Johannes Kepler, Galileo Galilei, Robert Fludd, Giordano Bruno and Nicolaus Copernicus: in absentia arguments on ‘happy Earths’ and the infinity of the cosmos

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Abstract. The ideas within Nicolaus Copernicus’ *De Revolutionibus Orbium Coelestium* (1543) and Giordano Bruno’s *De l’infinito, universo e mondi* (1584) created a new heliocentric image of the universe.[1] The concept of an infinite space without limits was beginning to appear in astronomy. Bruno was the first to break Aristotle’s sphere, producing a mass of arguments disclaiming its presence and verifying infinite space. Johannes Kepler was more careful in his treatment of the model of an infinite cosmos, mainly because of the contradictions in his own theory as expressed in his *Mysterium cosmographicum* (*Prodromus dissertationum cosmographicarum, continens Mysterium cosmographicum de admirabili proportione orbium coelestium: deque causis coelorum numeri, magnitudinisy motuumque periodiconim genuinis et propriis, demonstratum per quinque regularia corpora Geometrica*) (1596). Galileo Galilei, on the other hand, supported the idea of an infinite cosmos, describing ways in which to prove it, although it could not be verified because of a lack of adequate telescope observations. At the same time, Robert Fludd developed a radically different concept of the stages of creation, synthesising earlier ancient cosmological ideas and the biblical world outlook, and thus anticipating cosmological models of the first half of the twentieth century.

[1] N. Kopernik, *O vrashhenijah nebesnyh sfer* [N. Copernicus, *On the Revolutions of the Heavenly Spheres*], trans. I.N. Veselovsky (Moscow: Nauka, 1964); G. Bruno, ‘O beskonechnosti, vselennoj i mirah’, *Dialogi* [‘On the Infinite Universe and Worlds’, *Dialogues*], trans. M.A. Dynnik (Moscow: Gosudarstvennoe izdatel'stvo politicheskoj literatury, 1949), pp. 295–448.

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Introduction

Many sixteenth and seventeenth century philosophers who dared to ponder on celestial bodies supported the idea that the planets, their satellites and even the Sun itself were populated. Most considered that the features of every populated world correlated to the specifics of the inhabitants. Summarising those ideas, Alphonse Toussenel, in the nineteenth century, wrote that life on the cosmic worlds was supported by the stars' creativity, which they happily manifested. They give birth to us. They are imbued with the greatest honour – to arrange and sustain life on them.[2]

Every planet has its zodiac defined by its specific mode of rotation. Describing the life of hypothetical Moon inhabitants, Kepler wrote in his opus *Somnium, seu opus posthumum de astronomia*:

> [The] zodiac of the Moon inhabitants does not differ at all from ours. Actually, our zodiac in its annual movement rotates around the Sun. But the Moon rotates around the Earth…'[3]

Kepler further shows that inhabitants of the Moon's hemisphere who never saw the Earth would draw the same zodiac as the inhabitants of the visible part of the Moon. He stresses that, when moving from Earth to any other planet, we should draw a new zodiac according to the specifics of its movements.

Kepler's theoretical thesis shows the complexity of the lives of those inhabitants who live outside Earth. High variability temperature between day and night, a lack or shortage of water, a thin atmosphere – all these (according to Kepler observing the Moon through a telescope) create conditions where only a special creature could live, one that would more resemble a fish than a man. He extends his half-fantastic interpretation of his Moon surface observations to other celestial bodies, where he does not believe he would find the new 'happy Earths'. In Kepler's view,

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[2] K. Flammarion, *Mnogochislennost' obitaemyh mirov* [*The Multitude of Inhabited Worlds*] (Saint Petersburg: 1865).

[3] J. Kepler, 'Son, ili lunnaja astronomija', *O shestiugol'nyh snezhinkah* ['The Dream, or Lunar Astronomy', *On the Six-Cornered Snowflakes*], trans. Ju.A. Danilov (Moscow: Nauka, 1982), p.114.

