

New planets in the solar system — Uranus, Ceres and so on

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Abstract

The discovery of new planets and other celestial bodies in our solar system is discussed focussing on the end of the 18th and the beginning of the 19th century and on questions concerning names, terminology and classification concerning the newly discovered bodies.

1 Introduction

For many millennia there had been seven planets, the sun, the moon, Mercury, Venus, Mars, Jupiter, and Saturn. In the heliocentric system the Sun is surrounded by six planets, Mercury, Venus, Earth, Mars, Jupiter, and Saturn, the moon being the other bright object in the sky.

The first newly discovered celestial bodies in the solar system were the four satellites of Jupiter in 1610. For Galilei the satellite system of Jupiter was a small model of the solar system. However, together with the discovery of Saturn's ring the old image of the planets Jupiter and Saturn as single bodies in their orbits was already destroyed.

Still, the ancient system of planets worked till the discovery of Uranus in 1781. Herschel's discovery made it necessary to revise this ancient system of six or seven planets. Now it became clear that the "perfect" system of the past had been incomplete. Uranus was a planet which was larger than all the inner planets and could not be neglected.

Moreover, the discovery of Ceres in 1801 (i.e. only twenty years later) and further asteroids in the following years began a new era in the investigation of the solar system.

Two important aspects are nearly left aside here in this paper since they are dealt with in detail in many other papers and books. The emergence of the so-called Bode's law played a role in connection with the search for new planets. However, it was not decisive for the questions discussed here.

Also the already systematic search for an unknown planet beyond Uranus which led to the discovery of Neptune in 1846 will not be touched here in detail.

My paper will focus on the years between 1781, the time when new planets in the solar system were (nearly) unexpected till 1802, the time when it was already discussed how to classify possible new bodies.

2 The solar system without Uranus

2.1 Galileo Galilei

[2]

I should disclose and publish to the world the occasion of discovering and observing four planets, never seen from the beginning of the world up to our own times three little stars, small but very bright, were near the planet there are three stars in the heavens moving about Jupiter, as Venus and Mercury around the Sun.

These words of Galileo Galilei [2] describing his discovery of the later called Galilean satellites of Jupiter in 1610 mark an important step in the development of the knowledge of our solar system. The sun, the moon, and the five planets Mercury, Venus, Mars, Jupiter, and Saturn had been known to mankind from the beginning on, i.e. it is impossible to say who recognized them for the first time and when. In all ancient cultures the regular movement of the sun and/or the moon was used for calendrical purposes. The movement of the other five planets with respect to the fixed stars caused the attention of ancient peoples and made them attach a special role to these planets, as far as mythology and religion is concerned. Probably our seven day week is derived from these seven planets. At least in many European languages the

names for the seven days of the week are related to the seven planets, at least partially.

The new instrument called telescope made Galilei's discovery possible. The existence of four satellites of Jupiter was not only a breakthrough concerning the acceptance of the new Copernican system. Galilei compares the satellites of Jupiter surrounding Jupiter to Venus and Mercury surrounding the sun. It also opened the mind for further possible planets within this solar system.

By the way, Galilei had nearly discovered Neptune as a planet in 1612. However, his telescope was not strong enough, and the movement of Neptune relative to the fixed stars was too slow. So Galilei regarded Neptune as a regular star. For further details see [1].

The other important contribution of Galilei was the discovery of Saturn's ring, also in 1610.

2.2 Further discoveries in the 17th century

Now Jupiter and Saturn were no longer the single planets in their orbits around the sun. Moreover, comets had been discovered to be objects in the solar system and not just phenomena within the terrestrial atmosphere.

After the discovery of Io, Europa, Ganymede, and Callisto as satellites of Jupiter by Galilei in 1610 also satellites of Saturn were discovered in the second half of the 17th century:

Titan by C. Huygens in 1655, the other four by G. Cassini in 1671 Iapetus, in 1672 Rhea, and in 1684 Diane and Tethys.

But still there was the system of planets themselves as the main bodies in the solar system, now in the Copernican system six planets from Mercury to Saturn surrounding the sun. Could it be possible that there is another planet in the system comparable in size and behaviour to the other six?

2.3 Are there further planets? — The 18th century

On the first sight it looks as if no further planet could be expected. The system of ancient planets was still so deeply imbedded in the general culture of the people, and the newly found satellites of Jupiter and Saturn and Saturn's ring were too different from planets in order to disturb this image.

