ALESSANDRO GIOSTRA

Galilei and Kepler on the Mathematical Beauty of the World as a Divine Gift

The Scientific Revolution transformed the teleological view of the universe into a quantitative vision in which measurements play a key role in our understanding of nature. The contribution offered by Christian theology for achieving that new approach is well evidenced: the major protagonists of the modern scientific revolution, indeed, considered the universe to be a mathematical structure as the outcome of divine creation. Humans, in turn, are provided by God with mathematical archetypes for understanding the inner nature of the world, as an integral part of revelation. This paper focuses on the ideas expressed by Galileo Galilei and Johannes Kepler on the geometrical harmony of creation as a divine gift.

Keywords: Johannes Kepler, Galileo Galilei, science and faith, mathematical universe, Scientific Revolution, Christian origin of science, Book of Nature, Creation, God's design.

Scriptures and the harmonic universe

The belief in a universal mathematical harmony represents a common ground for the thinkers that opened the way for the achievements of exact science. However, historians of modern thought often disregard the notion that the harmonical universe is celebrated in the Scriptures as the outcome of actions performed by God. Although the main Christian confessions reject any kind of concordism, and despite the distinction between theological approaches and scientific discourse, the biblical message offers a coherent view of the world. According to the etymological origin of the term (*unum in diversis*), the Bible presents the universe as a coherent totality. The sameness of phenomena and the human ability to interpret them share God as their same origin; the appropriate metaphor of the two books, nature and Scriptures, that inspired many modern authors, clearly suggests the inner rationality and readability of the created reality.

The effect of the Divine Mercy providing natural reality with intelligibility, can be found in Psalm 136:4-9, in which the 'skillful' creation of the earth and heavenly bodies highlights that 'God's love endures forever.'[1] In the book of Jeremiah, the existence of human beings, as beneficiaries of Revelation, is closely

1 In this paper the Scriptural quotes are taken from: *The New American Bible*. Nashville – Atlanta – London – Vancouver: Catholic Bible Press (1987).

linked to the order guaranteed by natural laws. 'Thus says the LORD, He who gives the sun to light the day, moon and stars to light the night; Who stirs up the sea till its waves roar, whose name is LORD of hosts: If ever these natural laws give way in spite of me, says the LORD, Then shall the race of Israel cease as a nation before me forever.' (Jer. 31:35-36)

So natural laws are arranged within a broader theological dimension, highlighting the magnificence and unity of creation. In Sirach, a Deuterocanonical book of the Old Testament, the outstanding natural beauty is revealed as an objective quality that humans can contemplate in all its greatness. 'The clear vault of the sky shines forth like heaven itself, a vision of glory. The orb of the sun, resplendent at its rising: what a wonderful work of the Most High! […] Great indeed is the LORD who made it, at whose orders it urges on its steeds. […] The beauty, the glory, of the heavens are the stars that adorn with their sparkling the heights of God, at whose command they keep their place and never relax in their vigils.' (Sir 43:1-10) Scientific investigation starts with a registering of reality, whose analogical order is presupposed by natural researchers, who found their own activity on the commonality of phenomena. In the Deuterocanonical Book of Wisdom, contemplation of created reality is deemed to be the path to grasp God as the source of universal beauty. 'For from the greatness and the beauty of created things their original author, by analogy, is seen.' (Wis 13:5)

The specificity of science consists in systems of equations relating to the regularity of natural phenomena, and the quantitative approach is analogically based on the order and coherence of matter. Highlighting this basic presupposition is the goal of the passage in the Book of Wisdom, where it is announced that 'You have disposed all things by measure and number and weight.' (Wis 11:20) These words clearly show the goodness of creation as a necessary precondition of an incipient scientific approach. So, the quantitative ordering of nature entails the cultivation of mathematical subject-matters. Moreover, Wis 11:20 anticipated the modern conception of the regularity of physical laws, according to which every phenomenon can be exactly measured. In the beginning of time, the Creator imposed a mathematical regularity on physical phenomena as the core of a predetermined order.

