Tycho Brahe and Kepler in Prague: Multifold Reflections on Astronomy

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Abstract. The collaboration between Tycho Brahe and Johannes Kepler which took place at Prague in the very first years of the 17^{th} century indicates a significant moment for the evolution of ideas in astronomy. The second half of the 16^{th} century had been marked by the introduction of the Copernican system but it had not been accepted by the majority of the leading figures of astronomy of the era. Kepler was a young enthusiastic Copernican but his theoretical figures had to be evaluated by the observational data which Tycho Brahe and his assistants had collected intensively for many years by observing the heavens. Though Tycho was not a follower of Copernican Astronomy, his collaboration with Kepler would lead astronomy to its new era. The outcomes of their collaboration did not only confirm the wisdom of Kepler's theoretical predictions but also they vindicated the ability of Tycho Brahe to achieve outstandingly accurate measurements. On the other hand, the conclusions that derived from the meeting of these two different personalities formulated a major attack to the traditional Aristotelian interpretation of the heavenly motions which had been already affected since 1543 and contributed significantly for the acceptance of the Copernican system from the scholars of the 17th century. Our goal focuses on the trace of these multifold reflections on astronomy that derived from the meeting of "*the prince among the astronomers*" and the young obscure astronomer in Prague.

Key words: Astronomy, Tycho Brahe, Kepler, 17^{th} century, Prague

When the Baron Hoffman's carriage left the Austrian town Graz at 11^{th} of January 1600, it carried a willing-to-learn young astronomer Johannes Kepler. He went to the distinguished, peculiar imperial astronomer Tycho Brahe in Prague. It was indication for a vital push towards the confirmation of major issues concerning Universe as Copernicus introduced in the legendary *De Revolutionibus Orbium Celestium* 57 years ago. Although Tycho was not a follower of the Copernican astronomy, he contributed significantly for its documentation with his measurements. This indicates his scientific integrity. His collaboration with Kepler was going to be a key point for the radical evolution of astronomy to its new era. The outcomes of this collaboration were mutually gainful: they did not only confirm the wisdom of Kepler's theoretical predictions but also confirmed the ability of Tycho Brahe to achieve outstandingly accurate measurements for heavens. The conclusions that derived from the common work of these two different personalities formulated a major attack to the Aristotelian tradition for the interpretation of the heavenly motions and consequently to the reception of the Copernican system by the scholars of the 17^{th} century. So we will try to show it seems most likely that there were created multifold reflections from this meeting.

The Era of the People: The origins of the play can be traced from the middle of the 16^{th} century until the first decades of the 17^{th} century. It has been spread in the central and northern parts of Europe. The origins of this momentous meeting were in the northern, cold provinces of the kingdom of Denmark, at Knutstorp – nowadays the area belongs to Sweden – where Tycho was born in December 1546. His family was a noble one and had strong relations with the Royal Court of Denmark. He was an astronomer among princes and a prince among astronomers.

Tycho is considered to be an unusual nobleman who experienced the rise of power to the final point. That was the moment when he got the royal grant of the island of Hven in order to work undisturbed. However later, when King Frederik II died his days in Hven were numbered. He gradually faced the disgrace of the next King Christian IV who was not willing to finance anymore this domineering astronomer. Tycho Brahe was trusted to leave his observatory in Hven. He, his family and 60 weighed down carriages carrying his enormous amount of astronomical instruments and books out from Denmark. He brought them to the imperial Court of Prague, the centre for European politics at the end of the 16^{th} century where he has appointed as Imperial Mathematician. The final act of the play was there.

There, in Prague, the young provincial mathematician from a small country was impatient to proceed with his theory. Like any modern scientist, Kepler [1] had to verify the correctness of his theoretical achievements and hypotheses with the extremely accurate observational data that he could find at that time. Those were the records that the master of the observational astronomy at that time, Tycho Brahe, and his team had been collected very intensively for many years, a few decades before the introduction of the telescope. This experimental validation would offer Kepler gratification for his assiduous work on the interpretation of the harmony of the heavens. In other words, his ambition was to comprehend God's will when he created the Universe.

It seems that some basic elements of the personality of his parents affected Kepler. His mother for mystique thoughts inspired him. They shared the long walks when his mother showed him strange heavenly bodies like the supernova of 1572. His wanderer father [2] inculcated him the feeling of endless rush. He could not remain at any place and there was always a route ahead for him. Many times, he had left his family searching for a better luck. It seems that even he had recorded in his personal diaries the negative parts of their personalities and the years of his miserable youth, other their attributes affected him.

Kepler was a religious man. He lived an adventurous life and during his whole life, the death surrounded him. He was married several times but his wives died after they had given birth. Kepler grew up many children but few of them survived until adulthood. The deciphered of the universal stability he lived his life in decay, in the sublunary part of Cosmos as the Stagirite would have mentioned.

