

E pur si muove,

- Galileo.

4. DISCOVERY OF PLANET PLUTO.

Planets are with us from the very beginning. The first time when enough conscious mind looked at the sky, and started to ask first questions, must have taken place thousands of years ago. After the Sun and the Moon, the next interesting objects in the sky were planets. From ancient times there were five “moving stars” as they were called. Probably names of the week days originate from this fact. In some languages, like for example Spanish, still names of days of the week are closely matching names of planets. The country of origin of that is probably ancient Babylon, where astronomy was highly developed.

Five planets inherited from Babylon and Egypt by Greece, then by Romans and finally by our civilization, stayed with us for long years, as long as 15th century. That is when Polish astronomer Copernicus first time placed them in the right order. Just to refresh our memory, at that time we had the Sun, Moon, and “moving stars”, five of them: Mercury, Venus, Mars, Jupiter, Saturn. This was the beginning. The next step was possible only when more advanced technology was applied. As for the late 18th century in England, the telescope maker and organist William Herschel still had a kind of Leonardo da Vinci’s mind. In 1781 he spotted Uranus. With a curious mind and a long time spent on sky watching, he was rewarded with this spectacular discovery.

Half a century must have passed, before the next step could have been made. Uranus was very easy to observe. It is almost visible with the naked eye. Neptune on its turn was tricky. It is not that easy to find a moving object, that is not that bright, and the disk is not that easily visible. This is hard. The genius of two mathematicians, and the international effort was needed here. Back in those days there was no photography, and all observations were made “by hand”. There are many objects in the sky that look like planets when viewed through a small telescope. The observer was supposed to check two things, disk-like appearance of the object, and the fact that the object is moving in the sky. Since Neptune is not very bright, it was a very challenging task for the early 19th century astronomers, and help was needed from mathematicians.

Since the discovery of Uranus, astronomers were able to observe small differences in the predicted positions of Uranus in the sky. The observed positions of the planet were not matching predictions. The theory was formed, that the reason for the situation is the impacting heavy object supposedly a planet, located beyond the orbit of Uranus. The task of predicting the position of the hypothetical planet was not an easy one. Two mathematicians solved the problem independently, in England and in France, however they encountered problems convincing local astronomers. A third country was needed to do the observations (I still do not quite understand this), and finally in Berlin German astronomer J. Bodde spotted the planet in 1846. The planet was found this close to the predicted place, that it can be considered one of the greatest achievements of 19th century mathematics (please remember that days there was no computers and WINDOWS). The success was of this scale, that careful observations were performed. Everybody was hoping that by the same token, as in the case of Uranus, Neptune’s positions for sure will not match predictions, and the next planet would get discovered soon. Actually a wishful thinking kind of approach went that far, that indeed some perturbations were supposedly observed. Some guys here and there tried to do the same, as John Couch Adams and Urbain Leverrier in the case of Uranus. Observations, mathematical predictions, calculations, and nothing. Many many years passed, some planet hunters dropped off, some died, some said that maybe Neptune is the last planet. However one guy decided not to give up.

For Percival Lowell the goal was to find the planet 'X' (not only goal, he was also famous for his observations of Mars). He founded his private observatory in 1894 in Flagstaff Arizona, and dedicated portion of his life searching for the planet beyond Neptune. A few times he was very close to finalizing his ultimate dream. It looks like a few times PLuto was missed. It is very sad that Percival Lowell died before PLuto was discovered. In spite of the fact that he himself did not discover the planet, he prepared the groundwork for the discovery. His observatory in Flagstaff Arizona, was ready for the discovery with its new refractor and photographic technique of observations. Clyde Tombaugh was hired for the search of the planet in 1929. The attitude of the young man was needed for the success, he was 24. The idea of the search of the specific region predicted based on mathematical calculations was rejected at that time, and was replaced with the brute force approach. All the area of the sky around the ecliptic was being photographed, down to magnitude 16 (stars almost 10000 times fainter than the dimmest stars visible by the naked eye). The pictures were later scanned with use of the so called "blink comparator" during the day. The idea was, that if there was a moving object it would show up by its movement. Of course everybody thought those days, that a planet if discovered would be a big one. Probably the disk of the planet would be observable was the assumption, like in the case of any other known planet so far.

