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Article abstract

In 1616, the Holy Congregation for the Index prohibited the printing and reading of Copernicus’s On the Revolutions of the Heavenly Spheres (1543) on the grounds that heliocentrism contradicted the Holy Scriptures. According to Johannes Kepler, “To study the heavens is to know God as creator.” Moreover, “Since we astronomers are priests of the highest God in regard to the book of nature, it befits us to be thoughtful, not of the glory of our minds, but rather, above else, of the glory of God.” There is some precedent for such claims in John Calvin’s conception of the creation as a “Theatre of God’s glory” with its corollary of the so-called “two books”. Kepler’s defence of Copernican heliocentrism relies upon the distinction between the Book of Nature from the Book of Scripture. Building upon the soteriological foundations laid by Martin Luther, Kepler the astronomer-theologian also seeks to sharpen the distinction between a “visible” and an “invisible” heaven, with significant consequences for astronomical physics. The new astronomy is profoundly implicated in sixteenth-century theological controversies.

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THE "COSMOGRAPHIC MYSTERY" : JOHANNES KEPLER'S CONVERSION OF ASTRONOMY

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RÉSUMÉ : En 1616, la Congrégation de l'Index a interdit l'impression et la lecture de l'ouvrage de Copernic, Des révolutions des orbes célestes *(1543), sur le motif que l'héliocentrisme contredit les saintes Écritures. Selon Johannes Kepler, « étudier les cieux, c'est connaître Dieu en tant que Créateur ». En outre, « puisque nous, astronomes, sommes des prêtres du plus haut Dieu en ce qui concerne le livre de la nature, il convient que nous réfléchissions non à la gloire de notre esprit, mais plutôt, avant tout, à la gloire de Dieu ». Un certain précédent à de telles affirmations se retrouve dans la conception de Jean Calvin de la création comme un « théâtre de la gloire de Dieu » avec son corollaire desdits « deux livres ». La défense de l'héliocentrisme copernicien par Kepler s'appuie sur la distinction entre le Livre de la Nature et le Livre des Écritures. S'appuyant sur les fondements sotériologiques posés par Martin Luther, l'astronome théologien Kepler cherche également à préciser la distinction entre un ciel « visible » et un ciel « invisible », avec des conséquences importantes pour la physique astronomique. La nouvelle astronomie est profondément impliquée dans les controverses théologiques du seizième siècle.*

ABSTRACT : In 1616, the Holy Congregation for the Index prohibited the printing and reading of Copernicus's On the Revolutions of the Heavenly Spheres *(1543) on the grounds that heliocentrism contradicted the Holy Scriptures. According to Johannes Kepler, "To study the heavens is to know God as creator." Moreover, "Since we astronomers are priests of the highest God in regard to the book of nature, it befits us to be thoughtful, not of the glory of our minds, but rather, above else, of the glory of God." There is some precedent for such claims in John Calvin's conception of the creation as a "Theatre of God's glory" with its corollary of the so-called "two books". Kepler's defence of Copernican heliocentrism relies upon the distinction between the Book of Nature from the Book of Scripture. Building upon the soteriological foundations laid by Martin Luther, Kepler the astronomer-theologian also seeks to sharpen the distinction between a "visible" and an "invisible" heaven, with significant consequences for astronomical physics. The new astronomy is profoundly implicated in sixteenth-century theological controversies.*

At the outset of his treatise *Harmonices mundi* (*The Harmonies of the World*, 1619), a late work in which Johannes Kepler expounds his understanding of the

music of the celestial spheres, a harmony of beautiful musical proportions discernible in the varying velocities of the planets, he invokes inspiration from Plato's dialogue *Timaeus* :

> Before taking up these questions, it is my wish to impress upon my readers the very exhortation of Timaeus, a pagan philosopher, who was going to speak on the same things : it should be learned by Christians with the greatest admiration, and shame too, if they do not imitate him : *For truly, Socrates, since all who have the least particle of intelligence always invoke God whenever they enter upon any business, whether light or arduous ; so too, unless we have clearly strayed away from all sound reason, we who intend to have a discussion concerning the universe must of necessity make our sacred wishes and pray to the Gods and Goddesses with one mind that we may say such things as will please and be acceptable to them in especial and, secondly, to you too.*[1]

Kepler's epigraph to Book V of the *Harmonies* amplifies this theme of a sapiential theology in the form of a quotation from Galen :

> I am undertaking a holy discourse, a true hymn to God our Creator, believing that piety consists not in my sacrificing a great many hecatombs of bulls to Him, nor in my offering innumerable scents and spices ; but in my first learning myself, and then teaching others, both His greatness in wisdom, His greatness in power, and His nature in goodness. For I take as demonstration of the most absolute goodness the wish to embellish all things with the greatest possible adornment, and to envy no man his goods ; and I honour Him as good accordingly ; and furthermore I take it as a demonstration of outstanding wisdom, to seek out everything by which He might be adorned to the utmost ; and finally as a demonstration of irresistible power, to carry out all that He had ordained.[2]

And Kepler had done precisely this both at the outset of his first important treatise, the *Mysterium Cosmographicum*, first published in 1596 and reissued in a revised edition in 1621. The full title of the treatise is *Forerunner of the Cosmological Essays, which contains the Secret of the Universe on the Marvellous Proportion of the Celestial Spheres, and on the true and particular causes of the number, size, and periodic motions of the heavens, Established by means of the five regular Geometric solids*.[3] In the edition of 1621 Kepler greets his "friendly reader" with a poem which provides a helpful abstract of the main claims of the treatise :