If we focus on the troubles of his life, we feel amazed by his achievements. Not only survived, but he also overcame and continued with his life. He introduced new theories, which improved older ones. Although, Kepler has surrounded by wives and children during his whole life, he died alone having only his works around him. Should we consider it as a semiotic note for his life?

The second half of the 16^{th} century was a starting point for a new era of astronomy. Copernicus – finally in 1543 – had given his permission *De Revolutionibus Orbium Celestium* to be published, and the phantom of a new Cosmology had arisen over the scholars' community. Those first decades after the publication of *De revolutionibus Orbium Celestium* cannot be considered as successful for the acceptance of the Copernican cosmology. By that time, the necessary observational data, which would confirm the correctness of the radical hypothesis of Copernicus, had not been observed yet.

Consequently, the acceptance of the Copernican theory at that time depended on the radical point of view that any scholar decided to follow and not on the scientific confirmations for it. In other words, if a scholar was calling himself "*Copernican*" at those decades it sounded more a political thesis and less a scientific documentation.

Now, we have reached to a point where we can face more clearly the significance of Tycho's contribution to the progress of astronomy. The valuation of his work indicates that he was a man who had an eye on ancient astronomy and the other to the new method arisen from 1543. This procedure places him one-step behind Kepler.

He had not accepted the idea of the moving earth. This idea seemed to be beyond his beliefs for the harmony of Cosmos. He never abandoned the idea of circular motion in heavens [3]. On the other hand, the quality and the quantity of the observational data he had gathered for heavenly bodies constituted a catalytic factor for the overthrow of the Aristotelian cosmology and the strengthening of the Copernican model. Because, they represented the observational background for Kepler and helped him to proceed for the introduction of his three laws.

At this point, we can focus on an event so that we can justify the abilities of Tycho: He experienced a very rare event during his lifetime. At 1572 and 1604 [4], two supernovas appeared up in the sky [5]. Those appearances of the supernovas few decades before the invention of telescope were events, which unsettled the ability of the Aristotelian system to explain Cosmos. One of the fundamental questions, which astronomy should answer about the supernovas, was the determination and definition of the distance of these bodies from earth. Because, if the distance was less than the distance between earth and moon that would meant that their appearance was not really a challenge as there would be part of the sublunary part of cosmos, the part of change and decay. Actually, in 1572 there were some publications, which determined the distance of the supernovas within the sublunary part of Cosmos. On the other hand, Brahe who had in his hands very accurate measurements, disagreed with these publications and proceeded with the publication of his own conclusions derived from his measurements. According to his measurements, the supernova was located far away from the Earth. Surely, its distance from earth was not comparable with the radius earth – moon. He went one more step beyond and calculated the location of the supernova. According to his calculations, the supernova was located far away from the Earth, at the constellation of Cassiopeia, in the indestructible part of the Aristotelian Cosmos, at heavens. Tycho's calculation was a dramatic conclusion drift and a significant strike towards the Aristotelian authority [6].

Tycho introduced a mixed system for the planetary motions. It is most likely that he has started thinking of it since 1583. He held the Earth at the centre of Cosmos, fixed. The moon and the sun rotate around the Earth and the rest of planets rotate around the sun [3, p. 363-364; 7-9].

In 1589, the seventeen-years-old Kepler was studying at the famous University of Tubingen at Germany. The professor of astronomy was the prominent astronomer Mikael Maistlin. The university curriculum for astronomy was officially based on the Ptolemaic astronomy and Maistlin followed it. However – and this is important – Kepler's tutor was one of the very few astronomers who had been already convinced at that time in the correctness of the Copernican system. On the other hand, Kepler had already studied the books of Nicolaus of Cusa, written 100 years before Copernicus, where he had suggested the Earth's motion. Kepler, who also had been acquainted with ancient Greek corpus for nature, knew the objections arisen from the Pythagoreans about the Earth's immobility. As a result, Kepler during his studies in Tubingen had the chance to defend the Copernican hypothesis openly in two officially academic seminars.

He finished his postgraduate studies in 1591, when he was 19 years old. The board of the University handed him an official letter where they recommended the continuation of his scholarship adding that they "*expect something exceptional from him*". This "*exceptional*" thing could be not derived at that time. It had to wait because Kepler had to deal with matters that are more urgent. He had to earn his living. He accepted – half-heartedly – a position as mathematician to a faraway protestant school at Graz. At that period of his life he had not think to become a teacher of mathematics but was eager to follow his "*inner call*" to become pastor.

At the same period, the relations between Tycho Brahe and the new King of Denmark have started to be unsettled more because of the arrogance on behalf of Tycho for the young, new king. These two drifts, the settlement of Kepler to Graz and the worsening of the relations between Tycho and his king, quicken their meeting in Prague.