Many authors of the Christian tradition base their natural philosophy on the idea of a sapiential creation. In Augustine of Hippo's works, for example, the identity between Word and Wisdom sees the world order as part of God's providential design. Perceiving the vestiges of God means reading the beauty of creation as a mark of universal truth. Augustine understands the harmony of creation in terms of an ordered proportion, because eternal ideas are instantiated in matter. Put in other terms, the impressed forms call the intentional disposition of mind to understand the transcendent God as the origin of the universal beauty. The book of nature, as the outcome of creation, speaks to human beings and announces the glory of God (Ps 18:2). 'Some people, in order to discover God, read a book. But there is a great book: the very appearance

of created things. Look above and below, note, read. God whom you want to discover, did not make the letters with ink; he put in front of your eyes the very things that he made. Can you ask for a louder voice than that?'[2]

All those characteristics of the Biblical cosmos deeply impacted the scientific community in the XVI and XVII centuries. The celebration of the divine wisdom in designing everything resulted in the belief in a world that constantly displays its inner mathematical regularity. Furthermore, the stability of the universal harmony means the undeniable validity of God's action. The mathematical understanding of nature, as a hallmark of the Scientific Revolution, replaced the teleological arrangement of the world, dating back to the Aristotelian philosophy. The traditional conception, indeed, considered natural phenomena as goal-oriented processes aiming at achieving their inherent purpose. The shift from such an organismic worldview to a mechanistic universe was not immediate, as it was the outcome of the ongoing evolution of thought that started in the Medieval Age. The theory of impetus, formulated in the first half of the Fourteenth Century by the Scholastic philosopher John Buridan, anticipated the modern principle of inertia and represented a key step for the achievement of the laws of motion.

Although the Heliocentric theory incorporated both traditional and original assumptions, Kepler and Galilei welcomed it, not only for the removal of the earth from the centre of the planetary system, but mostly for the mathematical peculiarity of Copernican cosmology. Similarly to what Copernicus had done, they embraced a geometrical realism as a core belief in a harmonic universe. Consequently, in their opinion, the unalterable structure of creation entailed the impossibility of introducing mathematical solutions only to save appearances. The mathematizing of the universe in the modern age can be evaluated as the turning point towards exact science. Galilei's and Kepler's visions of science and natural theology offer a substantial contribution to this point of view.

The book of nature in Galilei's writings

Philosophy is written in this grand book which is continually open before our eyes – I mean the Universe – but before we can understand it we need to learn the language and recognize the characters in which it is written. It is written in the language of mathematics, and its characters are triangles, circles, and other geometrical figures, without which it is humanly impossible to understand a word of what it says. Without these, it is just wandering aimlessly in a baffling maze.[3]

This is probably the most famous of Galilei's statements, and its interpreta-

2 Augustine of Hippo, *Sermones* 68,6.

3 Galilei, G. *Selected Writings*. Oxford: Oxford University Press (2012), p. 115.

tion would be enough to understand the scientific program developed by the Italian scientist. Being far from any kind of science aimed only at saving phenomena, his mathematical realism exalts the harmonical universe shaped by God. Therefore, mathematics is seen as the divine language that guarantees to human beings the full intelligibility of creation. That metaphor was generally adopted by modern thinkers to emphasize that both of the books, nature and Scripture, come from the Creating Word. In accordance with the modern sense of the metaphor, mathematics constitutes the only reliable language for a coherent approach to phenomena. So mathematical precision confers nature with a beauty leading us to recognize God behind that indubitable harmony. A sort of ideal relationship between God and man is established on the basis of a cosmological language, rendering the world a harmonical reality. In the light of that principle, cosmology is integrated into a theological dimension, allowing scientists to keep their devotion to the Creator.

