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Pluto: The Farthest Planet (*Usually*)

Pluto, the ninth planet in our solar system, was not discovered until 1930 and remains a very difficult world to observe because it's so far away. At an average distance of 2.7 billion miles from the Earth, Pluto is a dim speck of light in even the largest of our telescopes. It takes almost 249 years to make one swing around the Sun, in a long looping orbit that takes it above and below the path of the other planets. (See the accompanying box for more on its unusual path.)

What Would It Be Like on Pluto?

While astronomers don't yet know many details about the landscape on Pluto, we do know that it's cold and dark out there. On average, Pluto is nearly 40 times as far from the Sun as we are. From that great distance, the Sun would look like a single, brilliant point of light (it would be only about 1/40th as big as the full Moon is in our sky — too small to appear as a disk.)

During the day, that tiny point illuminates the ground on Pluto with only 1/1500th the intensity of sunlight we receive on Earth. (That's still far from being "dark,'' though: the Sun's light output as seen from Pluto is about 250 times the light we receive from the Moon when it's full.) As you might expect, Pluto isn't warmed much by the Sun; astronomers estimate its surface temperature to be more than 200 degrees below zero, Celsius. This is a temperature so cold that skin would be as brittle as glass — and that some materials we're familiar with as gas or Earth (such as methane) would freeze solid.

New Discoveries in the Last Decade

Despite its great distance, Pluto has given up some of its secrets to careful study recently. Even though no spacecraft has investigated Pluto (and none is scheduled to), a happy circumstance is in part responsible for the accelerating pace of discoveries: Pluto is closer to us in the last two decades of the 20th century than it has been for the last 200 years (or will be for the next 200). Along with the great sensitivity and sophistication of today's astronomical instruments, this makes investigating Pluto from Earth less difficult now.

In 1978, for example, a relatively large satellite was discovered around Pluto and named Charon — and during the last half of the 1 980's, a rare alignment has made it possible to study Pluto and Charon much more effectively than ever before. For a brief period once every 124 years, observers on Earth are in a position to see Charon pass directly in front of and behind Pluto in its 6.4-day orbit around the planet. This "eclipse season'' began in 1985 and will end in 1990; there won't be another one until the 22nd century — and not until the *23rd* century will one happen when Pluto is this close. By making careful measurements of the eclipses, astronomers have made great progress in understanding the sometimes strange and puzzling properties of Pluto and its satellite.

Pluto is Not the Ninth Planet

Ever since 1930, school children have memorized the nine planets in order: Mercury, Venus, Earth, Mars, Jupiter Saturn, Uranus, Neptune, and PIuto. But between January, 1979 and March, 1999 that order is not correct. Pluto's eccentric (ellipse-shaped) orbit has brought it inside the orbit of Neptune, making it the eighth planet for two decades. Pluto's unusual position makes "What is the ninth planet?'' a great trivia question for a while.

Just in case students begin to worry that someday Pluto might collide with Neptune as the smaller planet crosses the orbit of the larger, you can reassure them. The two orbits are *tilted* relative to one another by 17 degrees) in such a way that they never actually "touch.'' (Imagine two enormous, slightly elongated hula hoops, one larger than the other. If the larger one is tilted relative to the smaller one, you can imagine that the two points where the larger hoop crosses through the smaller hoop's plane can be outside the smaller hoop.) Calculations indicate that Pluto's and Neptune's orbits are never closer than 385 million kilometers to one another and that (at least for the past several million years) the two planets themselves have never been closer than two and a half billion kilometers to each other.

Some Pluto History

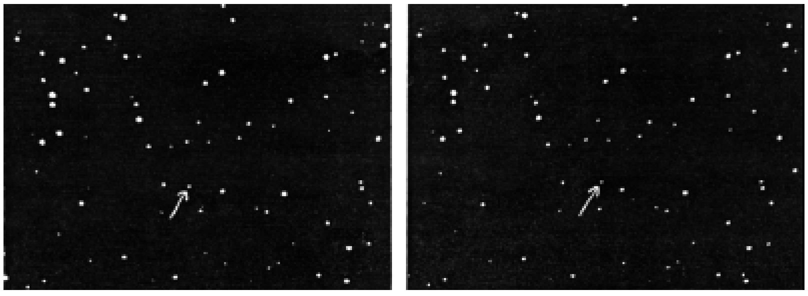
The eighth planet from the Sun, Neptune, was discovered in 1846 at precisely the position that two mathematicians one English and one French—had predicted it would be. John C . Adams and Urbain J.J. Leverrier had calculated that a new planet must be responsible for the fact that the motion of the seventh planet, Uranus, was not in accord with the laws of planetary orbits (derived from Newton's theory of gravitation). In essence, they reasoned that some significant body, more distant than Uranus, must be adding an extra influence on its movement. Astronomer Johann Galle at the Berlin Observatory then found Neptune on the very first night he began to search!