The way that Kepler worked can be considered as persistent, insistent, and full with metaphysical beliefs, which led him to mystical outcomes. The most representative case of this methodological approach was the connection he attempted in 1593 between the positions of the planets within Cosmos and the platonic solids. An idea, which though was false, inspired him for very long time. "*The delight I took in my discovery, I shall never be able to describe it in words*" [10, v. 1, 13], he wrote in his personal notes later about this idea.

His methodological approach was based on the quest of the *causes* for the regularity in heavens, although his position was that of an astronomer and not that of the philosopher of Nature. He chose to set a series of questions respective to Philosophy of Nature – if we follow the ancient Greek methodological approach "to save the phenomena" – and he overturned the tradition. Questions was such as "*What does it stand behind of what Cosmos seems to be like*"; "*According to which plan things seem to be like they are*"; "*Why God chose to create the solar system like this and not differently*". It seems that Kepler was attempting to enter into God's mind, to communicate with God and to approach God's will when he created Cosmos in order to interpret the natural principles which govern the Universe. Kepler had been obsessed by the idea of the existence of a hidden "*code*" which he should comprehend. He had a strong belief that beyond the apparent complexity of the Universe and the unlinked parts of the nature there was a pattern, logic and harmony, which were derived from God's Winsdom. Consequently, he was searching for relations and deep connections between music, astronomy, geometry and even medicine.

He went further on this way of thinking and believed that since God created the humans they could achieve the goal of fully understanding those deep interconnections. This approach of Kepler has led some researchers to conclude that his work is nothing more than a return to the medieval mysticism. However, the search for universal harmony, on which Kepler worked on tenaciously, is considered one of the cornerstones of the modern scientific method. Additionally, he was always searching to evaluate his outcomes with observational data. The best data he could expect to find was the ones that Tycho had in his catalogues.

At the same period that is the last 5 years of the 16th century, Kepler begun to be engaged with the question of the shorter yearly period of the smaller planets located closer to the Sun comparing with the ones located away from it. One inceptive possible answer was that the planets close to the Sun had to move in a shorter route. Kepler did not feel satisfied with this answer. He went on with this question looking for profound causes. He noticed that it seemed that the far-away planets were moving slower. That was the key point, which helped him to consider the existence of a force, which originates from the Sun and is responsible for planets' motions.

This idea was so innovative that his teacher, Mikael Maistlin who was already a supporter of the Copernican system, was irritated when Kepler informed him about it. He pointed out that idea could lead astronomy to decay because Kepler had not paid the respect. He ought to and had crossed the dividing line between philosophy of nature and astronomy (namely the use of mathematical tools in order to calculate the orbits of the planets).

During the spring of 1597, the paths of Kepler and Tycho started to get near. Tycho left the island of Hven and started wandering in Europe carrying with him his 3000 books and almost all of his astronomical instruments. Kepler also published his book *Mysterium Cosmograficum* and sent it to several scholars in Europe asking for their comments [11].

The personal connections of Tycho led him to Prague and inaugurated him as mathematician of Rudolf, the Emperor of the Holy Roman Empire. The same period Kepler was facing the every-day problems of the Protestants in catholic regions of Europe. He had lost his job. He was looking for a new one and he never had forgotten the eagerness of a thoroughly look on the observations of Tycho.

Tycho's invitation to meet with Kepler in Prague "*not as a guest but as a friend who I will welcome and as a very desirable colleague for the observations for heavens*" as he wrote to the invitation letter [10, v. 14, letter 154], was addressed to Kepler at 26th January 1600 and send his son with his personal carriage to bring Kepler to Prague.

Kepler was amazed with his visit to the cosmopolitan city. The first impression of Prague was like entering to a completely new world comparing with the provincial town of Styria where he lived. The relation with Tycho did not evolve as he expected as Tycho act snobbery to him and did not give him permission for full access to his data. At that period of his life, Tycho was fully aware of the quality of his work. This mysticism has related with his efforts to protect this work from malign treatments. He had experienced such an "*attack*" earlier in his life by one of his assistants. Kepler started to feel disappointed and began to irritate. He felt like Tycho discouraging him to improve his existing work. He wrote to his personal diary "*Tycho has the best observational data – that is the material to build up the building – and he has the workers too. He only misses one factor, the chief of the workers who can organize all these in order to work properly. Though doubtless, he has an exceptional mind as architecture, the range of the issues he deals with and the deepening of* *the truths he looks for is obstructed from the fact that Tycho is getting old. His mind and his strength have been diminished and will be diminished more in a few years and he will be not capable to conclude anything by himself*" [8, p. 256; 9; 12].

