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Kepler's Observations of the Supernova of 1604

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Abstract. In the fall of 1604 a very brillant Supernova lighted up, becoming a central subject for the astronomical debates of the time. Today that explosion is recalled with the name of Kepler's Nova, and really the German astronomer dedicated a large amount of energy in studying this unusual phenomenon. In this paper we want to outline how the book he published in 1606, his *De Stella Nova*, stands as a monument to accurate observations and geometrical demonstrations.

1. Introduction

In the fall of 1604 most European astronomers were observing the same celestial area, in which an extremely important conjunction was expected to appear. Right in those nights, and just in that part of the sky, a Nova lighted up as bright as Jupiter. Two years later Johannes Kepler published a book on the new star (Kepler 1606), and this became an opportunity to discuss all the most relevant questions about the structure, the constitution and the becoming of the Universe.

At this time Kepler was the mathematician of Rudolph II, and he was expected to pay particular attention to any possible influence of celestial phenomena on human life. But the *De Stella Nova* also pointed out the importance of accurate observations, geometrical demonstrations and a rational approach to astronomy.

In this paper, we shall first recover the atmosphere of feverish wait with which European astronomers looked at the sky in the fall of 1604, before giving a summary of the book in which Kepler collected all his material about the new star, *De Stella Nova in Pede Serpentarii*. To conclude, we shall examine Kepler's observations and the way he used them to confirm his own view of astronomy.

2. Waiting for a Great Event

To understand the interest of European astronomers in seeing the new star sparkling in the foot of Serpentarius, we go back to Graz, on 19 July 1595, when Kepler was lecturing in the Protestant Stiftsschule. On a blackboard a drawing helped him to explain how the conjunction of Saturn and Jupiter moved in the sky.

This conjunction is seen from the Earth every twenty years, each time moving eight zodiacal signs with respect to the previous time. So it composes a trigon, and falls always in the same three signs, disposed as the vertices of an equilateral triangle (cfr. Shea, this conference). Its position is translated about 9° every

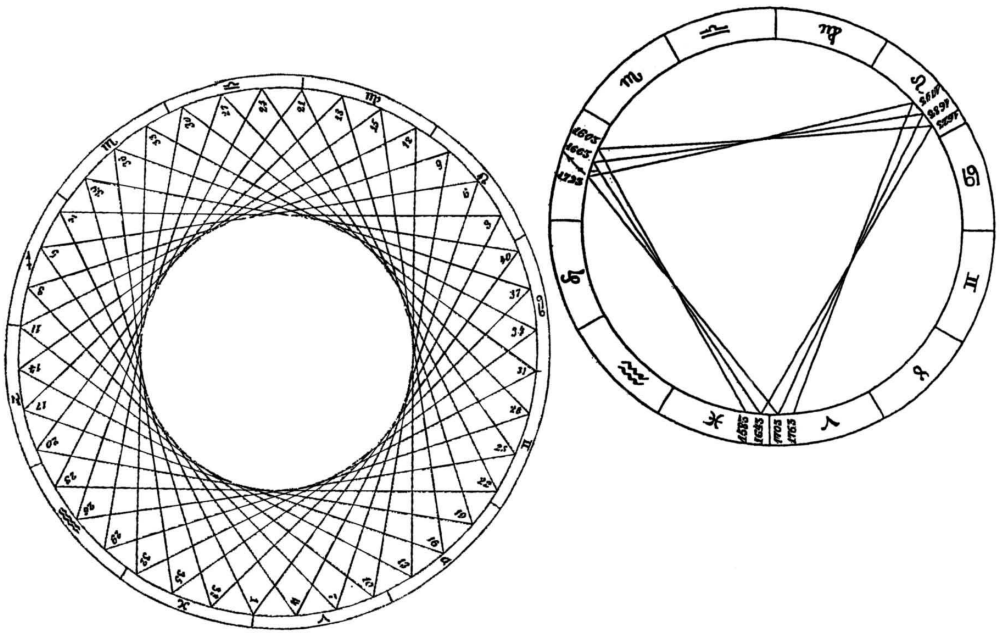

Figure 1. The entry in the Fiery Trigon of the major conjunction is explained in the *De Stella Nova* and in the *Mysterium Cosmographicum*.