A closer look, however, shows that there were scientists, mainly in the 18th century, who were at least not sure that there are no further planets. In a paper on Bode's Law Hoskin [6] cites authors who discuss possible still undiscovered planets. Some of these citations are partially cited here for the convenience of the reader.

William Wall (1727):

I think it very probable, that there are, belonging to the Sun, a great many more planets, than what we see, some perhaps *within* the Orb of *Mercury*, never seen nor to be seen by us; but a great number *without*, or beyond the Orb of *Saturn*, which we can never see

Wall regards the existence of further planets very probable. He seems to assume that at least some of them will never be seen by humans because of their remoteness.

More implicitly like other authors William Whiston shows that there could be further planets by just saying "the known planets" instead of "the planets".

William Whiston (1717):

Mercury is the nearest to the Sun of all the known Planets Saturn is the highest and most remote of all the known Planets.

There is another author in the middle of the 18th century Thomas Wright of Durham who clearly claims that "I am far from supposing our present knowledge of ye solar system perfect and fully known".

Apart from this general but wise statement he interestingly compares the states of astronomical and geographical knowledge of his time as follows.

Thomas Wright (around 1750):

Is it not more reasonable to imagine a coelum in cognito beyond ye known planets than to suppose a terra in cognito at present upon Earth.

Concerning the knowledge of the earth in the middle of the 18th century there were still ideas of an unknown continent (terra incognita) although most of the surface of the earth had been known already. Wright's ideas

above well reflect the impression that the known part of the sky is even much smaller.

Nearly at the same time Kant expressed the idea of an unknown planet because of the existence of comets with high eccentricity.

Immanuel Kant (1755):

Should there be between Saturn, the outermost of planets which we know, and the least excentric comet which descends to us from perhaps a distance 10 and more times greater, no more planet whose motion would come closer to the cometary motion than that of Saturn

A few years later Bonnet stated that 17 planets were known, counting all the bodies in the system as planets including the sun and the satellites. In this context he realized that the number of "planets" had increased since the beginning of the 17th century. Hence he was not at all sure that the number 17 is the end of the story. It is not clear whether he thought of further satellites or further planets themselves.

Charles Bonnet (1764):

We know seventeen planets but we are not sure that there are no more.

The fact that the distances of the planets show a relatively regular pattern lead to the formulation of Bode's law which will be left out in the discussion of this paper. It made new planets "possible" between Mars and Jupiter more than outside of the orbit of Saturn.

Around 1780, however, a new planet farther away than Saturn was not really expected. Even no new satellite of one of the major planets had been found since 1684, i.e. nearly a century ago.

3 Herschel discovers Uranus

On March 13, 1781 an astronomical discovery should answer the question for a new planet in the solar system. It proved the ancient knowledge of planets to be incomplete. However, it brought back the seventh planet as reconciliation, after the exchange of the geocentric system into the heliocentric one had decreased the number of planets from seven to six.

Like with Neptune (see above) it was not the first time that Uranus was seen through a telescope. The first name of Uranus was 34 Tauri, investigated by Flamsteed in 1690 as a star in the constellation of Taurus in his star catalogue.

J.-D. Cassini (1784):

A discovery so unexpected could only have singular circumstances, for it was not due to an astronomer and the marvelous telescope was not the work of an optician; it is Mr. Herschel, a musician, to whom we owe the knowledge of this seventh principal planet.

The above characterization of Cassini, the director of the Paris Observatory, is a good observation. It was a musician in England who in his free time built huge telescopes who made this discovery. Although Herschel is today known as a great astronomer, it was only the discovery of Uranus who made him an astronomer. Within a short time he had enough financial support and recognition in the English society. Hence Herschel could stop his musical activities and could focus on the building of new telescopes and new observations of the sky.

On the one hand, Herschel was the "new star" of King George of England who supported him generously. On the other hand, Herschel wanted to call the new planet "his star", i.e. King George's star (Georgium sidus). Many others proposed Herschel as the new planet's name. Only much later Uranus was generally accepted as the name of this "seventh principal planet". Its role as a major planet was never in doubt after it became clear that it was even the third largest of all the planets.

It was mainly the triumph of the new technology and maybe the openness of a very talented outsider who was responsible for the discovery of Uranus. The discovery as such could not be neglected and certainly brought the science of astronomy into a popular and leading role in the society.

The discovery of Uranus, of course, supported the idea of further possible planets. Hence another discovery 20 years later came not so unexpected.

4 Piazzis discovers Ceres

4.1 Giuseppe Piazzi

In the first night of the 19th century, on January 1, 1801, Piazzi in Palermo discovered a further body of the solar system, the first asteroid (concerning the name see below) Ceres. He was soon followed by Olbers (discovery of Pallas in March 1802), Harding (Juno in September 1804) and again Olbers who discovered Vesta in March 1807.