> Bruno as an advocate of the infinite cosmos considers that every world should differ from others by the number of types of its movements. So, if there are different types of movement, there are different intervals of time for these movements, produced by the periods; still more: if there are different intervals of time, so there must be different positions of the figures, produced by these intervals, as well as its type and perfection.[4]

Elements of anthropological principles formed in the twentieth century can be traced in Kepler's theoretical thesis:

> So, if one plots his theory on the similar ideas of similar worlds, one should create the similar people, namely the Galileis [the astronomers] observing the new stars in the new worlds, and in the numbers of the worlds. And what is the use of it? So, we must much more beware of stepping into the infinity than the philosophers do.[5]

Kepler saw the main contradiction in how Bruno disrupted his (Kepler's) ideal construction of the solar system to be his 'multitude other worlds':

> Let us suppose we have an infinity of worlds but not similar to ours. Consequently, their beauty is based on the different celestial bodies; they differ from our five perfect bodies; that is why they surrender the beauty of our world. So we may conclude that the beauty only of our world overcomes these worlds, if they do exist.[6]

However, Bruno insisted:

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[4] J. Kepler,'Razgovor s Zvjozdnym Vestnikom, nedavno nisposlannym smertnym Galileo Galileem, paduanskim matematikom', *O shestiugol'nyh snezhinkah* ['Conversations with the Starry Messenger, *On the Six-Cornered Snowflakes*], trans. Ju. A. Danilov (Moscow: Nauka, 1982), p.65, [hereafter, Kepler, 'Conversations'].
[5] Kepler, 'Conversations', p.65.
[6] Cit. F. Yates, *Dzhordano Bruno i germeticheskaja tradicija,* [*Giordano Bruno and the Hermetic Tradition*], trans. G. Dashevsky (Moscow: Novoe literaturnoe obozrenie, 2000), p.65 [hereafter, Yates, *Giordano Bruno*].

> In case we were on the Moon or on the other star, we should find ourselves in place, not very different from the Earth's, or, maybe even in the worth one; we should learn that there are the other celestial bodies, the same fine, or even much better, capable of providing more luck to their inhabitants.[7]

Kepler's cosmos and Fludd's universe

Kepler's views were in conflict with those of the English theologian and doctor of medicine Robert Fludd (1574–1637), whose model of the universe (with its unique geocentric cosmos) is not static or closed.[8] It includes all the main elements of the world models from Greek philosophy (mainly from Plato and the Pythagoreans), as well as from the Bible. Fludd's cosmos, at least partly, corresponds (is invariant) to the anthropological cosmological principle formed in the twentieth century. Fludd's cosmos evolves from a 'vacuum' to God-created man (who is similar to the cosmos) at the central point of the world created by God.[9] Fludd, in full accord with Plato, postulates man's similarity to the cosmos. Many of Fludd's elements from the stages of Creation are today considered 'early scientific' (see the first volume of *Utriusque cosmi maioris scilicet et minoris Metaphysica, physica atque technica Historia*, published in Oppenheim in 1617) and resonate with some elements of twentieth century cosmological ideas.

Unlike Kepler, Fludd did not limit himself to studying the planetary system (our planetary cosmos) alone. Considering its traditional ancient description and the biblical history of Creation, Fludd described the process of 'evolution' of the entire 'full-scale' universe, bringing to creation our cosmos and, as a consequence, man. The process is managed by the will emanating from God, 'above the highest (first) sphere' and

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[7] G. Bruno. 'Pir na peple', *Dialogi* ['The Ash Wednesday Supper', *Dialogues*], trans. M.A. Dynnik (Moscow: Gosudarstvennoe izdatel'stvo politicheskoj literatury, 1949), pp.43–161, p.60.

[8] T.V. Artem'eva, 'Britanskie mistiki v Rossii XVIII veka', *Filosofskij vek*, vyp. 17. Istorija idej kak metodologija gumanitarnyh issledovanij. Chast' 1, ['British mystics in Russia in VIII centur'", *Philosophical Age* 17, *History of ideas as a methodology of humanitarian research*, Part 1] (Saint Petersburg: Sankt-Peterburgskij centr istorii idej, 2001), pp.313–41.