time it appears in the same sign, so that, after 200 years, it falls in other three signs and we say that it changed trigon. Once every 800 years, a new cycle began and the conjunction fell again in the trigon of the signs of fire: Aries, Sagittarius and Leo. This event was expected to appear in the winter of 1603, and its importance was so great for the astronomical community that Kepler was explaining it to its class 8 years in advance. We know about this lesson because it is reported (together with the drawing, Fig. 1) in the prologue of his first book, the *Mysterium Cosmographicum* (Kepler 1596). This drawing gave Kepler an idea for the model of the Cosmos (Fig. 2) that he retained for all his life, and this is one more reason for the importance of this conjunction in Kepler's eyes.

According to Kepler, the relevance of the entry of the conjunction of Saturn and Jupiter in the Fiery Trigon is evident from a table (Fig. 3), compiled by him in the 7^{th} chapter of his *De Stella Nova*. Here we find the capital events that accompanied each new cycle of Fiery Trigon, from the beginning of time up to 1603. Dates were rounded out by Kepler himself.

The entry in the Fiery Trigon of the major conjunction between Saturn and Jupiter was enriched in 1604 by another planetary meeting, expected on 9 October, when Mars would join Jupiter a few days after it had left Saturn behind. Moreover, half way between one conjunction and the other, the three planets formed a tiny triangle, almost the miniature of the greater Fiery Trigon.

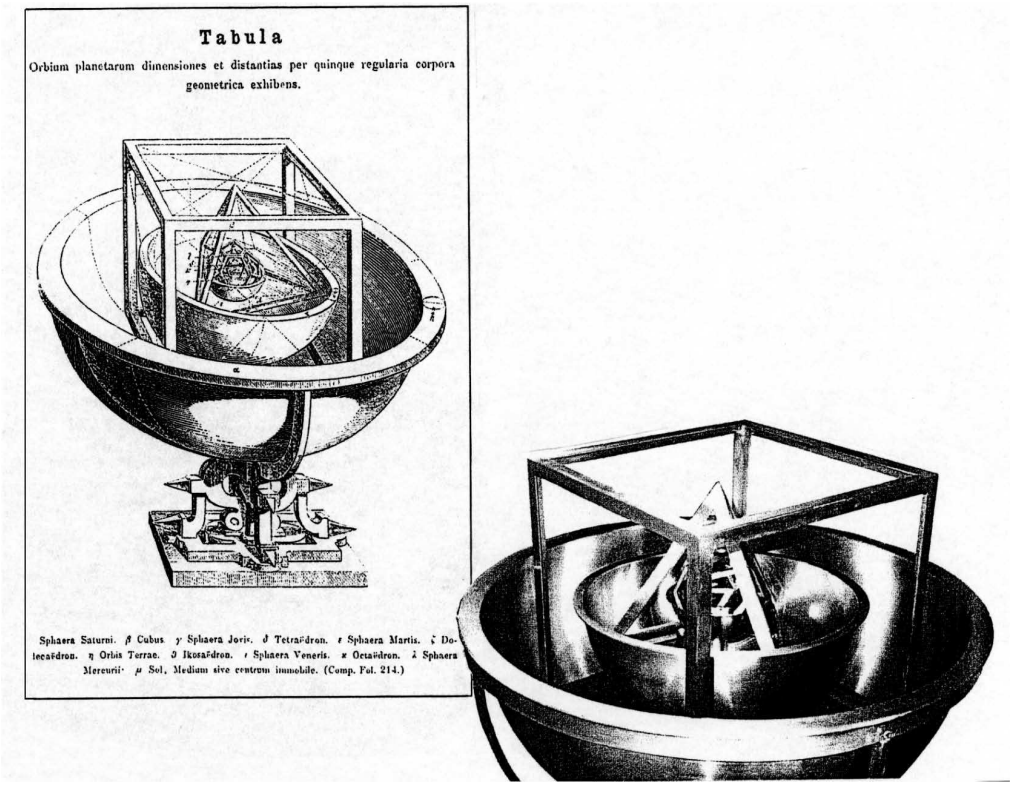

Figure 2. The cosmological model presented in *Mysterium Cosmographicum*.

