Mem. S.A.It. Suppl. Vol. 22, 26

Memorie della
Supplementi

Boscovich, the discovery of Uranus and his inclination to theoretical astronomy

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Abstract. On March 13th 1781 Frederick William Herschel observed a bizarre celestial body moving in the sky. Retrospectively, that astral body was not at all new at that point. It was observed by a number of astronomers since the end of 17th century (and maybe earlier). But they failed to find out its motion and catalogued it as a fixed star – each time a different one. On the other hand, Herschel realized it was moving, and catalogued it as a comet. That news of a new finding in the sky rapidly spread throughout Europe, and after some months the 'Herschel's comet' was correctly recognized as a new planet, which will be named Uranus. The present paper assumes the event of the discovery of Uranus and the assessment of its planetary nature as a system of complicated, interrelated processes which involved a number of actors in the 17th-century astronomical community. In this framework, the role of the Dalmatian-born jesuit scientist Ruggiero G. Boscovich is emphasized and the meaning of this discovery is discussed as an example of his interest in theoretical research more than in observational science.

1. Introduction

On March 13th 1781 Frederick William Herschel, born Friedrich Wilhelm, originally a German composer who made his own way in England as a skilled astronomer, observed a 'new' celestial body in the sky over Bath (Somerset), where he had established his instruments – originally as an amateur – in the garden of his house. Since 1779 he was attending a programme devoted to the survey of all the stars in the sky, with special attention for double stars. In March 1781, after having catalogued the stars of 4th magnitude, he begun more ambitiously with those brighter than 8th. On the night of March 13th, something drew his attention "in the quartile near Zeta Tauri", as he wrote down in his journal: he saw a brilliant disk which have the "curious" appearence of "either [a] Nebulous Star or perhaps a Comet", becoming convinced four nights later that it was indeed a new comet "for it has changed the place" (Miner 1990 p. 17). In the following months a consensus was reached amongst astronomers that such comet was in fact a planet. After discussion, it prevailed for the new finding the name advanced by the German astronomer Johann Elert Bode: Uranus.

Retrospectively, as early as March 1781 that astral body was not at all new. By the end of 1781, Bode succeeded in proving Uranus identity with the corresponding 'stars' in Flamsteed's catalogue and other catalogues (Bode 1781, pp. 218-219). An object of 6th magnitude, it was observed by a

Send offprint requests to: L. Guzzardi number of astronomers since the end of 17th century (and maybe earlier): John Flamsteed (1690, 1712, 1715), James Bradley (1748, 1750, 1753), Tobias Mayer (1756), Pierre Charles Le Monnier (1750, 1768, 1769, 1771). And yet, because of the big distance involved, they failed to find out its motion and catalogued it nearly everytime as a different star in the sky. However, Herschel could see its motion, therefore realizing it was no star and suggesting it was a comet. But alternative claims ascribing a planetary nature to the object, came as Herschel notified the new finding to the Astronomer Royal, Nevil Maskelyne. This happened just some days after Herschel's early observations. Through Maskelyne, the news of a new object moving in the sky (perhaps a comet or more spectacularly a planet) was spread throughout the European scientific community.

Other doubts about the cometary hypothesis advanced by Herschel in his communication to the Royal Society on March 26th (Herschel 1781) were raised by the French Astronomer of the Navy Charles Messier, who pointed out that the moving body they were observing actually appeared to have none of the usual characters of a comet (for instance, tail and coma).

As Maskelyne indicated in a letter to Herschel on April 23d, only accurate calculations of the path could prove whether it was a "regular planet moving in an orbit nearly circular round the sun" or "a Comet moving in a very eccentric ellipsis" (Miner 1990, p. 17). The Swedish astronomer Anders J. Lexell is commonly regarded as the first to have found (June 1781) an appropriate quasi-circular orbital path, proving it was a planet; however, at that time the "new" celestial body was no longer such sensational breaking news, for many other researchers (amongst others Ruggiero Boscovich, Angelo de Cesaris, Joseph-Jérôme de Lalande, Pierre F.A. Méchain, Barnaba Oriani, Jean Baptiste de Saron, etc.) were trying to find out its nature and determine its path.

As pointed out by some historians of science, this facts makes particularly difficult to establish with finality who in fact came first (Dadić 1965, p. 211 and Kuhn 1977, pp. 170-173). To begin with, from Boscovich and Lalande's works we know that as early as May 1781 Saron concluded that the distance of the observed object from the Sun was very large, comparable to the known distance at the present day (i.e. approximately between 18 and 20 UA). Then, Saron and Méchain applied Boscovich's general method for the determination of orbits and calculated an approximately circular path, typical for a planet. This is at least Boscovich's opinion, emphasizing Saron's and Méchain's contributions to the application of his methods for the determination of cometary and planetary paths (see Boscovich's own account of the early history of Uranus discovery in Boscovich 1785, pp. 474-476).