[9] Roberto Fludd, *Utrisque Cosmi Maioris Scilicel et Minoris, Metaphysica, Physica Atque Technica Histori* (Oppeniheimii, 1617).

transmitting it from one sphere to another – from the higher to the lower – down to Earth's sphere.

Fludd partly overcomes the 'limits' of the space. At least, 'space in general' – that is, 'God's space' – which is infinite, according to Fludd. The space of 'our world' (our cosmos, though extended with 'the highest' spheres being 'above the fixed stars' sphere) is closed but much enlarged in volume when compared to classical cosmos models (including Nicolas Copernicus's model) and is completed within the sphere of 'the fixed stars'.In comparing his concept with Fludd's concepts of the cosmos, Kepler (1621) considers his own schemes 'really mathematical' and calls Fludd's schemes 'hermetic'. He reproaches Fludd: 'you treat mathematical subjects in a hermetic way'.[10]

Fludd's cosmological model is possible as a mathematical (in a Pythagorean sense) development of Plato's ideas of man's similarity to the cosmos. Further, this model demonstrates 'the reason' our world has a complex nature, which is 'above' 'the fixed stars' sphere' or, in modern words – in the 'far cosmos' – that is, outside our galaxy. Considering the space beyond the first sphere, Fludd describes not the infinite space, but still a different 'early unknown' sequence of a higher range of spheres, the so called 'movement-transformation', of which, according to God's will, would result in the creation of the earthly world, the cosmos and man.

Kepler does not deny the special position of the Earth in space, despite his careful attitude towards the idea of an infinite cosmos and the substantiation of the heliocentric model. Kepler proposes measuring the distances to the celestial bodies, based on his new paradigm of the inevitable rotation of the Earth (measuring primarily the parallaxes of the 'fixed' stars):

> For the sake of observation, for which he was created, decorated and provided with eyes, man could not stand still in the centre; he was required to use our terrestrial ship for better observation, that is transported in space in annual rhythm; the man resembles a land surveyor, changing his position relative to the inaccessible objects, for distance between two stations would give him the proper basis for the measured triangle.[11]

Fludd's mathematics differs substantially from that of Kepler, who had partly overcome the mysticism of his early works. Fludd's mathematics is

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[10] Yates, *Giordano Bruno*, p.217.
[11] Yates, *Giordano Bruno*, p.66.

aimed at a search for harmony, connecting God, the higher spheres, the stars, the lower spheres (from the sphere of Saturn to the sphere of the Moon), the world of four elements in harmony, uniting man with the 'entire world' (his cosmos is the structured sphere space around Earth and the universe, the rest of space). Kepler rejects Fludd's ideas in favour of his own approach:

> First of all, he (Fludd) examines the whole cosmos and all its three parts – Empyrean, Heaven, Elements: me – only the heaven; but all the heaven, not only the planets' motion under the zodiac. Along with the ancients, who were concerned of the power of Harmony that consists of the abstract numbers, he considers it sufficient if he could prove harmony between some parts and defines them any way in numbers, ignoring any kind of unites (of measurement) connected in these numbers: I never search harmony in the objects, between which there is harmony, but they cannot be measured by the single qualitative measure.[12]

Fludd created a 'protocosmological' model based on intuitive assumptions based on biblical and ancient ideology. Kepler formulates and solves an astronomical task by analysing instrumental measurements. His intention was to use the complex data of the celestial bodies' movements (expressed in spherical coordinates) to create a spatial model and allow further estimation of the movements, determined by harmony. Harmony, according to Kepler, is essential, and finding and describing it using the language of mathematics is his principal goal. In addition, Kepler understands that the idea of infinite space would contradict his ideal and harmonious model of the cosmos – 'nearest to the Earth space'.