So , Tombaugh night by night photographed the sky, and during the day he was looking at his pictures "blinking them". Millions of stars were searched, almost unbelievable task. Brute force blind search kind of approach looking for the needle in the haystack. The amazing thing is, that it paid off. In 1930 he succeeded, he discovered the little planet that is the subject of my book.

The existence of the third planet not visible to the naked eye, was announced to the world on 13th of March 1930 (PL's birthday and 149th anniversary of the discovery of Uranus). It was an incredible success. The new planet was discovered, so there must be a disk observable in the sky through a telescope, that was the common way of thinking. The disks are visible for all other planets in the Solar System, and that is the reason why the light of the planet looks stable in the sky, while stars sometimes scintillate. This was the very first surprise in the long chain of "dropped down jaws". There was no disk. No disk ? No way, there must be a disk visible in a telescope, there was one for Uranus and one for Neptune, so there should be one for Pluto. No disk, period. OK, maybe the planet is small but very massive was the assumption. The common thinking was, that PLuto should be responsible for all problems with the Neptune's movements in the sky, so probably it is massive. As somebody observed, since its discovery PLuto started to lose weight, as years went by and better and better techniques of observations were used, the estimated mass of PLuto was disappearing. More and more precise instruments and still no disk observable in the telescope. Finally all the problems with Neptune's positions were explained as errors in earlier observations, so the main reason for keeping PLuto fat was gone. Based on the speed of this phenomenon of the "weight loss", it was observed that Pluto must disappear completely by the end of the century. I am afraid this happened, PLuto finally was almost excluded from the family of planets.

In the meantime more and more facts about PLuto were collected. Its orbit was calculated more precisely, and also there were first suggestions of the atmosphere. PLuto as most of the planets in the Solar System moves around the Sun on the elliptical orbit , it is positioned on the very elongated elliptical orbit though. I guess it is very well known fact that PLuto is not always the farthest from the Sun in the Solar family of objects. It takes PLuto almost 250 years to go around the Sun; during this time, for twenty years Neptune holds the title of the farthest planet from the Sun. In February 1999 PLuto got back to its usual place, and became the farthest planet from the Sun again. Twenty years between the year 1979 and the year 1999, PLuto was closer to the Sun than Neptune. The perihelion, that is the closest point to the Sun on its orbit, PLuto reached in September of 1989.

The orbit of PLuto is inclined to the main plane where all other planets move around the Sun. It is 17 degrees of inclination to the ecliptic to be precise, and that makes it the record holder for big objects in the Solar System, and the second one is Mercury with only seven degrees.

Probably the biggest discovery for Pluto, after the discovery of the object itself, was the discovery of its moon Charon. It looks like the only discovery of its kind in the history of astronomy. In 1978 James Christy noticed that on some pictures, the image of Pluto is unusually elongated on one side, and on some other pictures it is on the opposite side. The conclusion was, that there must be a moon there. It is hard to believe, that in spite of the fact that PLuto is located in the Solar System, the direct observation of the moon was not possible for such a long time. The short distance of Charon from PLuto, plus the long distance to the double system from the Sun, did not allow the ground based telescopes to see the satellite separately. The angular resolution of ground based telescopes is almost exactly a bit too little to see Charon. The so called “seeing” for ground based telescopes is on average around 0.5 arcsecond, that is also more or less the average angular distance between these two objects in our sky. So in a sense it is possible to see both objects separately in extremely good weather conditions (like for example on top of Mauna Kea on Hawaii), when “seeing” sometimes can be as good as 0.3 arcsecond or even less. The catch is that you must know that there is a satellite in order to observe it. Nobody expected PLuto to have a satellite this close and this big, so as a result nobody looked for it. Of course once Charon got discovered, a few observatories during exceptional “seeing” were able to confirm the existence of PLuto’s brother. Charon got discovered in 1978 on photographic pictures like PLuto itself, but accidentally, say it was just a coincidence.