As you can imagine, this success naturally led astronomers to wonder if even more distant planets could be found in this way. Unfortunately, Neptune takes 165 years to complete its orbit around the Sun and, as the 20th century arrived, it had only moved through a small part of its orbit. This made it very difficult to calculate the degree to which it was not orbiting "properly'' and other bodies might be disturbing it. Nevertheless, a number of astronomers attempted to calculate where a ninth planet might be from possible "oddities'' in the motions of both Uranus and Neptune.

The best-known predictor of a ninth planet was a wealthy Bostonian named Percival Lowell, whose advocacy of the possibility of life on Mars had brought him fame in the 1890's and 1900's. Lowell built one of the finest observatories in the country just outside Flagstaff, Arizona, in part to pursue his dreams of Martians and new planets. Neither could be found by the lime of his death in 1916.

Nevertheless, Lowell's dream was kept alive by the trustees and staff of the Lowell Observatory, and in the late 1920's Lowell's brother Lawrence (who was president of Harvard University for many years) gave $10,000 to fund a special wide-angle 13-inch telescope to make a thorough photographic search for a ninth planet.

Because the large photographs typically taken by such telescopes are full of huge numbers of stars, it was clear to the astronomers at Lowell that many months and perhaps years of careful photography — and very patient inspection of the photographs — might be required to find their planet. Someone would have to sit night after night in a cold, open dome and then spend the days searching the negatives for a moving minuscule black dot among the thousands of stationary ones. It occurred to them that it would perhaps be best to train a good amateur astronomer who could dedicate himself to the task.



Two telescopic photographs of Pluto (the dot at the arrow's tip) taken 24 hours apart. By carefully checking its position against the background star pattern, you can see that it has moved a little from the first picture (left) to the second (right). (Photographs courtesy of Yerkes Observatory.)

Pluto's Discovery

By happy coincidence, a young farm boy from western Kansas wrote to the director of Lowell in 1928, enclosing some careful drawings of Jupiter and M ars that he had made while observing with his home-made 9-inch telescope. A few months afterwards, 22-year old Clyde Tombaugh boarded a Santa Fe train at Larned, Kansas and arrived at Flagstaff 28 hours later to begin the search for what came to be called Pluto.

The typical photographic image Tombaugh used — recorded on plates of glass to have a good permanent record — might contain anywhere from 50,000 to 400,000 stars, galaxies, and asteroids. How could the faint image of a distant planet be distinguished?

The trick was to take two photographs of each region of the sky several days apart. Then the pair of plates could be put side by side into a machine called a blink comparator, in which the two images are quickly alternated (blinked) in a single viewer. If an object is in the same place on both plates (as a star wouId be), no motion will be seen as the plates are switched in the viewer. But if the object has moved in the few days that elapsed between the taking of the plates (as a planet would do), its image will "blink'' — shift back and forth against the still background of the stars.

Even with this machine, it was an enormous and painstaking task to cover the parts of the sky in which planets were expected to be found. It took almost a year of searching, but on February 18, 1930, while blinking two plates of a region in the constellation Gemini, Tombaugh discovered a new planet not far from where Lowell had predicted it wouId be — although much fainter than he had suggested. After confirmation and careful study, the announcement was made on March 13th, the 149th anniversary of the discovery of Uranus and the 75th anniversary of Percival Lowell's birth. Eventually, following the suggestion of a British schoolgirl, the planet was named Pluto, after the Roman god of the underworld. (Another point in favor of the name was that the first two letters were Percival Lowell's initials!)

Pluto's Moon

In 1978, astronomer James Christy was examining some photographs of Pluto taken with the U.S. Naval Observatory's telescope near Flagstaff — not far from Lowell Observatory. He noticed that the image was slightly distorted — it bulged out on one side as if Pluto had something next to it. After looking more carefully at photographs that had been taken in the past, Chrisly was able to show that Pluto had a satellite orbiting it at a distance of about 17,000 kilometers. He suggested the name Charon — after the boatman who ferried the dead into the realm of Pluto in mythology — and the name was made official by the International Astronomical Union in 1985.

Charon orbits around Pluto in about 6.4 Earth days, which is exactly the time it takes Pluto to spin around once on its axis. In other words, the day and month on Pluto are the same length, a situation which only holds for Pluto and Charon out of all the planets and satellites in the solar system.

However, there are many *artificial* satellites around Earth for which this is also the case. Called "geosynchronous'' satellites, these orbit above our planet's equator at exactly the same rate as the Earth spins — so they seem to "hover'' (22,000 miles up) over the same place on Earth all the time. Most satellites which are used to relay television signals are of this variety, so that receivers on the ground ("satellite dishes'') can just be pointed at one direction in the sky and then left alone — the geosynchronous satellite will always appear to be in just about the same place in the sky.