Piazzi's discovery led to a big international achievement in order to determine the orbit of the new body. In some sense it was the beginning of modern celestial mechanics (Gauss). Again in doubt was the name for the new body. Moreover, the question was how to classify these new bodies, even after the second (Pallas) had been found, and they both were much smaller in size.

4.2 The discussion of von Zach

In a paper of 1801 [7] von Zach discussed the names of celestial bodies. He remarked that the ancient planets have Roman (Latin) names like Jupiter although astronomy was a Greek rather than a Roman science. Now Herschel's planet had been named Uranus which is Greek. Von Zach proposed how to continue in a reasonable way. Whenever there should be found a planet beyond Uranus it must obtain a Greek name. However, later the eighth planet was called Neptune, and not Poseidon.

F.X. von Zach (1801): ...alle Planeten führen Römische und nicht Griechische Namen nach der Sprache Latiums, Coelus zu benennen.

Alle älteren Planeten, deren Entdeckung sich in die Dunkelheit der Zeiten verliert, mögen daher ihre Lateinischen Namen beybehalten.

Alle neueren Planeten sollen zur Unterscheidung Griechische Namen führen. Was Unterbrechung der Analogie schien, wird nun zur Harmonie. Sollte je jenseits des Uranus noch ein Planet entdeckt werden, so sey Griechisch seine hieroglyphische Benennung.

Von Zach proposed Hera as the name for the new planet (he even used the words "achter Hauptplanet"). This Greek name of a town in Sicily seemed

reasonable to him because of Piazzi and Palermo. Von Zach was not successful in this aspect, neither with Hera nor with the idea of an eighth planet. Ceres is a Sicilian goddess whose name was given to the celestial body by Piazzi.

4.3 Herschel's classification

Only one year after von Zach's paper a further "planet" was discovered by Olbers, comparable in size to Ceres (again much too small for a "Hauptplanet") and even quite close to Ceres concerning their distance from the sun.

This lead Herschel to consider the case more systematically [5].

In my early account of the moving star discovered by Mr. PIAZZI, I have already shewn that it is of a remarkably small size, deviating much from that of all the primary planets. But the very interesting discovery of Dr. OLBERS having introduced another moving star to our knowledge,

Herschel compared the "new Stars" (of Piazzi and Olbers) with his "GEORGIAN planet" and made him set up seven criteria for planets in order to distinguish them from stars and comets.

[5]

I should, for instance, say of planets,

1. They are celestial bodies, of a certain very considerable size.
2. They move in not very excentric ellipses round the sun.
3. The planes of their orbits do not deviate many degrees from the plane of the earth's orbit.
4. Their motion is direct.
5. They may have satellites, or rings.
6. They have an atmosphere of considerable extent, which however bears hardly any sensible proportion to their diameters.
7. Their orbits are at certain considerable distances from each other.

In the following Herschel discusses the "new stars" Ceres and Pallas concerning these seven criteria and concludes not to call them planets because of their small size (1), their geocentric latitudes (3), the lack of an atmosphere (6), and the fact that the orbits of Ceres and Pallas are too near to each other (7). Ceres and Pallas fulfill the criteria (2), and (4) whereas the existence of satellites or a ring (5) is unknown.

Herschel then gives five criteria for comets as follows.

[5]

1. They are celestial bodies, generally of a very small size, though how far this may be limited, is yet unknown.
2. They move in very excentric ellipses, or apparently parabolic arches, round the sun.
3. The planes of their motion admit of the greatest variety in their situation.
4. The direction of their motion also is totally undetermined.
5. They have atmospheres of very great extent, which shew themselves in various forms of tails, coma, haziness, etc.

After a detailed discussion Herschel cannot call the "new stars" comets. Hence he introduces a new term and defines "asteroids".

[5]

Since, therefore, neither the appellation of planets, nor that of comets, can with any propriety of language be given to these two stars, we ought to distinguish them by a new name, From this, their asteroidal appearance, if I may use that expression, therefore, I shall take my name, and call them *Asteroids*; planets, asteroids, and comets will in future comprehend all the primary celestial bodies that either remain with, or only occasionally visit, our solar system.

Asteroids are celestial bodies, which move in orbits either of little or of considerable excentricity round the sun, the plane of which may be inclined to the ecliptic in any angle whatsoever. Their motion may be direct, or retrograde; and they may or may not have considerable atmospheres, very small comas, disks, or nuclei.