This was a good chance for astronomers to correct their ephemerides, so, around 9 October, most European astronomers were observing that part of the sky between Sagittarius, Serpentarius and Serpent. Furthermore, according to some Arabian astrologers, such a conjunction could generate a comet, as it was supposed to have happened at the time of Bethlehem Star. And just in that zone, just in those nights, the new star lighted up.

It was on account of this double coincidence, in time and in place, that the new star of 1604 was observed by so many astronomers, becoming the subject of several books and debates. Some believed that such an event was a sign that had to be correctly interpreted, others wanted to use it as a support for their cosmological convictions, in particular as regards the possibility of novelty in the sky of the fixed stars, contrary to Aristotle and his followers.

Kepler hastened to publish a short text, in German, containing his first comments (Kepler 1604a). But he was the imperial mathematician of Rudolph II, a great lover of esoteric doctrines who expected a "last word" by his employed, who was highly esteemed by him. So Kepler committed himself to write a book about the meaning of the star, a commitment which he met, in his own way, in *De Stella Nova*.

Periodi.	Anni ante Christum.	A rerum origine.	Personae insignes.	Res coincidentes: tu lector cave a trigonis effectas dixeris.
1	4000	000	Adam.	Creatio mundi.
2	3200	800	Enoch.	Latrocinia, urbes, artes, tyrannis.
3	2400	1600	Noah.	Diluvium.
4	1600	2400	Moses.	Exitus ex Aegypto. Lex.
5	800	3200	Esaias.	Aera Graecorum, Babyloniorum, Romanorum.
6	Post Christum	4000	Christus Dominus.	Monarchia Romana. Reformatio orbis.
7	800	4800	Carolus Magnus.	Imperium Occidentis et Saracenorum.
8	1600	5600	Rodolphus II.	Vita, fata et vota nostra, qui haec disserimus.
9	2400	6400		Ubi tunc nos et modo florentissima nostra Germania? Et quinam successores nostri? an et memores nostri erunt? Siquidem mundus duraverit.

Figure 3. The major events occurred in each entry in the Fiery Trigon according to Kepler.

3. How De Stella Nova Presents Kepler Observations

The work came out in 1606, after Kepler had spent two years collecting as much material as he could about the new star. *De Stella Nova* discusses astronomical observations, astrological predictions and cosmological theories of various astronomers, philosophers and theologians.

The work started from his employer's expectations, but it resulted in completely Keplerian book, and like the other works written by Kepler it had to testify the Harmony of a Universe which is ruled by symmetries and interactions, in the sky as on the Earth.

The new star was discussed in a plenty of different ways, and it is hard for us to list them all. For this reason, the book reveals Kepler's personality; his interests range over astronomy and optics, music and biology, geometry and theology. We read about different positions about the dimension of the Cosmos (finite or infinite), the alterability of celestial matter, the meaning of astrology, the value of the method of parallax, etc. But Kepler always rested his opinions on precise observations of natural phenomena, and on rational reasoning.