This was the beginning of the real story with PLuto. Somehow the most exciting stories about Pluto are related to its satellite. Shortly after the discovery, astronomers realized that the position of the orbit of Charon is such, that eclipses of Charon by PLuto are just finished, or they will start shortly. Luck again, Charon was discovered before eclipses, seven years before the start of the eclipse season, and the eclipse season happens every 124 years. The eclipse season is a few years long, and during this time one of the objects is passing in front of the other, or is hidden behind the other one. The eclipse season took place between the years 1985 and 1991 (details are described later in the book), and allowed astronomers to add many more details to the description of the little world at the end of our planetary system. Charon is so big when compared to PLuto, that not only it can partly cover PLuto, but also huge shadow is projected on PLuto’s surface. The diameter of Charon is bigger than half of the diameter of PLuto, but only a bit . What astronomers were able to see (during eclipses), is not directly the two objects and the shadow, but just the change of the intensity of light of two combined objects. Just by checking the changes in the intensity of light, astronomers were able to say very much about physical properties of the two different objects. For example that two objects reflect light differently, PLuto is brighter and Charon is a bit dimmer. Another interesting observation is that there are bright and dark spots on PLuto’s surface, big differences, not very typical for other objects in the Solar System. An even more interesting discovery was, that there are seasonal changes on PLuto, related to changes in the atmosphere of PLuto, also brighter polar caps were observed. Also it was discovered that PLuto and Charon are composed of different materials. There is a very important fact that we should clearly mark here. PLuto was at its closest point to the Sun during the eclipse season. It reached perihelion in 1989, during the eclipse season, and because PLuto was that close, it was easier to observe all mentioned details (coincidence). Because its axis of rotation is inclined to its orbit by 122 degrees, during its voyage around the Sun PLuto shows us either its pole or its equator. Now the equator part is exposed to us. During the discovery in 1930 the pole portion was visible from the Earth.

Let us go back to the year 1930. PLuto was discovered during the day, from pictures taken on a few nights of observations. Here is the discoverer himself describing what happened.

“ In January 1930, I rephotographed Gemini. On the crystal night of 21 January, I took first plate of the DELTA GEMINORUM region. Soon after I started the exposure, a strong Northeast wind came up, and the 3rd magnitude guide star (DELTA GEM. (WN)) was darting about wildly, and swelled up to over 2 times the angular diameter of Jupiter (around one arcminute (WN))- completely fading away at times. I never saw worst seeing in my life before or since. I continued the exposure until the end of the hour and quit for the night. The images were badly swollen, but showed PLuto’s image in the right place- consistent with the shift on the 23 and 29 January plates, which I detected at about 4:00 PM Mountain Time on 18 February 1930.”

Please read the book “The Struggles to Find The Ninth Planet” by the discoverer himself, if you are interested in more details, the above text is from this book. It looks like something very special took place on the night on 21st of January, or maybe it is just my imagination, but first time I read the description of the event, I was under an impression like that.

Tombaugh’s effort was a continuation of the effort started by Percival Lowell as early as 1905. In the period 1905 through 1907, the first photographic search was made with a 5 inch lens having the usable field of 5 degrees along the Invariable Plane (plane where most of the planets are located in the Solar System), which is inclined 1.6 degrees to the ecliptic. PL (the symbol for PLuto and also Percival Lowell’s initials) scanned pairs of plates by laying one plate over the other (!), and using a hand magnifier. At that time, PLuto was outside of the search strip, and also too faint to be recorded .This was the first attempt to find PLuto.

In 1911, a photographic search was made mainly in the area of the constellation Libra. It was done with 40-inch reflector, using exposures of ten minutes or less, but due to tangential come (optical imperfection of the reflector), the field was limited to one degree. After one year, this attempt was abandoned. This was the second attempt in search of PLuto.