Infinite cosmos and the parallaxes of the fixed stars

There is a distinct division between those, such as Bruno, who accept an 'infinite cosmos' and those who, according to Kepler, 'should beware of stepping into the infinity further than the philosophers permit' among the astronomers and philosophers of sixteenth and seventeenth centuries.[13]

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[12] Yates, *Giordano Bruno*, p.393.
[13] Kepler, 'Conversations', p.65.

Those scientists could not accept the idea of infinite space because of the contradictions.

The problem of estimating the size of the cosmos is connected to the confirmation or denial of the heliocentric model. *The contours of the visible world*, that is the *sphere of fixed stars*, in the case of the heliocentric model is confirmed (approved) should it undergo visible changes because the Earth is moving; these changes are expressed as the 'fixed' stars' parallax displacement. Aristotle considered the lack of a parallax to be a manifestation of an immobile Earth.[14]

The problem of the absence of a visible parallax was resolved by Aristarchus of Samos, who decided that the distance from the Earth to the Sun was small in comparison to the distance from the Earth to the fixed stars.[15] But can one observe parallaxes (at least with all the stars), if the cosmos is infinite? A theory of infinity can apply when one can observe how a 'sphere', after being disintegrated at a certain radius (at which one can observe parallaxes of the closest stars), starts being reconstructed as this radius increases (where a parallax cannot be seen). Galileo Galilei (1610) changed the 'evident truth' about the quality of 'fixed stars'. Ancient constellations had been filled with stars that had never been observed, prior to the telescopes.[16]

> At first I decided to draw the whole constellation of Orion, but was later put down by the immense amount of stars and lack of time; I postponed the attempt till a better time: there are more than five hundred other stars dispersed amidst the old ones within one or two degrees. That is why besides three stars in the Zodiac and six in the constellation of Sword, that have been described before we have added eighty others in the vicinity, we noticed them recently. Intervals between them we kept accurately. The known, or the old, stars we depicted as big and double encircled them; the others, less visible, we

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[14] Aristotle, *O nebe* [*On the Heavens*], in 4 vol., vol.3, trans. P.D. Rozhansky (Moscow: Mysl', 1981), pp.263–378.

[15] I.N. Veselovsky, 'Aristarh Samosskij – Kopernik antichnogo mira', *Istoriko-astronomicheskie issledovanija*, ['Aristarchus of Samos - Copernicus of the Ancient World', *Historical and Astronomical Studies*], Issue VII (Moscow: Gos. izdatel'stvo fiziko-matematicheskoj literatury, 1961), pp.11–70.

[16] G. Galilei, 'Zvjozdny vestnik', *Izbrannye Trudy* ['The Starry Messenger', *Selected Works*], trans. I.N. Veselovsky (Moscow: Nauka, 1964) [hereafter, Galilei, 'Messenger'].

> depicted as smaller and underlined with two lines. We kept the difference in magnitude as accurate as possible.[17]

Galileo later interpreted his own results of the optical observations. His assessment of future possibilities of optical astronomy strengthened Bruno's (1584) theoretical prepositions:

> Our mind is not chained with the handcuffs of eight, nine or ten propellers. We know there is single heaven, single infinite etheric space, where these shining torches keep their distances for comfort participation in the continuous life.[18]

Kepler and Galileo: theory and practice

From ancient times, it was considered that to prove the annual rotation of the Earth around the Sun, it was necessary to observe star parallaxes within the 'sphere of the fixed stars'. This task can be accomplished by following two methods.

> 1. By applying direct measuring of the celestial coordinates of a star during the year, considering all stars to be equidistant from the Sun. That means the depth of the 'fixed stars' sphere' is much smaller than its diameter.
> 2. The second method is based on the assumption that the 'fixed stars' sphere' has its 'depth', and that brighter stars are 'closer' to the Sun than less bright stars. In this case, one is able to compare the changing celestial coordinates of the two objects within close angular deflection, but their distances to the Sun will be very different during the course of a year. This method has been known as the 'Galilei parallax test method' since the seventeenth century.