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1. *Timaeus*, 27c : "Ἀλλ' ὦ Σώκτατες, τοῦτό γε δὴ πάντες ὅσοι καὶ κατὰ βραχὺ σωφροσύνης μετέχουσιν, ἐπὶ πασῇ ὁρμῇ καὶ σμίκροῦ καὶ μεγάλου πράγματος θεὸν ἀεί που καλοῦσιν. ἡμᾶς δὲ τοὺς περὶ τοῦ πάντος λόγους ποιεῖσθαι πῃ μέλλοντας […], εἰ μὴ παντάπασι παραλλάττομεν, ἀνάγκη θεοὺς τε καὶ θεὰς ἐπικαλουμένους εὔχεσθαι πάντα, κατὰ νοῦν ἐκεῖνοις μέν μάλιστα, ἑπομένως δέ ἡμῖν εἰπεῖν." Johannes KEPLER, *Harmonice mundi libri V*, Linz, Austriae, Sump. Tambach, 1619. *Harmonies of the World*, transl. Charles Glenn Wallis, Amherst, N.Y., Prometheus Books, 1995, Proem.
2. KEPLER, *Harmonies of the World*, p. 169.
3. ID., *Prodromus Dissertationum Cosmographicarum : Continens Mysterium Cosmographicum, de Admirabili Proportione Orbium Coelestium, Deque Causis Coelorum Numeri, Magnitudinis, Motuumque Periodicorum Genuinis & Proprjis, Demonstratum, per Quinque Regularia Corpora Geometrica*, Tubingen, G. Gruppenbach, 1596 ; 2nd ed., Frankfort, Erasmus Kempfer, 1621. In his *Commentary on the Elements of Geometry*, Proclus states no few than four times that demonstration of the five Platonic solids is one of Euclid's two principal aims. Gottfried FRIEDLEIN, ed., *Procli Diadochi in Primum Euclidis Elementorum Librum Commentarii*, Leipzig, Teubner, 1967, p. 68, 70, 71, 74 (see also p. 82-83). Cited by Michael N. FRIED, "Book XIII of the *Elements*," in *History and Pedagogy of Mathematics*. *Proceedings of the 2012 Satellite Meeting, Daejeon, Korea*, p. 607-617.

Lector Amice Salve
Quid mundus, quae causa Deo, ratioque creandi,
Unde Deo numeri, quae tantae regula moli,
Quid faciat sex circuitus, quo quaelibet orbe
Intervalla cadant, cur tanto Iupiter et Mars,
Orbibus haud primis, interstinguantur hiatu :
Hic te Pythagoras docet omnia quinque figuris.
Scilicet exemplo docuit, nos posse renasci,
Bis mille erratis, dum fit Copernicus annis,
Hoc, melior Mundi speculator, nominis.
At tu Glandibus inventas noli postponere fruges.

Greetings, Friendly Reader
The World's design, Creation's how and why,
And whence God's numbers : laws that rule the sky —
The reason for six tracks, each interval,
And why the gap twixt Mars and Jove so gapes
Though neither of their spheres is principal —
Pythagoras will show with just five shapes.
We can, through his example, live again :
Two thousand years of error gone, explore
Still better, by Kopernik, than before !
Delay no more, but gather in my grain.[4]

Kepler stands in the tradition of Proclus for whom "Euclid belonged to the persuasion of Plato and was at home in this philosophy ; and this is why he thought the goal of the *Elements* as a whole to be the construction of the so-called Platonic figures".[5] In his commentary on Euclid's *Elements*, Proclus refers often to Plato's dialogue *Timaeus*. In his description of the impact of mathematics on the theory of nature, Proclus states :

> [Geometry] reveals the orderliness (*eutaxian*) of the ratios according to which the universe is constructed (*dedēmiourgētai to pan*) and the proportion that binds things together in the cosmos, making, as the *Timaeus* somewhere says, divergent warring factors into friends and sympathetic companions. It exhibits the simple and primal causal elements as everywhere clinging fast to one another in symmetry and equality, the properties through which the whole heaven was perfected (*ho pas ouranos eteleōthē*) when it took upon itself the figures appropriate to its particular region ; and it discovers, furthermore, the numbers applicable to all generated things and to their periods of activity and of return to their starting-points, by which it is possible to calculate the times of fruitfulness or the reverse for each of them. All these I believe the *Timaeus* sets forth, using mathematical language

4. Johannes KEPLER, *Mysterium Cosmographicum. The Secret of the Universe*, transl. A.M. Duncan, New York, Abaris Books, 1981 : "The nature of the universe, God's motive and plan for creating it, God's source for the numbers, the law for such a great mass, the reason why there are six orbits, the spaces which fall between all the spheres, the cause of the great gap separating Jupiter and Mars, though they are not in the first spheres — here Pythagoras reveals all this to you by five figures. Clearly he has revealed by this example that we can be born again after two thousand years of error, until the appearance of Copernicus, in virtue of this name, a better explorer of the universe. But hold back no longer from the fruits found within these rinds."

5. FRIEDLEIN, ed., *In Primum Euclidis*, p. 68. Cited by FRIED, "Book XIII of the *Elements*," p. 609.

> throughout in expounding its theory of the nature of the universe [literally, the "whole"] (*peri tēs phuseōs tōn holōn theōrian*).[6]

As the full title declares, the *Mysterium Cosmographicum* sets forth the agenda of Kepler's later mature publications — the *Astronomia Nova* of 1609,[7] the *Harmonies* (1619), and the *Epitome of Copernican Astronomy* (1618-1621).[8] Foundational to the project is Kepler's enthusiastic embrace of the heliocentric astronomy of Copernicus. Along with Giordano Bruno, and later Galileo, Kepler is among the few in the sixteenth century to do so with zeal and steadfast commitment. In his dedication of *On the Revolutions of the Heavenly Spheres* (1543) to Pope Paul III, Alessandro Farnese, Copernicus had been mostly careful not to assert that his astronomical speculations were at odds with Holy Scripture.[9] In an attempt to reduce the controversial impact of the claim that the earth was a celestial body, Andreas Osiander (1498-1552), Lutheran theologian and friend of Copernicus who saw *De Revolutionibus* through the press, anonymously added his own unsigned foreword *Ad lectorem de hypothesibus huius operis*. Osiander stated that Copernicus' system was a mathematical hypothesis intended to facilitate astronomical reckoning and not an attempt to declare literal, physical truth, that is to say, in the accepted astronomical idiom, the goal was to "save the appearances" :