In the end of the first day of his *Dialogue Concerning the Two Chief World Systems*, Galilei defines more specifically the nature of mathematical knowledge. His vision keeps the unbridgeable gap between God and his privileged creature: while divine knowledge is total and immediate, the human understanding is a limited ongoing process needing time. Anyway, 'I do not thereby abase it so much as to consider it absolutely null. No, when I consider what marvellous things and how many of them men have understood, inquired into, and contrived, I recognize and understand only too clearly that the human mind is a work of God's, and one of the most excellent.'[4]

Human knowledge highlights its inferiority to the divine, but the possibility of comprehending the beauty of the mathematical structure of the world undoubtedly shows that the knowledge of exact physical laws forms part of the divine design for humanity. Investigating that universal harmony represents a gift of the divine mercy, as one can read in the dedication of the same *Dialogue* to the Grand Duke Ferdinand II.

He who looks the higher is the more highly distinguished, and turning over the great book of nature (which is the proper object of philosophy) is the way to elevate one's gaze. And though whatever we read in that book is the creation of the omnipotent Craftsman, and is accordingly excellently proportioned, nevertheless that part is most suitable and most worthy which makes His work and His craftsmanship most evident to our view. The constitution of the universe I believe may be set in first place among all natural things that can be known. [5]

That is the reason why, in the conclusion of the *Dialogue*, Salviati, that is Galilei's spokesman, highlights that scientific research should remain within

4 Galilei, G. *Dialogue Concerning the Two Chief World Systems*. Berkeley and Los Angeles: University of California Press (1967), p. 104.

5 *ibid*., p. 3.

the scientific approach and cannot penetrate the divine mysteries. In simple words, Divine Grace has shaped our minds to enable us to investigate the structure of the universe; therefore, restricting our study into the quantitative realm and avoiding delving into supreme mysteries, represent basic points of the God-man relationship.

An admirable and angelic doctrine, and well in accord with another one, also Divine, which, while it grants to us the right to argue about the constitution of the universe […] adds that we cannot discover the work of His hands. Let us, then, exercise these activities permitted to us and ordained by God, that we may recognize and thereby so much the more admire His greatness, however much less fit we may find ourselves to penetrate the profound depths of His infinite wisdom.[6]

Beyond any kind of Aristotelian distinction between heavenly and elementary realms, Galilei considers the universe as an entangled reality in which scientific knowledge and religion overlap. So, God's rule over the world and his intervention in human life rejects any pantheist ideas and promotes coming to Him through the scientific investigation of nature. According to the father of modern science, even technological advances form part of God's providential plan; his own telescope, indeed, is not an exception. 'In our time it has pleased God to concede to human ingenuity an invention so wonderful as to have the power of increasing vision four, six, ten, twenty, thirty, and forty times, and an infinite number of objects which were invisible, either because of distance or extreme minuteness, have become visible by means of the telescope.'[7] A similar meaning can be found in the early pages of the *Astronomical Herald*, where he announced the results of his own pioneering use of the new optical instrument. The new astronomical features contradicted the Aristotelian-Ptolemaic cosmology and promoted the heliocentric system, although they were not decisive arguments in favor of the Copernican theory. Those great novelties led Galilei to deem his own instrument a clear instance of God's sapiential work. 'All which facts were discovered and observed a few days ago by the help of a telescope devised by me, through God's grace first enlightening my mind.'[8]

In the *Copernican Letters*, written between 1613 and 1615, Galilei draws inspiration from the principle of accommodation to demonstrate the compatibility of the Heliocentric hypothesis and those biblical passages literally describing the immobility of the Earth and the motion of the Sun. According to Galilei, the Bible is not a scientific book, and that presupposition implies that mathematical demonstrations should be the only source for natural knowledge. The study of the mathematical beauty of nature is grounded in God's will, and that

6 *ibid*., p. 464

7 *ibid*., p. 335

8 Galilei, G. *The Astronomical Herald*. Oklahoma City: Byzantium Press (2004), p. 5.

belief results in the absolute reliability of demonstrations based on the universality of mathematical language. Teaching common people the real structure of the universe is not the intention of the sacred authors, as only mathematical demonstrations allow human beings to comprehend that aspect of the beauty of the world. So, as regards to astronomical issues, biblical scribes cannot 'have said so little about them – almost nothing compared to the infinite, profound, and wonderful truths which are demonstrated in this science.'[9]