The next search was performed with use of the borrowed 9-inch camera from Swarthmore College. Nearly 1,000 plates were taken over the considerable area of the sky in the period 1914-1916. Only two of those plates contained the image of PLuto near the plate limit. The Lowell Observatory owned at that time a Carl Zeiss Blink-Comparator for scanning the pairs of plates, but the images of PLuto were missed ! This was the third attempt. If PLuto was discovered at that time, this book would have never been written (this will be explained later). Clyde Tombaugh was shocked when he learned, that these two plates were taken on March 19 and April 7 1915, almost at the worst possible time for detection (PLuto was very close to its stationary point, and was very hard to be detected by its movement in the sky). Tombaugh in his systematic search, in which he was finally successful, used the so called opposition point search approach. The area of the search in his approach was always apposite to the Sun. Thanks to this approach he was guaranteed that the object that he was looking for, would always move in the sky (would never be stationary), and would be visible at its best (pictures taken around midnight when the sky is very dark, and from the closest distance from the Earth).

In 1915 Lowell drastically revised the preferred region of the search to eastern Taurus. This region is in the Milky Way, and the plates were extremely rich in stars, and that slowed down the rate of scanning. Unfortunately Lowell died suddenly of a stroke at the age of 61, and no more planet searching was done for the next 13 years.

THE DISCOVERY OF PLUTO ORIGINAL DOCUMENT

LOWELL OBSERVATORY

Observation Circular

THE DISCOVERY OF A SOLAR SYSTEM BODY APPARENTLY TRANS-NEPTUNIAN

The message sent last night (March 12) to Harvard Observatory for distribution to astronomers read as follows:

"Systematic search begun years ago supplementing Lowell's investigations for Trans-Neptunian planet has revealed object which since seven weeks has in rate of motion and path consistently conformed to Trans-Neptunian body at approximate distance he assigned. Fifteenth magnitude. Position March twelve days three hours GMT was seven seconds of time West from Delta Geminorum, agreeing with Lowell's predicted longitude."

(For ease in finding object was referred to Delta Geminorum.
Position March 12.14 G.M.T. R.A. 7^h 15^m 50^s Dec. 22° 6' 49")

The finding of this object was a direct result of the search program set going in 1905 by Dr. Lowell in connection with his theoretical work on the dynamical evidence of a planet beyond Neptune. (See L. O. Memoirs, Vol. I, No. 1, "A Trans-Neptunian Planet," 1914). The earlier searching work, laborious and uncertain because of the less efficient instrumental means, could be resumed much more effectively early last year with the very efficient new Lawrence Lowell telescope specially designed for this particular problem. Some weeks ago, on plates he made with this instrument, Mr. C. W. Tombaugh, assistant on the staff, using the Blink Comparator, found a very exceptional object, which since has been studied carefully. It has been photographed regularly by Astronomer Lampland with the 42-inch reflector, and also observed visually by Astronomer E. C. Slipher and the writer with the large refractor.

The new object was first recorded on the search plates of January 21 (1930), 23rd, and 29th, and since February 19 it has been followed closely. Besides the numerous plates of it with the new photographic telescope, the object has been recorded on more than a score of plates with the large reflector, by Lampland, who is measuring both series of plates for positions of the object. Its rate of motion he has measured for the available material at intervals between observations with results that appear to place the object outside Neptune's orbit at an indicated distance of about 40 to 43 astronomical units. During the period of more than 7 weeks the object has remained close to the ecliptic; the while it has passed from 12 days after opposition point to within about 20 days of its stationary point. Its rate of retrogression, March 10 to 11, was about 30" per day. In its apparent path and in its rate of motion it conforms closely to the expected behavior of a Trans-Neptunian body, at about Lowell's predicted distance. There has not been opportunity yet to complete measurements and accurate reductions of positions of the object requisite for use in the computation of the orbit, but it is realized that the orbital elements are much to be desired and this important work is in hand.