> […] it is not necessary that these hypotheses should be true, or even probable ; but it is enough if they provide a calculus which fits the observations […]. For this art is absolutely and profoundly ignorant of the causes of the apparent irregular movements. And if it constructs and thinks up causes — and it has certainly thought up a good many — nevertheless it does not think them up in order to persuade anyone of their truth but only in order that they may provide a correct basis for calculation.[10]

Osiander alleges, not entirely accurately, that Copernicus held back from unequivocal assertion of the immobility of the sun at the centre of the world and the orbit of the earth. In the original Preface to the Reader of the *Mysterium Cosmographicum*,

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6. *In Eucl.*, p. 22-23. Quoted by FRIED, "Book XIII of the *Elements*," p. 615.
7. Johannes Kepler, *Astronomia Nova ΑΙΤΙΟΛΟΓΗΤΟΣ, seu Physica Cœlestis Tradita Comentariis de Motibus Stellæ Martis, Ex Obersvationibus G[enerosi] V[iri] Tychonis Brahe… Elaborata*, Prague, s.n., Anno Aerae Dionysianae 1609. English translation by William H. DONAHUE, ed., *Kepler's New Astronomy*, Cambridge, Cambridge University Press, 1992. See also DONAHUE's *Selections from Kepler's* Astronomia Nova, Santa Fe, N.M., Green Lion Press, 2008.
8. Johannes KEPLER, *Epitome Astronomiae Copernicanæ Usitatâ Formâ Quæstionum & Responsionum Conscripta*, Linz, Johannes Plancus, 1618-1621. *Epitome of Copernican Astronomy & Harmonies of the World*, transl. by C.G. Wallis, Amherst, Prometheus Books, 1995.
9. Nicholas COPERNICUS, *De Revolutionibus Orbium Cœlestium, Libri VI*, Nuremburg, J. Petreium, 1543. *On the Revolutions*, ed. Jerzy DOBRZYCKI, Baltimore, Johns Hopkins University Press, 1978. "I can readily imagine, Holy Father, that as soon as some people hear that in this volume, which I have written about the revolutions of the spheres of the universe, I ascribe certain motions to the terrestrial globe, they will shout that I must be immediately repudiated together with this belief. For I am not so enamoured of my own opinions that I disregard what others may think of them. I am aware that a philosopher's ideas are not subject to the judgment of ordinary persons, because it is his endeavour to seek the truth in all things, to the extent permitted to human reason by God."
10. "Ad Lectorem," in N. COPERNICUS, *On the Revolutions of the Heavenly Spheres*, transl. C.G. Wallis, Chicago, Encyclopædia Britannica, 1986, p. 505-506. Bruce WRIGHTSMAN, "Andreas Osiander's Contribution to the Copernican Achievement," in Robert S. WESTMAN, ed., *The Copernican Achievement*, Los Angeles, University of California Press, 1975, p. 213-143.

Kepler alludes to this reserve with respect to causality when he compares what he is doing with the earlier work :

> I was so delighted by Copernicus […] that I not only frequently defended his opinions at the disputations of candidates in physics but even wrote out a thorough disputation on the first motion […] but where Copernicus did so through mathematical arguments, mine were physical, or rather metaphysical […].[11]

In this remark Kepler draws a critical distinction between the hypothetical assumptions of traditional mathematical astronomy and what he terms "celestial physics", a causal account of planetary motion understood realistically : in the new astronomy it would not be sufficient merely to "save the phenomena". William Donahue points out that much of the discussion on the relation between scripture and astronomy Kepler had originally intended to include in the Preface to his first edition of *Mysterium Cosmographicum* (*MC*) in 1596 was censored by faculty at the University of Tübingen, but eventually appeared in his *Astronomia Nova* of 1609, and again in the second edition of *MC* in 1621.[12] Whereas like Ptolemy before him, and Tycho Brahe (1546-1601) after, Copernicus aims to formulate a mathematically concise explanation of the celestial motions with a view to giving a simple explanation of apparent irregularities in the celestial motions which were to be circular, regular, and uniform — in order to "save the appearances".[13] Kepler, by contrast to all three, turns, as he himself puts it "from astronomy to physics or cosmography."[14] To "save the appearances" is to demonstrate mathematical relationships which correspond to observation, without making any attempt to suggest a physical explanation for the relationships. According to the ancient view as defined by Geminus of Rhodes (110-40 BCE) :

> The hypothesis that underlies the whole of astronomy is that the Sun, the Moon, and the five planets move circularly and at a constant speed in the directions opposite to that of the cosmos […] it is no part of the business of the astronomer to know what is by nature suited to a position of rest, and what sort of bodies are apt to move, but he introduces hypotheses under which some bodies remain fixed, while others move, and then considers to which hypotheses the phenomena actually observed in the heavens will correspond.[15]

Ptolemy, Copernicus, and Brahe all agreed that celestial motions were circular or spherical, regular, and uniform. The vagaries of the wandering stars were to be explained by various complicated arrangements of eccentric circles (where the path of a heavenly body's motion was not centred exactly on the earth or the sun), epicycles

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11. KEPLER, *Mysterium Cosmographicum*, p. 63.
12. William H. DONAHUE, *Selections from Kepler's* Astronomia Nova, p. 1.
13. "I correlate the motions of the other planets and of all the spheres with the movement of the earth so that I may thereby determine to what extent the motions and appearances of the other planets and spheres can be **saved** if they are correlated with the earth's motions" (Nicholas COPERNICUS, *On the Revolutions of the Heavenly Bodies*, transl. Edward Rosen, London, Macmillan, 1972, p. 5). On "saving the appearances" (σώζειν τὰ φαινόμενα), see Peter BARKER, Bernard R. GOLDSTEIN, "Realism and Instrumentalism in Sixteenth Century Astronomy," *Perspectives on Science*, 6, 3 (1998), p. 232-258. G.E.R. LLOYD, "Saving the Appearances," *Classical Quarterly*, 28, 1 (1978), p. 202-222.
14. KEPLER, *Mysterium Cosmographicum*, p. 77.
15. GEMINUS, transl. James Evans and J. Lennart Berggren, *Geminos's* Introduction to the Phenomena *: A Translation and Study of a Hellenistic Survey of Astronomy*, Princeton, N.J., Princeton University Press, 2006, p. 49, 117.