So, who discovered the *planet* Uranus? Part of the answer depends on what is considered to be the peculiar mark to a particular discovery. If the initial stimulus is the most prominent feature, then the discoverer of Uranus was Herschel; but note that what made his discovery astonishing, namely that it is a planet, is due to ideas and calculations in which he played no role. If results are regarded as the essential aspect, then the discoverer was Lexell, because his calculations were more correct than others; but this hypothesis sounds even more arbitrary than the previous one because his priority is questionable and the parameter of correctness is fuzzy, either too strict or too loose.

Indeed, should we require an exact correctness, a perfect identity with calculations performed by us? Surely not, at least because our computation is also affected by (minor) errors due to assumptions, instruments and approximations. One could reply, for a calculation to be correct only small differences between current and past results should be allowed; but how small should a small difference be? And to what extent could small differences between calculations be regarded as trifling?

Furthermore, there is a fundamental question in the discovery of Uranus that seems to be overlooked in considering only individual contributions: the non-independency, and even the interdependence, of the researchers involved in the discovery of Uranus. This was a complicated process, from the early observations until the determination of its nature as a planet; and astronomers shared their observational data, views, methods, and computations in private letters and communications mostly before they published their results. This entire process may be termed "shared discovery". Though historians and philosophers of science usually stress the cases of scientific discoveries made by independent researchers, a more complicated process of sharing knowledge can be proven to underlie many scientific discoveries in the development of modern science, from the circulation of blood (traditionally ascribed to William Harvey in XVII century) to the introduction of the neutrino (generally attributed to Wolfgang Pauli's conjecture in 1934; see Guzzardi 2012 for more details).

An implication of this view is that a better understanding of such discoveries can be reached by investigating the "network" of scientists involved and their microcommunities and research traditions. In what follows I focus on Boscovich's network of professional and amateur colleagues in astronomy in order to account for Boscovich's own contribution in the process of discovering the planet Uranus. I will not give a whole account of Boscovich's works about the determination of Uranus path, partly because there is already a literature about this particular issue (Dadić 1965 and Dadić 1993); rather I will limit myself to reconstruct the different phases through which Boscovich became convinced of Uranus planetary nature starting from Herschel's cometary hypothesis. In the final section I discuss Boscovich's style in scientific research, pointing out his theoretical attitude. This could also provide a first hint – pointing to a topic which I can't expand on here – in order to account for Boscovich's scientific personality and his "scientific self" in the sense explored by Daston and Galison (2007).

2. A kind of a sorting post office

While Herschel was making his survey in Bath in 1781, Boscovich was in France since about ten years. In august-september 1772, as a consequence of the continuous fight with his jesuit collegues at Brera Observatory in Milan, he was removed from his office at the observatory. Nevertheless, his post as professor of optics and astronomy in Milan was preserved. He accounted for his behaviour and the scientific activities carried out in Brera in a detailed memorandum addressed to Milan plenipotentiary Carlo Firmian, but having as its last receiver Prince Kaunitz, the powerful *Staatskanzler* of Habsburg Monarchy, in charge for Austrian foreign affairs. The memorandum was intended by Boscovich as a defence of his own conduct; but he also blamed Brera Director Louis de La Grange and other collegues for hostility and intrigue against him (see Proverbio 1987).

The story came to an end only at the beginning of 1773, when Boscovich finally resigned his professorship. He initially thought of going to Poland, maybe travelling at first to his native Ragusa, where his mother was still alive. But the suppression of the Jesuit order (1773), rapidly extending from the European countries to the Papal State, made the things worse, and Boscovich accepted his French friends' suggestion to go to France, where he would be appointed as the Director of Naval Optics of the French Navy (for biographical details, see Hill 1961, pp. 85-91). During his twenty-years-long stay in France, Boscovich wrote his masterpieces in optics and astronomy, which he published only in 1785 in Bassano del Grappa under the collective title *Opera pertinentia ad Opticam et geometria*, in five volumes, (Boscovich 1785), dedicating it to King Louis XVI.