Keplers first concern in the *De Stella Nova* was to oppose common astrologers. According to him, the Zodiac, the names of the signs, the forecasts about the future were meaningless, idiotic things without any ground. Nevertheless, Kepler did not want to deny any possible interaction between celestial phenomena and human life. And in this sense, an adversary in *De Stella Nova* is Pico della Mirandola who, a century before Kepler, had completely condemned astrology, and any kind of study about interactions between celestial and terrestrial worlds. On the contrary, Kepler wanted to stress that different quantities of light or

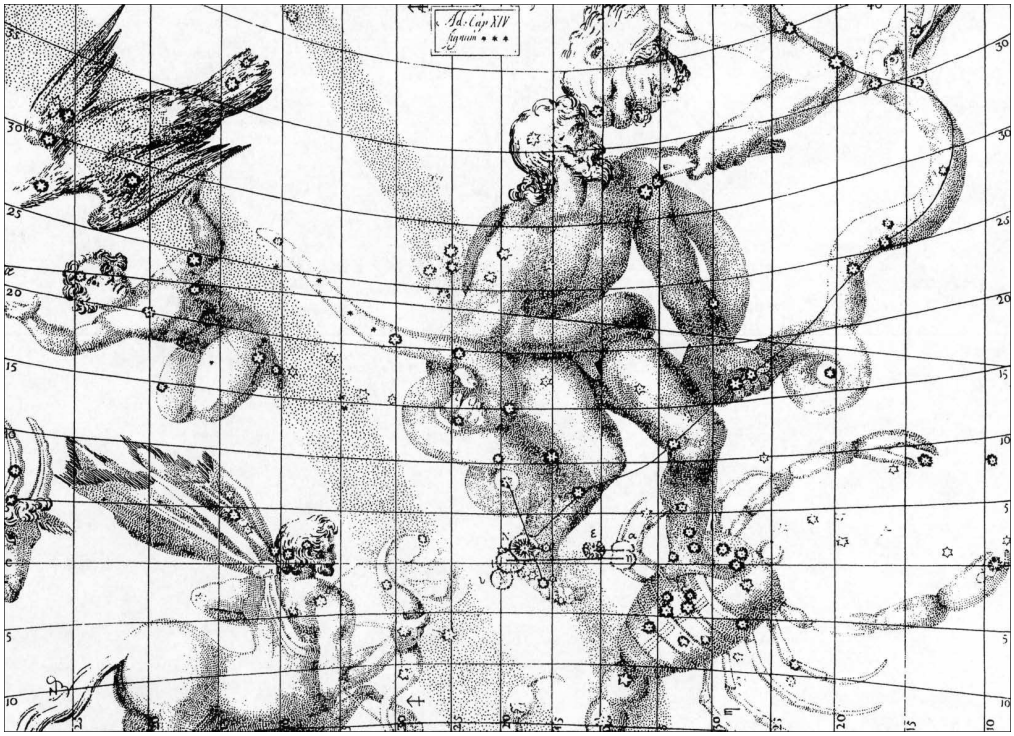

Figure 4. This drawing in *De Stella Nova* presents the part of the sky where the Supernova exploded.

different positions in the sky of the Sun or the Moon deeply influence men's lives, for example, simply in the case of agriculture. According to him, these influences are also to be expected, even if in a more subtle way, from other celestial bodies. In particular, he believed that particular dispositions of celestial bodies, like the ones studied in the "Theory of the Aspects", namely those disposition recalling geometrical regular polygons, had a special influence on sublunar life. As in many other of his works, Kepler connects geometry and music, and the concept of Harmony rules the Cosmos.

In the astronomical core of the book, Kepler addresses his main target, using a simple language, and analogies with everyday experience. In some paragraphs, the content becomes more technical, as if Kepler wanted to provide his mathematical results and geometrical reasoning for astronomers.

The observations, often recalled in the course of the book, are presented at the beginning of the first chapter, to highlight the principal condition to embark on a new enterprise, provide as many observational data as possible. Kepler's observations are compared with those of the most important European astronomers, as regards the shape, the color, the brightness, the dimensions of the new star, the duration of his visibility in the sky, and its position. Kepler concludes that the star is perfectly round and without any kind of tail, it sparkles, is multi-colored, and greater then Jupiter. Lighted up on 10 October, it remained invisible from October 1605 to February 1606, as that area of the sky had set under the horizon. The observations quoted in this first chapter are

qualitative ones; to read about Kepler's positional observations we have to wait until chapter 12.