(small circular paths whose centres moved along the principal circular path), or by equants (the point about which the angular motion of a heavenly body or the centre of an epicycle was uniform). All of this geometrical complexity served to sustain the underlying hypothesis of uniform circular motion. In Book VIII of *Paradise Lost* while Eve wanders off to inspect her "Fruits and Flowers" Raphael relates to Adam the divine amusement at the contrivances of mathematical astronomy :

> And Raphael now, to Adam's doubt proposed,
> Benevolent and facile thus replied.
> To ask or search, I blame thee not ; for Heaven
> Is as the book of God before thee set,
> Wherein to read his wondrous works, and learn
> His seasons, hours, or days, or months, or years :
> This to attain, whether Heaven move or Earth,
> Imports not, if thou reckon right ; the rest
> From man or angel the great Architect
> Did wisely to conceal, and not divulge
> His secrets to be scanned by them who ought
> Rather admire ; or, if they list to try
> Conjecture, he his fabric of the Heavens
> Hath left to their disputes, perhaps to move
> His laughter at their quaint opinions wide
> Hereafter ; when they come to model Heaven
> And calculate the stars, how they will wield
> The mighty frame ; how build, unbuild, contrive
> To save appearances ; how gird the sphere
> With centric and eccentric scribbled o'er,
> Cycle and epicycle, orb in orb.[16]

Kepler's attempt to render a physical and indeed, as he states, a "metaphysical argument" about the heavenly motions constitutes what we refer to as his "conversion of astronomy". In a sense Kepler was acting on a sound teleological maxim in his bid to simplify the mathematics. In his treatise *On the Heavens*, Aristotle states that "God and nature do nothing in vain, nothing superfluous."[17] Kepler cuts the Gordian Knot of mathematical astronomy with Occam's Razor by dispensing with the premise of uniform and regular circular motion as essential to the celestial phenomena, and substitutes in its place the beautiful geometry of the ellipse. By virtue of its two foci the ellipse enables the centring of the cosmos on the sun itself rather than upon some mathematical "mean sun". In actuality many of the planets move on ellipses which closely approximate a circle — as Apollonius of Perga asserts in his *Conic Sections* (ca. 200 BCE), the circle is a special case of an elliptical conic section where the two *foci* coincide. Every point on an ellipse has the property that the sum of the distances from it to the two *foci* remains constant. Motion on an ellipse is curvilinear, is continuous in its return upon itself, but the path is defined by the rectilinear opposition of the two foci ; thus the ellipse resolves into itself the Aristotelian opposition between

16. John MILTON, *Paradise Lost*, VIII.64-84. Dennis R. DANIELSON, *Paradise Lost and the Cosmological Revolution*, Cambridge, Cambridge University Press, 2014.

17. See ARISTOTLE, *De Caelo* (I.4, 271a33) : "Ο δὲ θεὸς καὶ ἡ φύσις οὐδὲν μάτην ποιοῦσιν."

the uniform circular motion of the incorruptible heaven and the motion between contraries of the corruptible sublunary sphere.

The title of one of Kepler's later treatises makes his cosmographical project plain : the *Astronomia Nova* (1609) is subtitled "*Aitiologetos, seu physica cœlestis*" — a "New Astronomy, based upon causes, or a celestial physics".[18] In the fourth chapter of *Mysterium Cosmographicum*, Kepler tells us "I think that from the love of God towards mankind many causes of things in the world may be deduced." This revelation of causality points to Kepler's "sacred mystery" : divine providence renders these causes intelligible. "My aim", he states in the *Astronomia Nova*,

> is chiefly to reform astronomical theory […] in all three forms of hypotheses [i.e. those of Ptolemy, Copernicus, and Tycho Brahe], so that what we compute from the tables may correspond to the celestial phenomena. Hitherto, it has not been possible to do this with sufficient certainty.[19]

Simon Grynæus, a school chum of Philipp Melanchthon and from 1524 Professor of Greek at the University of Heidelberg, was responsible for the first modern Greek edition of Ptolemy's *Almagest*.[20] Charlotte Methuen has shown that Grynæus argued for the legitimacy of mathematically based arguments in establishing the correct interpretation of observational data.[21] As Kepler's poem prefaced to the *Mysterium* announces, his aim is to demonstrate "what the world is like, that is, God's cause and plan for creating it" (*Quid mundus, quae causa Deo, ratioque creandi*). "And now at last with the divine Copernicus it pleases [me] to cry out : 'Certainly such is the divine handiwork of the Good and Great Creator'."[22] For Kepler the "mysterium" is this "divine handiwork" expressed through the geometrization of space — the immanence of the divine providential reason in creation.