In France he had influential friends in science and politics like Lalande, Messier and Saron, who would give their contribution to the determination of Uranus orbit. In a letter Boscovich wrote in 1779 to his former pupil Francesco Puccinelli we can see a first assessment of these scientific contacts. At that time Boscovich was hosted at Prince Franz-Xaver von Sachsen's home in Pont-sur-Seine: "I came here to this Prince of Saxony, where I remained for two weeks in pleasant company: then, three leagues away from here, I visited Monsieur Saron, the President a Mortier of the

Table 1. Boscovich's letters about Uranus

Place (Boscovich)	Date	Receiver
Pont-sur-Seine	1781 April 29th	A. Cesaris (Brera)
Pont-sur-Seine	1781 June 10th	F. Reggio (Brera)
Noslon (Sens)	1781 July 4th	Reggio/Cesaris (Brera)
Noslon (Sens)	1781 July 8th	Reggio (Brera)
Noslon (Sens)	1781 July 15th	Reggio (Brera)
Noslon (Sens)	1781 July 15th	Natale Boscovich*
Bignon	1781 August 5th	Cesaris (Brera)
Bignon	1781 August 10th	Natale Boscovich*
Moussau (Boynes)	1781 September 8th	Puccinelli*
Moussau (Boynes)	1781 September 22nd	Cesaris (Brera)
Moussau (Boynes)	1781 September 29nd	Cesaris (Brera)
Moussau (Boynes)	1781 October 6th	Reggio/Cesaris (Brera)
Moussau (Boynes)	1781 October 11th	Cesaris (Brera)
Moussau (Boynes)	1781 October 13th	Reggio/Cesaris (Brera)
Paris	1781 November 19th	Cesaris (Brera)
Paris	1782 January 7th	Cesaris (Brera)
Paris	1782 January 28th	Cesaris (Brera)
Paris	1782 February 18th	Cesaris (Brera)
Paris	1782 March 25th	Cesaris (Brera)

Parliament of Paris: he is a great man of letters and a great connoisseur of astronomy, possessing many astronomical instruments which he brings along. He loves all my methods and understands them very well, and makes his own calculations basing on them, and draws: he is the most honest, friendly, modest man of the world [...]: I very delightfully and most peacefully spent fifteen days together with them and Monsieur Messier, who was there and is a truly friend of mine" (Boscovich 2009b, p. 160).

During his long stay in France, Boscovich did not lose his scientific contacts with Italy. Writing to Puccinelli in Pescia (Tuscany) two years later, he gave a brief account of his research on the strange new 'comet' first observed by Herschel in 1781. But the very interesting piece of correspondence about it is represented by Boscovich's letters to Brera astronomers. They were firstly published in 1912 by the Jugoslavian Academy of Science and Arts and then in 1938 in a new edition by Giovanni Virgionio Schiaparelli, the Director of the Observatory of Brera in Milan (Schiaparelli 1938). This book contains sixteen of the letters written by Boscovich on 'the planet-to-be' Uranus. The letters are listed in Table 1. Though they do not appear in Schiaparelli's edition, the Uranus-letter to Puccinelli as well as the correspondence with Natale Boscovich about Herschel's finding, quoted in the present paper, are marked with (*) in the list in Table 1.

In the first letter on 29th of April 1781 to Andrea de Cesaris, who was a leading astronomer in Brera, Boscovich said he was willing to forward an annex addressed by Messier to him and Francesco Reggio. Then he added: "He [Messier] add up for me Mr Maskelyne's observations and those made by others in England from the 1st April to the 16th, while the observations by himself [i.e. Messier's observations] are from the 16th till the 24th. Monsieur de La Lande, in a letter I received the day before yesterday, had sent me three observations [...]". (Schiaparelli 1938, pp. 62-63).

In the Archives of the Astronomical Observatory of Brera you can find the annex together with the letter quoted above. Indeed, it contains Maskelyne's and Messier's observations, with additional data by J.-J. de Lalande; unfortunately, this was clearly a mistake made at the time the Archive was organized under Schiaparelli's supervision. Of course there are Maskelyne's and Messier's observations in April reported in Boscovich's letter; but there are also observations by Lalande which date on May, and Boscovich's letter dates on April 29th. (The manuscript is to be found in the Archivio storico dell'Osservatorio di Brera, Corrispondenza scientifica, cart. 83).

You could think that an error might have been occured in writing here "May" rather than "April", maybe in a moment's inattention. But after confrontation with the observations taken in Paris in May 1781 and published by Lalande in his paper about Uranus (Lalande 1782, p. 539), we have to infer there was no error here. Data were really got in May. Rather, the mistake has been made by Schiaparelli's archivist in ordering the Brera Archives. So, this sheet of paper has surely been transmitted later than the end of April, maybe with the second known letter by Boscovich, on June 10th, or maybe later (for a more detailed account, see Guzzardi 2012).