As the Scriptures are written for ordinary people, we should not start discussing physical issues from the authority of biblical passages. Thus, only 'sense experiences and necessary demonstrations', founded upon mathematical reasoning, can disclose natural laws. Consequently, biblical authors had to accommodate their language to the understanding ability of common people. 'Nature, on the other hand, never transgresses the laws to which it is subject, but is inexorable and unchanging, quite indifferent to whether its hidden reasons and ways of working are accessible to human understanding or not [...] for not every statement of Scripture is bound to such strict rules as every effect of nature, and God is revealed just as excellently in the effects of nature as in the sacred sayings of Scripture.'[10]

The mathematical harmony of the universe is directly involved in the interaction between faith and science. Preventing scientists from revealing the exact mathematical laws of the world means cancelling the significance of many biblical verses that announce the outstanding beauty of God's creation. 'And to forbid the whole science of astronomy would be nothing less than contradicting a hundred passages of Holy Scripture, which teach us that the glory and greatness of God are wonderfully revealed in all his works, and made known divinely in the open book of the heavens.'[11]

Kepler's cosmology

Johannes Kepler deserves a special consideration among the most eminent thinkers of the Scientific Revolution, not only for having expressed the three laws of planetary movements. In his investigation he adopted a typical deductive method, in which the mathematical harmony of the planetary system was the basic presupposition upon which he found his astronomical research, that resulted in a very elegant and accurate model of the heavens. His meticulous search for real causes of heavenly motions trusted in the Biblical message as something that constitutes the premise of his achievements. In a letter written in 1598 to the Baron Herwart Von Hohenburg (1553-1622), Kepler declared

9 op. cit., Galilei 2012, p. 68.
10 *ibid*., p. 67
11 *ibid*., p. 77

that astronomers can be compared to priests, as their understanding of celestial laws leads to recognize the work of the Creator. 'Since we astronomers are priests of the highest God in regard to the book of nature, it benefits us to be thoughtful, not of the glory of our minds, but rather, above all else, of the glory of God.'[12]

Kepler's Platonism lies in the assumption that the universe is patterned upon geometrical forms, the only conceptual tools able to guarantee unity and beauty to nature. However, that vision does not prevent him from combining Platonic philosophy with Christian revelation. As humans created in the image of God, they share with the Divine Mind the mathematical archetypes upon which nature is structured. Similarly to what Galilei writes in the *Dialogue Concerning the Two Chief World Systems*, he defends his conception against the risk of drawing from it a false equivalence between God and man.

Those laws are within the grasp of the human mind; God wanted us to recognize them by creating us after his own image so that we could share in his own thoughts. For what is there in the human mind besides figures and magnitudes? It is only these which we can apprehend in the right way, and if piety allows us to say so, our understanding is in this respect of the same kind as the divine, at least as far as we are able to grasp something of it in our mortal life. Only fools fear that we make man godlike in doing so; for the divine counsels are impenetrable, but not his material creation.[13]

Kepler's heliocentric cosmos is a direct consequence of a realist view that cannot accept an astronomy aimed at merely saving appearances. God's love for humanity led to the formation of a universe, adapted to the human ability to understand it, disclosing the greatness of His supreme intelligence behind the mathematical regularity of the heavenly realm. The following words recall the meaning of the above mentioned *Wisdom* 11:20. Thus, if the Creator arranged everything according to number, measure, and weight, man's ability to understand the world must reflect a mathematical character or, to put it more simply, science is founded upon mathematics. 'We see how God, like a human architect, approached the founding of the world according to order and rule and measured everything in such a manner, that one might think not art took nature for an example but God Himself, in the course of his creation took the art of man as an example, though man was to appear only later on.'[14]

The book of the heavens must be interpreted as a rational entity that is geometrically shaped. Heavens and Scriptures are written in different languages, but the presence of God in nature can be grasped thanks to its mathematical

12 Kepler, G. *Gesammelte Werke*, Munich: C.H. Beck (1938), XIII, p. 193.

13 Frankenberry, N. *The Faith of Scientists in Their Own Words*, Princeton and Oxford: Princeton University Press (2008), p. 45.