This issue was discussed in the sixteenth century in terms of the problems of the infinity of space and heliocentrism. Later, Galilei, like other astronomers of his time, although he lacked the technical tools to practice

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[17] Galilei, 'Messenger', p.36.

[18] G. Bruno, *Dialogi* [*Dialogues*], trans. M.A. Dynnik (Moscow: Gosudarstvennoe izdatel'stvo politicheskoj literatury, 1949), p.60.

the method, describes it in his 'Third Day' of *Dialogo sopra i due massimi sistemi del mondo, tolemaico e copernicano* (1632):

> It is not excluded totally that in times we shall find some body, the observation of which would allow to conclude on their annual rotation; so the stars not less than the Sun itself would be willing to come to arbitration witnessing this rotation in favor of the Earth. I do not think the stars are dispersed along the spherical surface an equal-distant from the centre; I think they are differently remoted from us – some may be 2–3 times more remote than some others; so if one could find with the help of telescope some very small star close to one of the biggest and if the first star were in a very high position, one could see a considerable change in their mutual disposition – the same as it takes place with the planets in the upper positions. This should be said especially about the stars on the ecliptic.[19]

That means if a position of brighter star is close to the ecliptic, it resembles a remote planet, would show a 'loop', and would be of a small angular size. At the same time, a close but weaker star would remain fixed.

Some years earlier, Tycho Brahe had tried to measure parallaxes. His assessment of the diameter of the sphere of the fixed stars – in order to prove that it was impossible to observe the parallax of the 1577 comet – may be found in polemics between Galilei and Sarsi:[20]

> For You, Your Grace, could be evidenced, that my words are well funded, let us examine the proof on page 123 of Tycho's thesis on the 1577 comet in the final part of his *Astronomiae Instauratae Progymnasmata*. In this opus Tycho is proving that the Comet moved not below the Moon, comparing his observations with one of Tadeáš Hájek in Prague …<…> Tycho writes that one and the same fixed star could be seen

[19] G.Galilei*, Dialog o dvuh glavnejshih sistemah mira — ptolemeevoj i kopernikovoj* [*Dialogue Concerning the Two Chief World Systems—Ptolemaic and Copernican*], trans. A.I. Dolgov (Moscow–Leningrad: Gos. izd. tehniko-teoreticheskoj literatury, 1948), p.275.

[20] Lotario Sarsi Sigenzano pseudonym of Orazio Grassi (1583–1654), Britannica Online, https://www.britannica.com/biography/Orazio-Grassi [accessed 10 August 2021].

> from two points *A* and *B*, not mentioning a small size of *AB*, being vanishing small as compared to immense size of the stars' sphere.[21]

Using optics to observe a pair of stars rather than a single one is much more effective. Discovering the parallax of one of the stars would greatly contribute towards confirming the idea of the Earth rotating around the Sun. Finding the difference in the parallax between two objects would allow the observer to estimate the 'depth' of the stars' sphere: this would indicate the limit of the stars' penetration into the 'depth' of space and would offer proof for a final thickness ('depth') of this 'sphere'. This means it is possible to prove both Copernicus' heliocentric idea as well as Bruno's idea of 'infinite etheric space'.

According to this statement, it is quite effective to observe a pair of objects, one of which we can observe with optical instruments (let them be still very simple). The closer the visible position of the stars, the more convincing should be the change in their mutual positioning. Despite the technical complexity of these measurements, by using this method, one has more chances to observe the parallax, since the parallax of a weaker object *a priori* equals zero, and it may be used as a fixed reference point, comparing to which one can observe the motion of a brighter star (thus, on an assumption, it is at a shorter distance to us).