In brightness the object is only about 15th magnitude. Examination of it in the large refractor—but without very good seeing conditions—has not revealed certain indication of a planetary disk. Neither in brightness nor apparent size is the object comparable with Neptune. Preliminary attempts at comparative color tests photographically with large reflector and visually with refractor indicate it does not have the blue color of Neptune and Uranus, but hint rather that its color is yellowish, more like the inner planets. Such indications as we have of the object suggest low albedo and high density. Thus far our knowledge of it is based largely upon its observed path and its determined rates of motion. These with its position and distance appear to fit only those of an object beyond Neptune, and one apparently fulfilling Lowell's theoretical findings.

While it is thus too early to say much about this remarkable object and much caution and concern are felt—because of the necessary interpretations involved—in announcing its discovery before its status is fully demonstrated; yet it has appeared a clear duty to science to make its existence known in time to permit other astronomers to observe it while in favorable position before it falls too low in the evening sky for effective observation.

—V. M. SLIPHER.

Flagstaff, Arizona
March 13, 1930

Clyde W. Tombaugh

Please notice the beautiful well placed signature of the discoverer (this will be explained later), as well as the information about three points in the sky where PLuto was first noticed, positions of Pluto for days 21st, 23rd and 29th of January 1930 (please notice also DELTA GEMINORUM).

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Below the coincidences related to the discovery of PLuto, and coincidences related to discoveries of details about PLuto system are listed.

1. First in a long search of the planet, PLuto was missed on photographic plates in the years 1914-1916. If PLuto was discovered at that time, it would be too far from the ecliptic and this book would have never been written (this will be explained later).

2. The director of the Lowell Observatory V.M. Slipher started the search himself in April 1929 in the Gemini region. He blinked a few photographic plates himself, and missed PLuto ! (this fact is not well exposed in books, since it was the director of the observatory himself). If PLuto was discovered by Slipher in 1929 this book would have never been written (PLuto was too far from the ecliptic at that time). Later Clyde T. continued the search for the planet. PLuto was discovered many months later, after almost a full circle of pictures around the sky (45 million stars on the photographic plates “blinked” !!!), when Clyde T. was back in Gemini region again.

3. The discoverer (Clyde Tombaugh) was under impression that something very special happened on the night of 21st of January of 1930, exactly at the time when he was taking picture of the very first “discovery point” of PLuto. The strong wind, that he experienced only one time in his lifetime as he described that later in his book, just a coincidence (or maybe just my imagination). The fact is that the quality of the picture taken on 21st of January was very bad (this is not my imagination).

4. The telescope used by C.T. for his famous discovery, was a 13-inch refractor with a focal length equal 1700 mm. Therefore on photographic plates used for taking pictures the scale was equal 30 mm for one degree. It is very easy to calculate that by using 17 by 14 inch plates, the sky was covered seven degrees north and seven degrees south from the ecliptic. The inclination of the orbit of Mercury is equal seven degrees, and it was the highest value known. All known planets in the year 1930, before the discovery would fit in this area. However, PLuto has inclination equal 17 degrees. Nobody expected this high value of inclination. As a result PLuto could have been outside of the area of the sky where it was searched for. It just happened that it was inside, in spite of the fact that the probability was higher for PLuto being outside (!). Please think about it. The probability for being inside the search area is equal $7/17$, and for Pluto positioned outside of the search strip is equal $(17-7)/17 = 10/17$. Pure luck, Pluto was at the right place at the right time. Of course if PLuto was not there it would not be found by Clyde Tombaugh.

5. The discovery of PLuto took place very, very close to ecliptic, as a result all three original discovery points are in the area eclipsable by the Sun. PLuto could have been discovered somewhere else in the sky, farther from the ecliptic. The probability of discovering PLuto only ten arcminutes from the ecliptic I estimate to $1/6$ (10 arcminutes divided by 60 arcminutes in one degree) multiplied by 17 (inclination of PLuto’s orbit to the ecliptic in degrees), this is around one in one hundred. Please note that neither Uranus nor Neptune were discovered this close to ecliptic, in spite of the fact that the probability was much higher for these planets, since their inclinations to ecliptic are much lower (0.8 degrees for Uranus, 1.8 degrees for Neptune, while PLuto’s inclination is 17). Of course both planets were not discovered on photographic plates, since there was no photography in the late 18th century and early 19th century. However, based on the date of discovery we can precisely calculate their positions for the moments of discoveries.