4. The Observations

As we have already said, Kepler's views are founded on observational data. At a first glance we might have the impression that observations are not so important, because chapter 12, entitled "The observations of the new star", is only one page long, and we find only 5 observations made by Kepler or in his presence, and another 2 made by other people. Really few if compared with all the measurements presented in chapter 11, meant to illustrate the astronomical events, as conjunctions or particular dispositions, of Saturn, Jupiter and Mars, from December 1603 up to the lightening of the new star. The reason is that the Nova is "motionless" in comparison to the fixed stars, and it is useless to repeat the same numbers several times.

Kepler did not try to figure as the "discoverer" or the first observer of the new star. He reports that on the morning of Monday, 11 October, Johannes Brunowsy rushed into his home to say that on the previous night he had seen a new star. Brunowsky was a meteorologist, and at first Kepler thought he had made a mistake, and he waited until the evening to check with his own eyes. But he was disappointed by the weather. It was cloudy, and rain and clouds did not permit to him a good sighting until 17 October. In relating his first observation, he describes his observational instrument: an iron sextant, with a constant error, due to a crooked pointer, of $4'$.

In the account of his third observation we can appreciate the shrewdness of a man longing for precise data. On that night he was with Franz Tengnagel in the Imperial Garden of Prague. Tengnagel was the narrow-minded son-in-law of Tycho Brahe. He hoped to be the heir of his scientific work, and he often opposed Kepler and the publication of his works, which, using the measurements by Tycho, showed the defects of his cosmological system. Tengnagel was the heir also of some valuable astronomical instruments, as Tycho had spent large amount of money to be able to make admirably precise observations (in naked-eye astronomy times). Kepler did not want to loose the opportunity of measuring the position of the new star with Tycho's instruments, and this was the reason why he was there on that night. The other measurements reported in chapter 12 refer to the last or the first day in which the star was clearly visible above the horizon (27 October 1604 and 21 February 1605). Kepler claimed to have the precision of $2'$ of an arc, even if he recognized that his measurements were marred by atmospheric refraction.

In addition to his observations, Kepler quotes those made by David Fabricius, mentions those by Justus Byrgius (the instrument maker of the Emperor) and Johan Brengger, as the most reliable. In other chapters, or in some letters, Kepler speaks about other observers, and he feared that many wished to create an astrological event, for 9 October, the evening of the conjunction.

The following chapter uses the method of Tycho in his *Progymnasmatis*. The position of the star is taken in order to get its astronomical coordinates in several independent ways. This chapter is really hard if someone is not an expert, and seems written to persuade the astronomers.

5. What Kepler Did with His Observational Data

We have mentioned that the pages explicitly dedicated to observations are few, and that several topics are discussed in the book. The new star, and the coincidence of its lightening up in the place and in the days of an important conjunction, was the occasion to discuss about the structure and the dynamic of the Cosmos, and their power to influence the terrestrial world. Kepler lived in a cultural context very different from ours, and he thought that a better knowledge of symmetries, interactions and harmonies of the different aspects of divine creation could help man to understand his Creator. God put his imprint in every fold of Nature, and Kepler moved like an investigator, who is trying to reconstruct a plan. This is the reason why in *De Stella Nova* we find, side by side, chapters about the Bible and pages about the dimensions of the planetary orbits. But Kepler was revolutionary in his reasoning: his investigations are always founded on precise observations. This is the reason why he succeeded in finding his famous three law, even if he lived in a cultural and scientific world that was still so far away from that of Newtonian mechanics.

According to Kepler and his contemporaries, the lightening of the New Star challenged the Aristotelian immutability of the sky. As his contemporary Galileo, Kepler said that if Aristotle were living in those days, he would change his mind more easily than his followers. Two different aspects were discussed: 1- Was the nova really over the lunar sphere? and 2- What was it exactly and how was it generated? As regard the second question, there were different answers. To simplify, first of all there were those who thought that it was formed in the depth of the sky (with different ideas about the mechanism of its generation), second those who believed that it was constituted from a piece of our atmosphere that rose up through the celestial spheres. Kepler was in the first group, but he opposed the position, common to astrologers and some physicists, according to which the new star had been directly generated by the conjunction of two planets, just as the meeting of two people can generate a baby.

