole complete light, within the planet's 17 hour rotation the poles flip there complete light and dark for the next 21 years.

11. What is the story behind the rings of U.?
In 1977 U. passed in front of a relatively bright star. A number of astronomers watched, expecting to see the star dim as it passed behind U.'s upper atmosphere and thus to learn about the haze layer's structure. Instead they discovered U. had rings! Voyager 2 revealed that the rings are much narrower than those of J. or S.. Most of the ring material is confined in nine narrow bands.

12. What is unique about N.'s rings?
They are Arc-Rings! Voyager 2 confirmed that the rings contain thicker arclike segments.

13. What is the story behind the number of satellites U. has?
Before Voyager 2 five moons of U. were known and named after characters in Shakespeare's Midsummer Night's Dream. But ten smaller moons were discovered in 1985 and 1986 as astronomers studied Voyager 2's photos, for a total of ~~15~~ 27 satellites. Titania - disc 1787

14. What surprise did astronomers find when they saw photos of Miranda, the smalles of U.'s largest five moons?
The rule of thumb was that smaller size signifies less internal activity, so Miranda like our moon should only have craters, but unexpectedly it is the most fractured and resurfaced of all the moons. (picture page 236).

15. What is the story behind the number of satellites N. has?

Only two were known before Voyager 2's flight though the solar system in 1989, but the spacecraft discovered five more.

16. List at least three facts you find interesting about Triton, N.'s largest satellite:
1). Triton's motion is in the backward, or retrograde, direction compared to all the other moons.
2). Triton has few impact craters, which means that its surface must be, geologically speaking, very young.
3). Triton has a thin atmosphere. Voyager 2 instruments showed that the atmosphere is mostly nitrogen, with some methane.
4). Voyager cameras revealed active, erupting geysers or volcanoes with columns of dark smoke rising vertically 26,000 ft into the sky, where they were then sheared off by jet-stream winds.

17. What is the story behind Pluto?
Because N.'s gravity did not account for irregularities in U.'s motions scientists looked for one more planet. Percival Lowell began a search for a ninth planet in 1905 (Einstein's miracle year) but it wasn't discovered until 1930 when Clyde Tombaugh **(1906-1997)** found it on Lowell Observatory photos. After it was named for a god of the underworld, a new planetary symbol (P) was created from the first two letters, which were also Lowell's initials.

18. Give four reasons why Pluto's planet status was being questioned by some astronomers. Note that the astronomical association responsible for Pluto's planet status have not even considered putting it's planet status up for a vote, so Pluto will remain a planet.
1). It is much smaller than any other full-fledged planet. It is even smaller than our Moon. Note: Since Ganymede and Titan are larger than Mercury, Mercury would have to go also.
2). Its orbit is not close to twice the size of N/'s, in keeping with other planet spacings; instead it overlaps N.'s orbit.
3). Over fifty other objects roughly $1/10^{th}$ Pluto size or smaller have been discovered in the Keiper belt of which Pluto is a part of.
4). Pluto's moon Charon discovered in 1978 is much larger in diameter with respect to its planet (57%) than are most moons. Note: Pluto does have a moon!
5). Pluto may indeed be more closely related to the Keiper belt comet objects that to planets.

19. What is Planet X and does it exists?

THE SEARCH FOR PLANET X

Modern astronomers are detecting patterns in the outer planets which suggest the presence of another planet in our solar system. Some claim will be able to see it in 2003 but these people have no good hard data to back it up. If interested in Planet X search the internet and see what you can find out about it.