14 op. cit., Kepler 1938, I, p. 6

proportionality, that offers human beings the chance to contemplate it. 'Here is treated the Book of Nature which is so highly praised by the Holy Scriptures [...] Why should we Christians take less pleasure in contemplating since it is our task to honor God in the right way, to worship and admire Him? Our worship is all the more deep, the more clearly we recognize the creation and its greatness.'[15]

In Kepler's view, the structure and working of the universe cannot be distinguished from questions regarding its origin. Creation bears the stamp of the divine mathematical mind; geometry shapes the physical structure of the universe and becomes the basis for creaturely praise. Kepler draws from Aristotelianism the form-matter dualist approach, though his own hylomorphic account of reality is based on a reductionism, according to which the unchanging quantity stands for the natural substantiality, as numbers are the main pattern in the mind of God. 'It was matter which God created in the beginning; and if we know the definition of matter, I think it will be fairly clear why God created matter and not any other thing in the beginning. I say that what God intended was quantity. To achieve it he needed everything which pertains to the essence of matter; and quantity is a form of matter, in virtue of its being matter, and the source of its definition. Now God decided that quantity should exist before all other things.'[16]

The extraordinary beauty of Kepler's world is grounded on his own realism and an objective natural knowledge can only result in the contemplation of its mathematical proportions. Kepler sees science as a divine pursuit and a mystical union with the divine mind, and that is why universal mathematical beauty forms part of God's announcement to humanity. 'Why indeed? Unless because by a most perfect Creator it was absolutely necessary that a most beautiful work should be produced [...] This pattern, this Idea, he wished to imprint on the universe, so that it should become as good and as fine as possible; and so that it might become capable of accepting this Idea, he created quantity.'[17]

Although the German astronomer, as other scientists used to do, developed his hypotheses in accordance to the need to compare observations with predictions, mathematical symmetry as a real quality of the world is the standpoint of his investigation. Against any sort of subjectivism, his realist approach is strengthened by the idea that beauty proves the divine origin of mathematical astronomy. Within that perspective, analogous to revelation, geometry is unique and the proportionality of matter shows the divine love for humanity. 'Geometry is unique and eternal, and it shines in the mind of God. The share of it which has been granted to man is one of the reasons why he is the image of

15 op. cit., Frankenberry, p. 43

16 *ibid*., p. 39.

17 *ibid*., pp. 40-41.

God. Now in geometry the most perfect class of figures, after the sphere, consists of the five Euclidean solids. They constitute the very pattern and model according to which this planetary world of ours was apportioned.'[18]

Kepler provides his planetary system with a broader metaphysical foundation, as he incorporates God's quantitative ideas into the substantial order of matter. He appeals to the concept of the divine design to establish the existence of a God-man providential relationship. Providence as a primary cause of the universe implies that man, being an intelligent creature, must contemplate the work of the Supreme Wisdom. Kepler's preoccupation with questions such as goal and meaning prompts him to believe in a world infused with full intelligibility for the benefit of his privileged creature. God's governing providence is displayed in mathematical regularity as an evident instance of the divine manifestation to man. In sum, creation is made for worship, and astronomy is a divine discipline helping to encourage religious belief.

It was his wish to invite men to consider the benefits accruing to them from each of these works of the six days. I, too, implore my reader, when he departs from the temple and enters astronomical studies, not to forget the divine goodness conferred upon men, to the consideration of which the psalmodist chiefly invites. I hope that, with me, he will praise and celebrate the Creator's wisdom and greatness, which I unfold for him in the more perspicacious explanation of the world's form, the investigation of causes, and the detection of errors of vision. Let him not only extol the Creator's divine beneficence in His concern for the well being of all living things, expressed in the firmness and stability of the earth, but also acknowledge His wisdom expressed in its motion, at once so well hidden and so admirable.[19]

Mathematics is coeternal with the divine mind, and celestial dynamics is understood as the best opportunity to join mathematical cosmology with theology. In the following words, forming part of *The Harmony of the World*, the idea of mathematics having a divine origin is openly stated.