Kepler knew this was impossible, because a conjunction is due to an optical effect: the two planets are always far away one from each other, even when they seem so close from the Earth. He preferred an analogy with spontaneous generation: as on Earth, when there is an "excess of disorder", we observe the birth of new things (he recall the generation of lice from the dirty hair, and fleas from excessive sweat, especially in women!). In a similar way, an excessive "disorder" in the celestial matter could generate a new star. In Kepler's opinion, the Nova had too elements in common with the other fixed stars e.g. its scintillation, its immobility, to be a kind of vapour or flame.

According to Kepler, the Nova was a good occasion to support the method of parallax. In *De Stella Nova* Kepler explained this method very simply and very differently from what he did in the pages of his, almost contemporary, *Astronomiae pars optica* (Kepler 1604b)[1]. In *De Stella Nova* he compared celestial objects, at different distances from the Earth, to the reader's nose, to his finger, to the book he is reading (*De Stella Nova*), to the floor of the room where he stands. His intent is to convince "every" reader of the validity of this geometrical

[1]You can compare Kepler (1604b, ch. 9) and Kepler (1606, ch. 15).

method. It seemed impossible for him that even some astronomers (he mentions Antonio Lorenzini, who was working in Padua) could deny the validity of the parallax in judging celestial distance. Why if it could be understood even by the common reader!

Aristotle was not the only authority that was called into question by this new star. According to the followers of the Ptolemaic system, a weak point of Copernicanism seemed to be the fact that the planetary distances from the Earth were astonishingly great. We recall that in Ptolemaic hypothesis the distances were obtained from relative measures plus the theory of the Aristotelian plenum, i.e. the a priori hypothesis that there can be no empty space between one planetary orbit and the others. Since Copernicus what they called Cosmos (what we would call our planetary system) had become much greater than it had been believed. Kepler wanted to demonstrate that in Copernican, Ptolemaic or Tychonic astronomy, the dimensions are alike. Only the center changes, not the dimensions or the velocities implied.

Let us conclude with something that seems less important for astronomy, but has a special place in *De Stella Nova*. It is the attempt to answer whether such an event as a Supernova, in coincidence with those conjunctions, has some effect on our life, or can be interpreted as a mysterious message from God.

This was the reason why Kepler had been asked to write the book, and apparently he was only following the request of his employer. But in all those pages we discover Kepler's wit. First of all, he lists all the most different effects that had been attributed to comets, conjunctions, and even to the Nova. After pages of quotations, his conclusion is simply this: the only proved effect the Nova had on terrestrial world was to give work to printers.

He concluded with another long series of quotations about the possible interpretations one could give of this extraordinary event. He spoke about Turks, Christianity, the beginning of a new era and the end of the world. But, he declared, if God wanted to say something, he could use good prophets, who speak in everyday language! The God, who came on Earth like a man, is not going to reveal something only to astrologers or astronomers.

For Kepler, the lightening of the Nova in coincidence with the Fiery Trigon was not a mystery to be interpreted, but an opportunity to confirm that a Nova is really a new star (as so many astronomers were looking at that celestial area in those night). If Providence had something to do with this coincidence, it was probably to give men the possibility of better understanding the real structure of his Cosmos. As we learn from *De Stella Nova*, the way is precision in observational measurements.

6. Conclusion

In the *De Stella Nova* we find a summary of crucial questions connected with astronomy at the beginning of the XVII century. This book shows that Kepler lived in a cultural world that was different from the modern one. In such a context, Kepler showed his true strength and his belief in the power of precise observations and rational reasoning. In this way, he succeeded in using the Nova as a light to know the structure and the dynamics of the Cosmos.

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