This definition is "sufficiently extensive to take in future discoveries" [5].

5 The discovery of Neptune

As already explained above the development of the search for further planets will not be discussed here in detail. After further discoveries of minor planets the search for an transuranian body was successful in 1846, e.g. see [3]. On the very day of its discovery by the Berlin astronomer Galle the following letter of Alexander von Humboldt was sent to Caroline Herschel, the sister of William Herschel.

[4]

Berlin, 25. Sept. 1846

Geehrteste Frau und Freundin!

In Anerkennung der bedeutenden Dienste, welche Sie der Astronomie als Mitarbeiterin Ihres unsterblichen Bruders, Sir W. Herschel, durch Entdeckungen, Beobachtungen und schwierige Berechnungen geleistet haben, beauftragte mich Sr. Majestät, der König, vor seiner Abreise nach Schlesien, Ihnen in seinem Namen die goldene Medaille für Wissenschaft zu überreichen,

Aber ich weiß, daß ich auf Ihre Verzeihung hoffen darf,, und bitte um diese Milde besonders heute, dem Tage, an welchem mein junger Freund Dr. Galle, der astronomische Assistent an unsrer Sternwarte (zum Triumph der theoretischen Astronomie sei es gesagt) den transuranischen Planeten aufgefunden hat, welcher von Leverrier als Ursache der Störungen des Uranus angezeigt wurde.

Ihr Alexander Humboldt

It is often forgotten that Caroline was not only the sister of William but an important astronomer of her own. On the occasion of her 96th birthday Caroline Herschel is informed by von Humboldt to have been awarded the golden medal for science by the Prussian king. The letter came half a year late, in fact, due to an error in a French lexicon of astronomy concerning Caroline Herschel's birthday.

However, it came exactly in time concerning the discovery of a new planet. Here von Humboldt just speaks of a transuranian planet. There are no longer difficulties with terminology. Moreover, the new planet later called Neptune did not come as a surprise like Uranus 65 years earlier. It had more or less been expected because of the orbit calculations for Uranus.

6 Conclusion

The historical discussion of this paper ends in 1846 with the discovery of Neptune. In 1930 Pluto as the ninth planet was discovered. Until recently it seemed clear that there are nine planets in our system, apart from satellites, asteroids, comets, and other smaller bodies.

Since 1992 the situation is changing. In this year the first transneptunian member of the Kuiper belt was discovered (1992QB1) with a semi major axis of 44.35 AU. Among these Kuiper belt objects (KBO) the most remarkable are Varuna (20,000 Varuna), found in November 2000 and Quaoar (2002LM60), found in October 2002. Not only they were given names of non-European mythology. Varuna is an Indian god, and Quaoar is a god of the pre-Columbian Indians of California. Also in size they reach half of Pluto's diameter.

It looks as if the questions of 200 years ago which were discussed in this paper concerning how new bodies in the solar system should be named and how they should be classified are still important today.

A sentence like "There are nine planets in our solar system" is no longer accepted without discussion. Probably either Pluto will lose its status as a planet or further bodies will have to be accepted as planets.

The look into the future, however, is not the task of a historian. On the other hand, the history of astronomy can teach us to be a bit more careful about the astronomical knowledge of today. Many people are so convinced that just now our knowledge in astronomy and science is without errors and more or less complete. Even this nice picture of nine planets in our solar system which dominated most of the 20th century may turn out as incomplete knowledge.

References

- [1] S. Drake, C.T. Kowal, Galileo's sighting of Neptune, *Scientific American* 243 (6) (1980), 52-59.
- [2] G. Galilei, *Sidereus Nuncius*, Venezia (1610).
- [3] M. Grosser, *The discovery of Neptune*, Cambridge (Mass.) (1962).

- [4] J. Herschel (ed.), *Caroline Herschel's Memoiren und Briefwechsel (1750-1846)*, Berlin (1877).
- [5] W. Herschel, *Observations on the two lately discovered celestial Bodies*, *Philosophical Transactions* 92 (1802), 213-232.
- [6] M. Hoskin, *Bode's law and the discovery of Ceres*, in: J. Linski, S. Serio (ed.), *Physics of solar and stellar coronae*, Dordrecht (1993), 21-33.
- [7] F.X. von Zach, *Über einen zwischen Mars und Jupiter längst vermutheten, nun wahrscheinlich entdeckten neuen Hauptplaneten unseres Sonnen-Systems*, *Monatliche Correspondenz* (1801), 592-623.