To a better judgment, the real attachment to Boscovich's April-29th-letter should be identified with the only piece of correspondence between Charles Messier and Brera astronomers which is preserved at the Brera Archives. This letter, written in French, was addressed to the Messieurs Reggio et Cesaris,– / Astronomes de Milan" and announces Herschel's finding. A transcription of it is given in Table 2 (the original letter is preserved in the Archivio storico dell'Osservatorio di Brera, Corrispondenza scientifica, cart. 83)

Note that Messier does not mention Herschel because he got the news from Maskelyne, and the name of Herschel was not at all famous in Europe at that point. Remarkably, the same scheme of indirect communication occurred with Bode, the Director of Berlin Observatory. Bode (1781) refers to his correspondence with Maskelyne, but he apparently failed to recognize Herschel, who is reported to be "*ein sehr aufmerksamer Liebhaber der Astronomie zu Bath in England*" (i.e., a very scrupulous amateur of Astronomy from Bath, in England), whose name according some sources should be "Mersthel" or, according to others, "Hertschel", "Herthel", "Herrschell", "Hermstel". So Bode wonders "what exactly is his name?", though most of his sources may have (correctly) agreed that "he [i.e. Herschel] should be German by birth".

3. Boscovich's attitude towards astronomers in Brera and his inclination to the theoretical work

To summarize, Messier's letter was transmitted to Brera by Boscovich as an annex to his writing on April 29th. Furthermore, Messier gave Boscovich his own observations (made in April) and Maskelyne's data. On the same sheet of paper where Messier's and Maskelyne's data where recorded, Boscovich wrote down observations which his friend Lalande carried out in May. This was the annex to Boscovich's letter on June 10th, his second letter about Herschel's discovery to Brera astronomers, or maybe it was an even later annex.

In his correspondence on June 10th, Boscovich admitted for the first time he was becoming convinced that what in March-April 1781 appeared to be a comet was in fact a planet: "I don't know yet whether it is a comet or a planet; but I'm beginning to believe it is a planet, and it is better to wait for the end of July to make sure"; however, by that time he was informed about Saron's calculations and maybe Lexell's.

For all these reasons, Boscovich's correspondence with Brera astronomers from the years 1781-1782 is interesting in more than a respect: it obviously represents a journal of Boscovich's opinion change regarding Uranus from comet to planet; it accounts for Boscovich as the main source of information in Paris for Brera Observatory and his acting as a kind of a sorting post office for Brera (on June 10th, Boscovich also informed the Brera astronomers that he was delivering to Messier the observation carried out by them in Milan); it shows his willingness to share information, data, ideas, methods by himsef and by others; finally, it indicates his attitude – at least towards Brera astronomers – as a leading researcher who can advise, stimulate and even guide the scientific work.

Especially the last point (Boscovich's guiding attitude) reflects his theoretical interest. As

Table 2. Messier's letter to the Brera Astronomers on April 25th, 1781

[*verso*]
[...]
Messieurs Reggio et Cesaris,
– Astronomes de Milan
[...]

[*recto*]
Messieurs .

Un observation bien importante et bien interessante est cellecy. J'ai recu il y a peu de jours une Lettre de M. Maskelyne, dont la quelle il me mandoit, qu'il pervissoit une nouvelle Cométe; mais toute différente de celles que j'avois observées jusquá present: C'est a dire sans aucune apparence d'atmosphére, de chevelure, n'y de queue: Elle ressemble aux Etoiles fixes de la 6.e grandeur, et en Angleterre les astronomes regarde cette Cométe comme une nouvelle planéte. Son mouvement en ascension droite n'est que de 8 secondes de tems aú de 2 min. de degré par jour. Sa déclination est presque nul. Elle fuit l'ordre des signes.
D'apres la Lettre de M. Maskelyne, je l'ai cherchée et ce na pas éte sans peine que j'ai pú la trouver et la reconnaitre, á cause de sa ressemblance avec les Etoiles fixes de la 6.e grandeur. Voici trois positions d'apres les quelles, vous connaitrai son mouvement et que vous pourai la trouver et l'observer: figuré vous quelle rassemble exactement aux Etoiles de la 6.e grandeur, brilliante comme Elle sans cheveleures n'y queue. La première observat. est celle de M. Maskelyne.