Pluto's moon Charon, then, can be thought of as a "Pluto-synchronous'' satellite — it would always be in the same place in the sky if you were on Pluto. It would be an eerie sight, too. Even though Charon is only about a quarter the size of our own Moon, it's so close to Pluto that it would look bloated to Earth-trained eyes: it would be *eight times* as wide as the full Moon appears on Earth, covering 64 times as much sky. (It would be *dim*, though — remember that it is *reflected sunlight* that makes a moon shine, and sunlight out there at Pluto and Charon is very dim.) Hanging in the same place in the sky, day and night, it would go through its full cycle of phases from one Pluto day to the next (that is, every 6.4 Earth days) . During the "eclipse season'' there would be an eclipse of the Sun for a while every day (while Charon blocks the Sun from view) and an eclipse of the moon at night (while Charon moves through Pluto's shadow).

The Latest Discoveries

Pluto is so far away and difficult to see that not very much could be pinned down about its detailed characteristics until the "eclipse season'' began. Since no spacecraft is scheduled to visit Pluto, this is our one and only chance for the foreseeable future to understand what happens in the distant realm that (usually) marks the edge of our planetary system. Astronomers at various observatories have been studying the Pluto-Charon system intensely and a preliminary report on their work was given at a recent meeting of the American Astronomical Society in Austin, Texas.

The diameters of the two bodies could be measured accurately for the first time during the eclipses. Pluto turns out to be only about 2300 kilometers across (1400 miles) — clearly making it the smallest planet in the solar system. In fact, seven moons (including the Earth's) are larger than Pluto.

Charon is about 1300 kilometers wide (or roughly 800 miles). While much smaller than our Moon's 3500 kilometer diameter, this is so large compared to Pluto — more than half as big — that some astronomers are now speaking of the Pluto-Charon system as a "double planet.'' The next closest thing to a double planet is our own Earth-Moon system, but our satellite is only about one-fourth the diameter of our planet. (It must be noted that these measurements of Pluto's and Charon's diameters are not — and cannot yet be — precise. It would not be surprising if the numbers given here wind up being "wrong'' by a hundred kilometers or so after all the measurements from the eclipse season are evaluated.)

By measuring Pluto's pull on Charon as the satellite moves around the planet, astronomers can estimate the mass of Pluto. (Current best estimates are that Pluto's mass is about 3/1000th that of the Earth.) From knowing the mass and the diameter, Pluto's average density (mass per unit volume) can be calculated, giving us a due to what this remote world is made of. On a scale where water has a density of 1.0 and the Earth about 5.5, Pluto comes in at about 2. This means it cannot be made just of ice, but must also contain denser (rocky) material. Knowing Pluto's approximate mass and diameter also allows us to estimate the strength of Pluto's gravity at its surface — it turns out to be only a percent or two of Earth's! A 100-pound Earth student would weigh only a pound or two on Pluto.

The faint reflected sunlight we pick up from the two bodies shows that Pluto has a surface with a considerable amount of frozen methane (sometimes called "swamp gas'' on Earth), while Charon's surface seems to be mostly water ice. The very existence of methane ice is an indication of how cold things must be out there — methane does not become a solid until the temperature drops to nearly 200 degrees below zero Celsius.

With its small size, relatively large moon, and weird orbit, Pluto certainly seems like an oddball world compared to the other planets in the outer solar system. One explanation that is sometimes offered for its unusual properties is that it was once a moon of Neptune that escaped long ago and took up an independent orbit after a while. However, even though Pluto's orbit sometimes carries it closer to the Sun than Neptune is, today their orbits never actually cross. This is because Pluto's orbit is in fact outside Neptune's at the places where their planes cross. (On the other hand, planets' orbits do change somewhat over very long periods of time, so it is possible that Pluto's and Neptune's orbital paths did actually cross long ago.) Furthermore, scientists are not sure what might have caused such a moon to escape and how an escaped moon could have a satellite of its own; so Pluto's origin must remain one of the solar system's unsolved mysteries for now.

Resource Corner

Books About Pluto:

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- Tombaugh, C. & Moore, P. *Out of the Darkness: The Planet Pluto.* 1980, Stackpole Books.

Articles About Pluto:

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- Croswell, K. "Pluto: The Enigma at the Edge of the Solar System'' in *Astronomy*, July 1986, p. 6.
- Eberhart, J. "Pluto: Limits on its Atmosphere, Ice on its Moon'' in *Science News*, Sep. 26, 1987, p. 207. (1-page news article.)
- Eicher, D. "How to Hunt Down Pluto'' in *Astronomy*, Apr. 1 9B4, p. 35.
- Harrington, R. & B. "The Discovery of Pluto's Moon'' in *Mercury*, Jan/Feb 1979, p. 1.
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- Mulholland, D. "The Ice Planet'' in *Science 82*, Dec. 1982, p. 64.
- Tombaugh, C. "The Discovery of Pluto'' in *Mercury*, May/June 1986, p. 66 and Jul/Aug 1986, p. 98. (The full story by the discoverer.)