That is why Kepler suggests using Galilei's discovery of stars for such measurements:

> It is much desirable, if a comet appears, to measure precisely its parallaxes (as in case of the Moon) by a mass of tiny stars visible only in your instrument. This would allow you to measure a distance to the Comet more precisely than earlier.[22]

Here Kepler mentions the 1577 comet investigated by Tycho Brahe, when he came to a conclusion that the comet was moving 'above the Moon'.[23] But Kepler goes further. He suggests that the comet should have a greater parallax than the Moon despite its magnitude being much less than the

[21] G. Galilei, *Probirnyh del master* [*Test Cases Master,* original title in Latin *Il Saggiatore*], trans. Ju.A. Danilov (Moscow: Nauka, 1987). p.39.
[22] Kepler, 'Conversations', p.47.
[23] Ju. Belyi, *Tiho Brage* [*Ticho Brahe*] (Moscow: Nauka, 1982), p.157.

Moon's. Kepler suggests using specific 'tiny stars' visible 'only in your instrument', following the proposal that the 'tiny stars' discovered by Galilei are much more distant and their parallaxes may be assumed to be equal to zero.

To obtain more sensitive measurements with this method, an original approach was proposed: to base calculations on the nearest stars' parameters. In common observations (without optics) these objects appear as a single star. Despite numerous attempts, the effect was difficult to observe, especially if one of a pair of stars was brighter and the other weaker. Observation and theory were limited by the technology of the time.

In the second half of the sixteenth century, Brahe collected enough data to substantiate geocentrism, but could not overcome the 'self-evident static' of the Earth, despite using better instruments, observation methods and a higher quality of mathematical interpretations.[24] Brahe could not accept a new theory before it was confirmed with observation data.

The calculation of the parallaxes of the 'fixed stars' was an extremely important ideological advance (the first such attempts were started by ancient Greek philosophers) even if the discovery of such parallaxes would offer clear proof of a heliocentric universe.

Because of the absence of observed parallaxes, Aristotle declared the 'centricity' of the Earth. Aristarchus of Samos gave the correct explanation for the visible absence of a parallax – it was because of the very small diameter of the Earth's orbit compared to the diameter of the 'stars' sphere'.

In the second half of the sixteenth century, Brahe (familiar with the world system of Copernicus) put the Earth at the centre of the world –as did Aristotle – despite his conviction that all the planets, excluding the Moon, rotate around the Sun. In considering the question of the possible diameter of the 'fixed stars' sphere', he concluded that this diameter could not be considerably greater than Saturn's orbit.

Brahe considered that 'fixed stars' sphere' had a finite long radius, and if the Earth rotated around the Sun, in half a year its position in space would change by twice its orbit's diameter. Brahe considered its value as immense. In 1589 he wrote to Ch. Rothmann, that if one adopts Copernicus' system, the fixed stars would become much more distant:

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[24] On Ticho Brahe see: I.N. Veselovsky, Ju.A. Belyi, *Nikolaj Kopernik* [I.N. Veselovsky, Yu.A. Belyi, *Nikolaus Copernicus*] (Moscow: Nauka, 1974), p.392 [hereafter, Veselovsky, Belyi, 1974].

> Do you consider possible the distance between the Sun (prospective centre of the world) and Saturn not being 1/700 the distance from the fixed stars' sphere? Still more – the space should be without stars, and quite deserted. Certainly, this should be *sine qua non*, if the annual Earth cycle, observed from the fixed stars should be only one minute. If so, the visible diameter of fixed stars of the third magnitude, being also equal to one minute, should be of the Earth's orbit size.'[25]

Brahe did not agree with the new estimated size of space. Neither did he agree with the idea of infinite cosmos/universe – even the size of the world being 700 times the distance from the Sun (as a hypothetical centre of the world) to Saturn (as a hypothetical limit of the solar system) was impossible for him to accept.

Brahe insisted on the need for observation (or 'sensitive experience') as the basis of theory. He would not agree to a theory without substantiating observations, and the dimensions of the cosmos (a diameter of 700 radii – distances – to the hypothetical centre) from the Sun to the most distant planet Saturn seemed to him impossible. Theoretical knowledge, according to Brahe, cannot supersede experience.