Tycho, finally consented Kepler to work on Mars case, the most difficult planet taking in account its orbit. Kepler considered this entrusting as recognition of his spiritual mind. He did not feel satisfied again. According to his point of view, he had accepted Tycho's invitation thinking that he would access Tycho's observational data in order to confirm his theoretical hypotheses and after his arrival in Prague, he faced that things were not as he had in mind. He realized that Tycho – who was not a supporter of the Copernican system – wished to use Kepler's abilities for the confirmation of his own model for the motions of the planets actually.

The causes for the obstacles Tycho raised for Kepler's access to his observational data have to be seeking to his anxiety for the possibility that the work of Kepler might bring to light his own predictions as erroneous. He could not ignore the abilities of his young assistant on the other hand. Finally, he compromised with the record on behalf of Kepler of a written promise that he would never inform any third party the secrets of his research based on Tycho's data.

The difficulties between the communications of the two men continued until the unexpected and early death of Tycho at October 1601. Tycho being at his death bed repeated continually one phrase: "*Let me not seen to have lived in vain*" [13-14]. Kepler got down to this petition of Tycho. A few years later, he wrote at his work *Astronomia Nova* "*Tycho, even though he knew that I was a supporter of Copernicus, asked me to present my conclusions based to his hypotheses*" [10, v. 3, 89].

After Tycho's death, Kepler has appointed as imperial mathematician and finally he achieved a full access to Tycho's observational data. The following years were the most creative years of his life, though he had continuous conflicts and quarrels with Tycho's family for the issue of the proper use of Tycho's archive.

In 1604, one more supernova explosion was visible in the sky and Kepler published his work *Astronomia Nova*. He sustained that this star was located far away from the limits of the sub-lunar Cosmos, near the sphere of the fixed stars. That conclusion was one more point of impoverishment of the Aristotelian authenticity. The other stand of the ancient Greek astronomy, the circular orbits of the planetary motions, was active in the mind of most of the scholars, even Kepler's. His theoretical adequacy and the innovative attitude that inspired him allowed him to affiliate and accept the elliptic orbits as the proper ones for the planetary motions. He, also, went on and approached the concept of a force which was derived from the Sun and causes the motion of the planets at their specific locations we observe them. All these innovations that he has introduced were supported and speeded up by the observational data, which Tycho had gathered. In other words, Kepler could not reach such conclusions if he had not accessed the accurate and marvellous data of Tycho Brahe.

We can conclude that the outcomes of their meeting in Prague started to be important at the first half of the 17th century when its multifold reflections labelled the progress of astronomy as well as the confirmation of the Copernican aspects and the collapse of the

Aristotelian Cosmos. That meeting offered: 1) Confirmation of the accuracy of Tycho's work. It has to be considered as pure scientific; 2) Documentation of the Copernican system which was contained in Tycho's data; 3) Quickening of the introduction of Kepler's laws. 4) The meeting formulated the major research project of Astronomy at the 17th century.

References and Remarks

1. Kepler had been born in 1571, so he was 25 years younger than Tycho.
2. Kepler's father was a soldier of fortune.
3. J. L. E. **Dreyer**, *A History of Astronomy from Thales to Kepler,* Dover, New York (1953) 345-371.
4. Tycho had died in 1601.
5. The previous appearances of supernovas have been recorded at 1006 and 1054.
6. At the same period, Kepler's mother took her 5-old son to the surroundings hills of Leonberg to watch the strange heavenly body arisen in the sky.
7. It is most likely that it had begun to come to his mind sometime in 1583.
8. K. **Ferguson**, *Tycho and Kepler*, New York: Walker & Company (2004) 140-141, p. 147.
9. T. S. **Kuhn**, *The Copernican revolution: Planetary Atronomy in the Development of western Thought*, Harvard University Press, Massachusetts (1957) 202-204.
10. M. **Caspar**, W. von **Dyck**, F. **Hammer**, V. **Bialas** (Eds.), *Johannes Kepler Gesammelte Werke*, **22** vols. Munchen, Deutsche Forschungsgemeinschaft & Bavarian Academy of Sciences (1937), v. 1, 13; v. 3, 89; v. 14, letter 154.
11. One of the distinguished readers of Kepler's book was a young professor of the University of Padova, Galileo.
12. It has written during March 1600. See J. **Schmidt**, *Johann Kepler; sein Leben in Bildern und eigener Berichten*, Rudolf Trauner Verlag, Linz (1970).
13. J. L. E. **Dreyer** (ed.), *Tychonis Brahe Dani Opera Omnia,* 15 volumes, Copenhagen, Libraria Gyldendaliana (1913 – 1929), vol. 10, 3. This story has written at the end of Tycho's collection of astronomical observations without any indication for the writer but it has recognized to be Kepler's handwriting.
14. E. **Rosen**, *Three imperial Mathematicians: Kepler trapped between Tycho Brahe and Ursus,* Abaris Books, New York (1986) 312-313.