The term μυστήριον appears sixteen times in the New Testament : the "mystery of the kingdom of God" (Mk. 4:11), the "mystery of faith" (1 Tim. 3:9), the "mystery of the union between Christ and the Church" (Eph. 5:32), the "mystery of resurrection" (1 Cor. 15:51, 52) and in several instances this word is rendered as *sacramentum* in the Vulgate. What is this *mysterium* ? In his First Epistle to Timothy (3:16), Paul observes : "great is the mystery of godliness (μέγα ἐστὶν τὸ τῆς εὐσεβείας μυστήριον) : God was manifest in the flesh, justified in the Spirit, seen of angels, preached unto the Gentiles, believed on in the world, received up into glory." In almost all of these passages of Scripture *mysterium* (or *sacramentum*) refers to the Christian proclamation concerning the joining together of the divine and human natures in the Incarnation and Resurrection of Christ, the union of eternal, incorruptible,

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18. Johannes KEPLER, *Astronomia Nova ΑΙΤΙΟΛΟΓΗΤΟΣ*, English translation by William H. Donahue, ed., *Kepler's New Astronomy*. See also DONAHUE'S *Selections from Kepler's* Astronomia Nova.
19. KEPLER, *Astronomia Nova*, p. 4-5.
20. Κλ. Πτολεμαίου Μεγάλης συντάξεως βιβλ. 13 = *Claudii Ptolemaei Magnæ constructionis, id est Perfectæ cœlestium motuum pertractationis*, lib. XIII, ed. Simon GRYNÆUS, Basle, Walderus, 1538. This edition is prefaced with a dedication to Henry VIII and includes the commentaries of Theon of Alexandria.
21. See Charlotte METHUEN, *Kepler's Tübingen : Stimulus to a Theological Mathematics*, Brookfield, Vt., Ashgate, 1998, p. 171.
22. KEPLER, *Mysterium Cosmographicum*, p. 82.

and immortal being with the temporal, corruptible, and mortal. The Matin Responsory for the Feast of the Nativity invokes the "magnum mysterium et admirabile sacramentum" of the Incarnation. How might this scriptural formula assist in our attempt to understand Kepler the cosmological astronomer ? Kepler's intent may perhaps be discerned from a remark in his *Epitome of Copernican Astronomy* where he promised that he would teach "the truth concerning the mutable nature of the heavens." He appeals to Psalm 102:25-26, in which both heaven and earth are said to "wear out like a garment"[23] to question the Aristotelian-Ptolemaic assumption of the eternity and incorruptibility of the heavens :

> It seems to me that the truth concerning the mutable nature of the heavens can be taught conveniently ; but someone else judges that students and teachers equally are thrown into confusion by this doctrine. But it is not without its use in explaining even those parts of the philosophy of Aristotle which are clearly false, as Book VIII of the *Physics* concerning celestial movement and Book II of *On the Heavens* concerning the eternity of the heavens — so that a comparison could be made between the philosophy of the gentiles and the truth of Christian doctrine.[24]

The conversion of the incorruptible heaven of Aristotle and Ptolemy with its uniform circular motion into a "mutable vesture" has its just analogue in the launching of the formerly stationary and corruptible earth into celestial orbit. The Christian dogma to which Kepler refers posits the union of the mortal and the immortal, the corruptible and the incorruptible, a *mysterion* famously formulated by Paul in his Epistle to the Corinthians.[25] In his poem *An Anatomy of the World*, published in 1611 "wherein, by occasion of the untimely death of Mistress Elizabeth Drury, the frailty and the decay of this whole world is represented", John Donne articulates the cosmic anxiety which attends this early modern astronomical controversy :

> And new philosophy calls all in doubt,
> The element of fire is quite put out,
> The sun is lost, and th'earth, and no man's wit
> Can well direct him where to look for it.
> And freely men confess that this world's spent,
> When in the planets and the firmament
> They seek so many new ; they see that this
> Is crumbled out again to his atomies.
> 'Tis all in pieces, all coherence gone,
> All just supply, and all relation ;
> Prince, subject, father, son, are things forgot,
> For every man alone thinks he hath got

23. Psalm 102 : 25 Of old hast thou laid the foundation of the earth : and the heavens are the work of thy hands. 26 They shall perish, but thou shalt endure : yea, all of them shall wax old like a garment ; as a vesture shalt thou change them, and they shall be changed : 27 But thou art the same, and thy years shall have no end.

24. KEPLER, *Epitome of Copernican Astronomy*, Book IV, Chicago, Encyclopædia Britannica, 1986, p. 849.

25. 1 Cor. 15:54 : So when this corruptible shall have put on incorruption, and this mortal shall have put on immortality, then shall be brought to pass the saying that is written, Death is swallowed up in victory.

To be a phoenix, and that then can be
None of that kind, of which he is, but he.[26]

Where indeed to look for a place to stand : "no man's wit / can well direct him where to look for it." Christian dogma was not without ambiguity, however. The Psalmist declares that "the Lord has fixed the orb of the earth (*orbem terrae*) which will not be moved" (96:1) and this cosmically centred stability had long been supported by the same natural philosophy Kepler challenged, by Aristotle in his *Physics* and *On the Heavens*, and by Ptolemy in *The Almagest*. Copernicus was careful not to assert that his astronomical speculations were contradictory of Holy Scripture. And so his work was not summarily prohibited by the Congregation for the Index ; and not until the first trial of Galileo in 1616 was publication and reading of *On the Revolutions of the Heavenly Spheres* "suspended until corrected".[27] In 1620 these corrections were indicated. Nine sentences, by which the heliocentric system was represented as factually certain, had to be either omitted or changed. This done, the reading of the book was once again allowed.[28]

For theologians of the early modern period much was at stake in the claims of the new astronomy. Martin Luther, Philipp Melanchthon, and John Calvin all rejected the heliocentrism of Copernicus. In his *Tischreden* we find Luther observing :

> There was mention of a certain new astrologer who wanted to prove that the earth moves and not the sky, the sun, and the moon. This would be as if somebody were riding on a cart or in a ship and imagined that he was standing still while the earth and the trees were moving. [Luther remarked] 'So it goes now. Whoever wants to be clever must agree with nothing that others esteem. He must do something of his own. This is what that fellow does who wishes to turn the whole of astronomy upside down. Even in these things that are thrown into disorder I believe the Holy Scriptures, for Joshua commanded the sun to stand still, and not the earth [Josh. 10:12]'.[29]