Size of the cosmos and the fixed stars' diameters

According to sixteenth and seventeenth science, the size of space was connected to the problem of estimating the value of stars' diameter; the fact that the stars kept their fixed sizes (according to Brahe) was further proof of the fixed position of the Earth and the limited space in the cosmos. Brahe could not verify the immense scale described by Bruno and credits only the precision of his own measurements. Those measurements could not disclose the parallax of any celestial body except for the Moon.

Returning to the stars' 'doubling' optic effect fixed in the image of heaven by Bayer, it is necessary to note that it was described and explained by Galileo, who stated that these observations were obvious results of the new telescope method. Further attempts to use telescopes for discovering parallaxes, as described by Galileo, were all in vain until the mid-nineteenth century. However, attempts were constantly made as the

[25] Veselovsky, Belyi, 1974, p.392–393.

heliocentric model came to dominate. This fact predestinated the vector of research.

In 1674 Robert Hooke was trying to measure the γ parallax of the Dragon, but he gave it too high a value – 20 to 30 seconds of arc; this was later disproved by James Bradley (1693–1762). John Flamsteed (1646–1719) tried to find the parallax of the Pole (North) Star and also overstated its value, which was disproved later.

James Gregory (1638–1675) in 1675. and Christiaan Huygens (1629–1695) in 1695. turned to this method for finding a parallax using optically close pairs of stars. Pierre Simon, Marquis de Laplace (1749–1827), referred to a Doctor Long, was still trying to discover it. Huygens (1629–1695) experimented with the parameters of ζ Ursa Major, but failed to measure a parallax. Later it was found that ζ Ursa Major is a double-star system. During 1714–1715 Jacques Cassini (1677–1756) attempted to find the parallax of Sirius; like his predecessors, he calculated an inflated figure.

In 1781 Frederick William Herschel (1738–1822) compiled a catalogue of the close stars of different magnitude. A discovery confirming the Earth's rotation around the Sun, using Galileo's method, was made in the nineteenth century. Friedrich Georg Wilhelm Struve (Russian: Basil Jacob Struve; 1793–1864) in 1835–1838 obtained the first reasonable result: Vega – α Lyr and a star of 11th magnitude in 43 seconds from it (parallax – 0.26 seconds).[26] In 1837–1840 Friedrich Wilhelm Bessel (1784 – 1846) measured the parallax of Cygnus 61 using two stars of 10th and 11th magnitude, at 8 and 12 minutes of distance from it (parallax 0.34 seconds). Struve and Bessel stated that the parallax of weak stars equals zero.[27] The task of calculating the parallax (two components of α Centaurus) was solved by the First Royal Astronomer of Scotland, Thomas James Alan Henderson (1798–1844), professor at the Edinburgh University, simultaneously with Bessel and Struve based on Kaap's observations.[28]

Conclusion

The problems of demonstrating heliocentrism and calculating the size of the cosmos by measuring stars' parallaxes preoccupied many astronomers

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[26] Z.K. Novokshanova (Sokolovskaya), *Vasily Jakovlevich Struve* (Moscow: Nauka, 1964).

[27] P.S. Laplas, *Izlozhenie sistemy mira* [P.-S. Laplace, *Explanation of the System of the World*] trans. V.M. Vasil'eva (Leningrad: Nauka (Leningradskoe otdelenie), 1982), pp.293–301.

[28] K.K. Lavrinovich, *Fridrih Vil'gel'm Bessel'. 1784 – 1846* [*Friedrich Wilhelm Bessel. 1784 – 1846*] (Moscow: Nauka, 1989), pp.212–18.

in the sixteenth and seventeenth centuries, but difficulties in making observations did not prevent advances in theory. The idea of an infinite cosmos – despite being unproven – was accepted by the scientific community in the seventeenth century. The majority of astronomers (beginning from Galileo's time) not only accepted the idea of the infinite universe but also strived to obtain practical proof of the concept. Astronomers 'considered themselves part of this infinite Universe', when the search for its rational proof had just started and was to last for about three hundred years.