From the point of view of time, PLuto was in the proper area only for a “short while” in comparison to its 248 years long time for one rotation around the Sun. To be more precise, only less than two years there was a chance of catching Pluto in the area eclipsable by the Sun, so close to ecliptic, and this happened (!).

6. The discovery of PLuto in the sky took place very close to the star DELTA GEMINORUM and this star is the brightest star of all in the area eclipsable by the Sun. In fact this star almost marks the place in the sky where the orbit of PLuto, crosses the plane of the ecliptic. This is the so called node of the orbit of PLuto. PLuto happened to be very close to its node during the discovery. Of course there is one more node, on the opposite side of the sky. This position PLuto will reach in the year 2054. There is no special star at the other node of PLuto's orbit, the only node that is marked by the star (the brightest of all that the Sun can eclipse) is the one where PLuto was discovered.

7. Clyde Tombaugh referred to the star DELTA GEMINORUM in his original discovery document (probably not realizing that the star is the brightest of all eclipsable by the Sun, since from a scientific point of view it does not matter). PLuto passed this close to the star shortly after the discovery (less than one arcminute ! The odds are equal $1/180 \text{ degrees} * 60 \text{ minutes/degree} = 1/10800$!), that Clyde T. decided to expose this fact in his Observation Circular. Please read it carefully - "...For ease in finding object was referred to Delta Geminorum...".

8. In his document C. Tombaugh clearly mentioned three discovery points 21st, 23rd, 29th of January 1930, in spite of the fact that he discovered PLuto blinking pictures taken on 23rd and 29th. My guess is that the quality of the picture from 21st of January was very bad (strong wind)

In his search C.T. was taking three pictures and was selecting the best two for blinking. Originally only two pictures used to be taken, but in September 1929 Clyde T. all of the sudden started to take three pictures, in order to be able to select the best two for blinking (?).(You will understand later why three pictures are so important from the point of view of my book.)

9. PLuto's moon Charon was discovered in the year 1978 by accident, on photographic plates. One can easily imagine that Charon would have not been discovered for a few more years, up to the time of Hubble Telescope (1990 - after mutual eclipses in PLuto+Charon system). This is a big coincidence (!).

10. Charon was discovered just seven years before the eclipse season of PLuto+Charon pair. If it was discovered a few years later, after the eclipse season, we would not know that the maximum eclipse time is coincidentally related to the closest point of PLuto on its orbit around the Sun. This book would have never been created in such a case (it will be explained in details later). Thanks to mutual eclipses (1985 -1991) of PLuto+Charon many facts about both objects were collected, including estimations of masses and sizes. Please remember that the eclipse session in the PLuto+Charon system happens every 124 years.

11. The end of the century, and PLuto just passed through its closest point to the Sun called perihelion, this took place on 5th of September of 1989. PLuto was visible better thanks to the closer distance to the Sun, and allowed us to look closer at its structure. For twenty years (1979 - 1999) PLuto was our guest. It was closer to the Sun than Neptune, we must wait almost 240 years for the next visit of PLuto.

12. One more thing that should be mentioned here. After the incredible success with mathematically predicted position of Neptune, and the discovery made based on that, many people tried to calculate the position of the next planet. Of course PLuto is very small, and could have not perturbed positions of Neptune, and Uranus in the sky. On the other hand nobody knew that. Everybody expected the new planet ' X ' to be very similar to Neptune. Many people tried to calculate and predict the position of the unknown planet. By coincidence, the data that Percival Lowell used for his search, predicted the position of the planet ' X ' not far from the place in the sky where PLuto was really positioned. Some books expose this fact as a great success, this is too far going speculation with facts for me.