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26. John DONNE, *An Anatomy of the World*, London, (W. S.) for S. Macham, 1611 ; STC 7022, ll. 205-218.
27. At his second trial in 1633, Galileo was found "vehemently suspect of heresy" and sentenced to house arrest which lasted until his death in 1642. Annibale FANTOLI, "The Disputed Injunction and its role in Galileo's Trial," in Ernan MCMULLIN, ed., *The Church and Galileo*, Notre Dame, Ind., University of Notre Dame Press, 2005, p. 117-149, esp. p. 136.
28. In 1620, in Decree XXI, the required corrections were officially announced. This is an extraordinary measure since for very few books did the Index specify the type of changes to be made. The ten emendations were designed to make Copernicus' book appear hypothetical and not the description of a real physical work. The following passage from the Dedication of Copernicus's work to Pope Paul III was deleted in 1620 : "Perhaps there will be babblers who claim to be judges of astronomy although completely ignorant of the subject and, badly distorting some passage of Scripture to their purpose, will dare to find fault with my undertaking and censure it. I disregard them even to the extent of despising their criticism as unfounded. For it is not unknown that Lactantius, otherwise an illustrious writer but hardly an astronomer, speaks quite childishly about the Earth's shape, when he mocks those who declared that the Earth has the form of a globe. Hence scholars need not be surprised if any such persons will likewise ridicule me. Astronomy is written for astronomers. To them my work too will seem, unless I am mistaken, to make some contribution also to the Church, at the head of which Your Holiness now stands." This deleted passage is Edward Rosen's translation.
29. Martin LUTHER, *Luther's Works*, Vol. 54, *Table Talk*, ed. Helmut T. LEHMANN, Philadelphia, Fortress Press, 1967, p. 358-359. Michel-Pierre LERNER, "Aux origines de la polémique anticopernicienne (II). Martin Luther, Andreas Osiander et Philipp Melanchthon," *Revue des sciences philosophiques et théologiques*, 90, 3 (2006), p. 409-452. Edward ROSEN, "Kepler and the Lutheran Attitude Towards Copernicanism in the Context of the Struggle between Science and Religion," *Vistas in Astronomy*, 18 (1975), p. 317-338.

In his biblical commentary, Calvin avoids any reference to Copernicus when he addresses Joshua 10. In a sermon on 1 Corinthians, however, Calvin warns against those who say, "that the sun does not move and that it is the earth that moves."[30] In 1633, the Roman Inquisition concluded the trial of Galileo at the Church of Santa Maria Sopra Minerva with his condemnation for heresy. According to legend, Galileo is reported to have muttered "*e pur si muove*" after being compelled to recant his claim that the earth moves around the immovable sun rather than contrariwise. In a formal Injunction on 26 February 1616, Cardinal Bellarmine had warned Galileo to abandon this "false Pythagorean doctrine", also taught by Nicolaus Copernicus, as "altogether opposed to Holy Scripture".[31] Unlike Galileo, Copernicus had the good sense not to accentuate the physical actuality of heliocentrism, and so, owing in part to the intervention of Osiander, escaped official condemnation excepting the four-year suspension of his work 70 years after his death. Kepler's *Epitome of Copernican Astronomy* (1618-1621), however, remained on the *Index Librorum Prohibitorum* from 1621 to 1835.

In the preface to his *Almagest*,[32] a work originally titled the *Mathematical Treatise* (Μαθηματικὴ Σύνταξις) or *Great Treatise* (Ἡ Μεγάλη Σύνταξις), Claudius Ptolemy (100-170 CE) affirms Aristotle's division of the theoretical sciences into three genera : "the physical, the mathematical, and the theological".[33]

> For given that all beings have their existence from matter and form and motion, and that none of these can be seen, but only thought, in its subject separately from the others, if one should seek out in its simplicity the first cause of the first movement of the universe, he would find God invisible and unchanging. And the kind of science which seeks after Him is the theological ; for such an act can only be thought as high above somewhere near the loftiest things of the universe and is absolutely apart from sensible things. But the kind

30. Calvin's attitude towards Copernicus and heliocentrism has been the subject of debate. Richard STAUFFER, "Calvin et Copernic," *Revue de l'histoire des religions*, 179, 1 (1971), p. 31-40 ; cited in Herman J. SELDERHUIS, ed., *The Calvin Handbook*, Grand Rapids, Eerdmans, 2009, p. 452. See also Edward ROSEN, "Calvin's Attitude Toward Copernicus," *Journal of the History of Ideas*, 21, 3 (1960), p. 431-441 ; Joseph RATNER, "Some Comments on Rosen's 'Calvin's Attitude Toward Copernicus'," *Journal of the History of Ideas*, 22, 3 (1961), p. 382-385 ; Christopher KAISER, "Calvin, Copernicus, and Castellio," in Richard C. GAMBLE, ed., *Calvin and Science*, New York, Garland, 1992, p. 45-47.

31. Maurice A. FINOCCHIARO, ed. and transl., *The Galileo Affair. A Documentary History*, Berkeley, University of California Press, 1989. "At the palace, the usual residence of Lord Cardinal Bellarmine, the said Galileo, having been summoned and being present before the said Lord Cardinal, was, in the presence of the Most Reverend Michelangelo Segizi of Lodi, of the order of Preachers, Commissary-General of the Holy Office, by the said Cardinal, warned of the error of the aforesaid opinion and admonished to abandon it ; and immediately thereafter, before me and before witnesses, the Lord Cardinal being present, the said Galileo was by the said Commissary commanded and enjoined, in the name of His Holiness the Pope and the whole Congregation of the Holy Office, to relinquish altogether the said opinion that the Sun is the centre of the world and immovable and that the Earth moves ; nor further to hold, teach, or defend it in any way whatsoever, verbally or in writing ; otherwise proceedings would be taken against him by the Holy Office ; which injunction the said Galileo acquiesced in and promised to obey. Done at Rome, in the place aforesaid, in the presence of R. Badino Nores, of Nicosia in the kingdom of Cyprus, and Agostino Mongardo, from a place in the Abbey of Rose in the diocese of Montepulciano, members of the household of said Cardinal, witnesses."