For geometry, [...] is coeternal with God, and by shining forth in the divine mind supplied patterns to God, as was said in the preamble to this Book, for the furnishing of the world, so that it should become best and most beautiful and above all most like to the Creator. Indeed all spirits, souls, and minds are images of God the Creator if they have been put in command each of their own bodies, to govern, move, increase, preserve, and also particularly to propagate them.[20]

The direct consequence of Kepler's pioneering work is that natural science

18 *ibid*., p. 55.

19 Kepler J. *New Astronomy*. Cambridge: Cambridge University Press (1992), p. 65

20 op. cit., Frankenberry, p. 56

is directed towards a transcendent goal. God grants man specific skills to appreciate the natural order, and that ability allows a unitary understanding of creation. So human beings must praise God for the possibility to achieve that natural harmony, by allowing their participation in the divine perfection. 'I thank Thee, Creator Lord, because Thou hast made me delight in Thy handiwork, and I have exulted in the works of Thy hands. So, I have now brought to completion the work of my covenant, using all the power of the talents which Thou hast given me. I have made manifest the glory of Thy works to men who will read these demonstrations, as much as the deficiency of my mind has been able to grasp of its infinity.'[21] The final words of the *The Harmony of the World* can be considered a sort of synthesis of Kepler's cosmology. 'Praise him, sun and moon; give praise, all shining stars. Praise him, highest heavens, you waters above the heavens' (Ps 148:3-4). That is the Psalm inspiring his cosmological reflection, that serves as his theological aim. The harmony and beauty of the heavens witness the Creator's majesty and excellence. 'The heavens declare the glory of God' (Ps 19:2), therefore admiration of their supreme beauty bids the celestial realm itself to celebrate the divine Wisdom in a universal acclamation of her sovereignty. 'Great is our Lord, and great is His excellence and there is no count of His wisdom. Praise Him heavens; praise Him, Sun, Moon, and Planets, with whatever sense you use to perceive, whatever tongue to speak of your Creator; praise Him, heavenly harmonies, praise him, judges of the harmonies which have been disclosed; and you also, my soul, praise the Lord your Creator as long as I shall live.'[22]

In another meaningful text, Kepler is clearly inspired by the following words from the New Testament: 'for in him were created all things in heaven and on earth, the visible and the invisible […] all things were created through him and for him.' (Col 1:16-17) The ordering work of a purposeful creation is connected to the role of man within the supreme design. The constant presence of Wisdom alongside the world's construction leads Kepler to emphasize the goodness of God's handiwork, whose contingent character owns an intrinsic value. If the celestial order is established to be revealed, then man is called to recognize God's purposive action and praise its religious finality. 'For from Him and through Him and in Him are all things, "both sensible and intellectual," both those of which we are entirely ignorant and those which we know, a very small part of them, as there is yet more beyond. To Him be praise, honour, and glory from age to age. Amen.'[23]

21 Kepler, J. *The Harmony of the World*. Philadelphia: American Philosophical Society (1997), p. 491.

22 *ibid*., p. 498.

23 *ibid*., p. 498.

Conclusions

The emergence of exact science in the modern age can be connected to the basic principles of the Christian faith. More in detail, modern science originated in the Scientific Revolution, whose main protagonists believed in the Creator as the origin of the universal harmony. Establishing an incompatibility between Christianity and science would be nonsensical for an objective reconstruction of the historical development of the scientific discourse. Galilei's and Kepler's conceptions on the mathematical universe as a divine gift provide further evidence to that consideration.

Alessandro Giostra is a teacher of philosophy and history in Italian high schools, and member of Deputazione di Storia Patria per le Marche (Ancona).