		T. vrai	ascens. dr.	déclin. B
	2	8h 34' 0"	84° 21' 56"	23° 33' 37"
avril 1781	16	9 8 45	84 51 31	23 34 58
	24	7 47 9	85 12 13	23 35 30

J'ai l'honneur d'étre avec toute la considération.
Messieurs
Vôtre trés humble et trés
obéissant serviteur
Messier

Paris hôtel Cluny. 25. avril 1781
[...]

a young scholar in Rome, he had discussed a dissertation on comets in September 1746 (Boscovich 1746), and by 1774 a full theory of cometary path determination appeared in the *Mémoires de l'Académie des Sciences* (Boscovich 1774; see Dadić 1993). When the news of a new comet observed by Herschel spread throughout Europe, he initially (April 29th) thought that he could merely apply his ten-years-old theory. But he was aware of the difficulties; he soon admitted (April 29th) that his method yielded "two different orbits" and some corrections were required, becoming convinced in the quoted letter on June 10th that problems were growing more and more (see Dadić (1965) and Giorgilli's contribution to the present volume).

However, he seemed to be confident that all of the problems could be treated in the context of his theory. He anticipated he was willing to sent to his Brera colleagues observations made in Paris and, most of all, "an abstract [...] containing an extended application of my theory to that celestial body. I don't know yet whether it is a comet or a planet, but I'm beginning to think it is a planet". Such a document, which Boscovich said he would address to Lalande, has never been found and it is even questionable whether Boscovich had ever sent it. In any case, the idea of a pure application would have been abandoned in the following months. Beginning with the next letter to Brera Observatory (July 4th), he expounded in detail various changes he was introducing in his original method, announcing on August 5th that he was willing to write a brief paper for the *Effemeridi*. By that time (August 5th), Boscovich's hard work for refining his original theory was basically finished, for he had told his brother Natale about this in a letter on July 15th, being a guest in Sens at cardinal Paul d'Albert de Luynes' "maison de plaisance" (a country house which remarkably had an observatory because of cardinal's strong interest in astronomy): "I sent a 60 pages-letter about its [Uranus', or better still 'Herschel's comet'] very unusual path. It has just little motion: it is surely very far, well beyond Saturn [...]. I made an effort to develop interesting theories and perform calculations, where I make mistakes because of my age [...]. All this and other things keep me busy, so that I hardly have free time". Finally he added on a separate sheet of paper the figure he would publish in his work (see Boscovich 2012 and Boscovich 1782).

The draft reached Brera with a letter by Boscovich dated on September 22nd. Then, he sent major corrections after few days (September 29th) and a final latin version on October 11th. However, the paper would never appear in the *Effemeridi* probably because of its length, but it was translated in Italian by Antonio Maria Lorgna and published by himself under the title "Teoria del nuovo astro osservato prima in Inghilterra" in the *Memorie di Matematica e Fisica della Società Italiana*, Tomo I, Verona 1782, pp. 55-82 (see Boscovich 2009a and Boscovich 1782). Nevertheless, the Brera Astronomer Angelo de Cesaris quoted Boscovich's work and the correspondence with him in De Cesaris (1781).

Remarkably, in these letters Boscovich repeatedly insisted that his colleagues in Brera should apply the renewed theory and calculate with this. As arguable from the correspondence, this was a typical behavior pattern for him, and one that he adopted also with calculators like Lalande and Saron or an observer-calculator like Méchain. Though Boscovich made his computation by himself, as it is clear from the letter to Natale quoted above, the most important thing in his eyes was the theory itself. On September 22nd he wrote: "This method [...] determinates the kind of the conic section. You might take four observations [...], apply the numbers and, if an appropriate result is founded, put it in yours Effemeridi: this will give an excuse [pretesto] to publish the paper [opuscolo]".

This preoccupation for theory becomes understandable if one compares Boscovich's *Teoria del nuovo astro* with other papers on Uranus. Take for instance Lalande's *Mémoire sur la planète de Herschel* (read at the French Academy of Sciences on 1781 Decembre 22nd): in modern terms it is a review on Uranus and collects the most important observations made in Europe. Or take Lexell's *Recherches sur la nouvelle Planète découverte par M. Herschel* (read at the St. Petersburg Academy of Science on 1782 March 11th): it provides Lexell's determination of Uranus orbit, accounts for the observations and calculations performed, giving (some of) the orbital elements and claims for his priority. Boscovich's *Teoria del nuovo astro* did much more. However mistaken his orbital elements could be, Boscovich expounded a whole geometrical method to find distances, positions, orbit sizes and paths. Of course his theory responds to a specific need: determinig the path of the new celestial body, that means determining his nature. But while this was the real and only subject of Lexell and Lalande's contributions, Boscovich aimed to build a thoery which, regardeless Uranus, applied to comets and planets as well.

This was also the reason why Boscovich did not feel *personal* attraction towards an application of his theory, but hoped that collegues were ready to embark on such enterprise. From his side, he was most interested in a comprehensive theoretical framework, that is a framework which could be able to guide present and future research. And this is also the reason why the story about Boscovich and Uranus tells us something about the style of his astronomical activity in general.

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