32. *Almagest* is an Arabic transliteration of the work's Greek title μεγίστη : al-majisṭī (المجسطي).

33. PTOLEMY, *The Almagest*, ed. R.C. TALIAFERRO and C.G. WALLIS, Chicago, Encyclopædia Britannica (coll. "Great Books of the Western World," 16), 1952, p. 5.

> of science which traces through the material and ever moving quality, and has to do with the white, the hot, the sweet, the soft, and such things, would be called physical ; and such an essence since it is only generally what it is, is to be found in corruptible things and below the lunar sphere. And the kind of science which shows up quality with respect to forms and local motions, seeking figure, number, and magnitude, and also place, time, and similar things, would be defined as mathematical.[34]

Kepler's new science of Astronomy adheres to a unification of physics, mathematics, and theology in a resolute attempt to restore coherence and intelligibility to the cosmos — an attempt to repair "all just supply and all relation".

The *Mysterium Cosmographicum* presents a Christian Neo-Pythagorean argument for the geometrical structure of the cosmos combined with an account of causality : theology, mathematics, and physics combined.[35] This early work published when Kepler was aged just 25 reveals the strong theological bent that became a hallmark of his approach to astronomy throughout his career :

> Here we are concerned with the Book of Nature, so greatly celebrated in sacred writings. It is in this that Paul proposes to the Gentiles that they should contemplate God like the Sun in water or in a mirror. Why then as Christians should we take any less delight in its contemplation, since it is for us with true worship to honour God, to venerate him, to wonder at him ? The more rightly we understand the nature and scope of what our God has founded, the more devoted the spirit in which that is done.[36]

As we have seen, Kepler represents the cosmos as an orderly nested arrangement founded upon the five regular solids described by Plato in the *Timaeus* (55d) and by Euclid in Book XIII of *Elements of Geometry* (and according to Euclid there can only be five) : the tetrahedron, cube, octahedron, dodecahedron, and icosohedron.[37]

For Kepler's cosmographical purposes, each regular solid is circumscribed and inscribed by a sphere ; five solids, six spheres. All of the vertices of the circumscribed sphere touch the inside of that sphere. And conversely, the vertices of the inscribed sphere simultaneously touch all the faces of that regular solid. The planets are attached to these spheres with the sphere of the fixed stars beyond the outermost sphere of Saturn. Through the "Book of Nature" the divine providential activity of the creator is accessible to the astronomer.[38] "Since we astronomers are priests of the highest God in regard to the book of nature, it befits us to be thoughtful, not of the

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34. PTOLEMY, *The Almagest*, p. 5.
35. Peter BARKER, Bernard R. GOLDSTEIN, "Theological Foundations of Kepler's Astronomy," *Osiris*, 16, *Science in Theistic Contexts : Cognitive Dimensions* (2001), p. 88-113, esp. 99-103, 112-113.
36. KEPLER, *Mysterium Cosmographicum*, p. 53 ; *Gesammelte Werke*,ed. M. CASPAR, München, C.H. Beck, 1937 (herafter *KGW*), vol. 1, p. 5, l. 24-29 ; cp. *KGW* 8, 16, 24-29. 1 Cor. 13:12 "videmus nunc per speculum in enigmate."
37. See Michael N. FRIED, "Book XIII of the *Elements*," p. 607-617.
38. In a letter to his mentor Michael Maestlin (1550-1631) on 3 October 1595, Kepler writes : "'I am concentrating [on the materials which form the basis for the *Mysterium*] so that this may be made public as quickly as possible, to the glory of God, who wishes to be known (*agnoscere*) through the Book of Nature" (*KGW* 13, 40, 2-3). Quoted by BARKER and GOLDSTEIN, "Theological Foundations," p. 96, n. 23. See also Kenneth J. HOWELL, *God's Two Books. Copernican Cosmology and Biblical Interpretation in Early Modern Science*, Notre Dame, Ind., University of Notre Dame Press, 2002.

glory of our minds, but rather, above else, of the glory of God."[39] The revelation obtainable from that book is not confined to the hypothetical constructions of mathematics. Through the Book of Nature the causes of the divine plan for the world are in principle knowable by man. It is noteworthy that Kepler concludes his *Mysterium Cosmographicum* with a valedictory theological reflection in the form of an adaptation of Psalm 8, "O LORD our Governor, how excellent is thy Name in all the world ; thou that hast set thy glory above the heavens !"[40] In Kepler's concluding hymn divinity transcends the visible cosmos, yet is providentially immanent in its manifestations of order — the world as a "theatre of the divine glory". Kepler underscores his credentials as a "sapiential theologian" in this reconciliation of the two books, the Book of Nature and the Book of Scripture. Another late-sixteenth century sapiential theologian, Richard Hooker, sums up this two-fold aspect of holy Wisdom in a distinct but related context :

> […] there can be no lesse acknowledged, then that her seate is the bosome of God, *her voyce the harmony of the world*, all things in heaven and earth doe her homage, the very least as feeling her care, and the greatest as not exempted from her power ; both Angels and men and creatures of what condition so ever, though each in different sort and manner, yet all with uniforme consent, admiring her as the mother of their peace and joy.[41]

Like Kepler, Hooker insists upon the honour due to both books :

> Whatsoever either men on earth, or the Angels of heaven do know, it is as a drop of that unemptiable fountaine of wisdom, which wisdom hath diversly imparted her treasures unto the world. As her waies are of sundrie kinds, so her maner of teaching is not meerely one and the same. Some things she openeth by the sacred bookes of Scripture ; some things by the glorious works of nature : with some things she inspireth them from above by spirituall influence, in some thinges she leadeth and trayneth them onely by worldly experience and practise. We may not so in any one speciall kind admire her that we disgrace her in any other, but let all her wayes be according unto their place and degree adored.[42]

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39. Letter to Herwart von Hohenburg of 26 March 1598 : "Ego vero sic censeo, cum Astronomi, sacerdotes dei altimissimi ex parte libri Naturae simus […]" (*KGW*, 13, 193, 14-19). See Max CASPAR, *Kepler*, New York, Dover Publications, 1993, p. 88-89.

40. Psalm 8, transl. Miles Coverdale, *Book of Common Prayer* (1662) :
O LORD our Governor, how excellent is thy Name in all the world ; * thou that hast set thy glory above the heavens !
2 Out of the mouth of very babes and sucklings hast thou ordained strength, because of thine enemies, * that thou mightest still the enemy and the avenger.
3 When I consider thy heavens, even the work of thy fingers ; * the moon and the stars which thou hast ordained ;
4 What is man, that thou art mindful of him ? * and the son of man, that thou visitest him ?
5 Thou madest him lower than the angels, * to crown him with glory and worship.
6 Thou makest him to have dominion of the works of thy hands ; * and thou hast put all things in subjection under his feet :
7 All sheep and oxen ; * yea, and the beasts of the field ;
8 The fowls of the air, and the fishes of the sea ; * and whatsoever walketh through the paths of the seas.
9 O LORD our Governor, * how excellent is thy Name in all the world !

41. *Lawes* I.2.3 ; 1:60.27-61.6 [my emphasis].

42. *Lawes* II.1.4 ; 1:147.23-148.6. See *The Wisdom of Solomon* 11:20.

In his own embrace of a Wisdom theology Kepler reveals a methodological feature of his idea of *Mysterium*. Where the model of *mysterium* in Scripture is the hypostatic union of the divine and human natures in Christ, so here Kepler upholds a doctrine of providential Wisdom simultaneously natural and revealed. Kepler's confidence in the intrinsic intelligibility of the physics of celestial motion, "number, size, and periodic motions of the heavens", and the accessibility of their causes, are founded on his belief in the divine providential ordering of the natural world. Kepler invokes an argument of intelligent design such as that made by Cicero in *De natura deorum*,[43] and combines this with an invocation of the Wisdom theology of Scripture. Thus he concludes with a hymn to God the Creator and Governor in the form of a paraphrase of Psalm 8, a standard scriptural authority for a Natural Theology of Divine Providence :

> Now, friendly reader, do not forget the end of all this, which is the conception, admiration, and veneration of the Most Wise Maker. For it is nothing to have progressed from the eyes to the mind, from sight to contemplation, from the visible motion to the Creator's most profound plan, if you are willing to rest there, and do not soar in a single bound and with complete dedication of spirit to knowledge, love, and worship of the Creator. Therefore with pure mind and thankful spirit sing with me the following hymn to the Architect of this most perfect work :
>
> Great God, Creator of the Universe,
> And our eternal power, how great thy fame
> In every corner of the whole wide world !
> How great thy glory, which flies wondrously
> Above the far-flung ramparts of the heavens
> With rushing wings ! The babes salute it, spurning
> The breast, replete, and with his halting lips
> Bears powerful witness — witness which confounds
> The haughty enemy, who shows contempt
> For thee, and shows contempt for law and justice.
> Yes, to believe thy Godhead is within
> This spacious sphere, let me look up astonished
> At thy achievement of this mighty heaven,
> The work of the great Craftsman, miracles
> Of thy strong hand ; see how thou hast marked out
> The five-fold pattern of the starry spheres,
> Dispensing light and spirit from their midst ;
> See by what law thou dost control the reins
> Of their eternal course ; see how the Moon
> Varies her path, her toils, how many stars
> Thy hand has scattered over that boundless field.
> […]
> Great God, Creator of the Universe,

43. Two passages in CICERO's treatise of natural theology, *De natura deorum*, where the philosopher argues that this knowledge of things divine is "engraved" on the minds of men. "Intelligi necesse est deos, quoniam insitas eorum vel potius innatas cognitiones habemus. Quae hobis natura informationem deorum ipsorum dedit, eadem insculpsit in mentibus ut eos aeternos et beatos haberemus" (I.17). The second reference is from Bk. II.4 : "Itaque inter omnes omnium gentium summa constat ; omnibus enim innatum est, et in animo quasi insculptum esse deos." Compare to Rom. 1:20 and 2:14.

And our eternal power, how great thy fame
in every corner of the whole wide world ![44]

As Sachiko Kusukawa has pointed out, Kepler learned the notion of "astronomy as a praise of God" from Jacob Heerbrand, his theology tutor at the Tübinger Stift. Heerbrand himself had been Philipp Melanchthon's pupil at the University of Wittenberg, an intellectual genealogy which places Kepler in the distinctively Lutheran tradition of natural philosophy.[45]

SOME CONCLUSIONS

Kepler's Cosmographical Mystery may be expressed in (at least) five ways :

First, there is Kepler's distinctive hermeneutical method of joining together the authority of the Book of Scripture and the Book of Nature in the common task of Wisdom Theology — "As [Wisdom's] waies are of sundrie kinds, so her maner of teaching is not meerely one and the same" (*Lawes* II.1.4). This sapiential approach epitomizes an epistemological *mysterium* in the sense that natural, human capacity of rational inquiry into the causes is able to discern the immanent providential plan also revealed in the Scriptures. The language of *mysterium* is appropriate in the context of this union of human capacity and divine disclosure, an incarnation of Wisdom as it were.

Secondly, there is a further *mysterium* suggested by Kepler's geometrization of space through the unification of the mathematical and the physical according to the nesting of the five regular solids. In this we see an appeal to Pythagorean teaching as a means of demonstrating his thesis of immanent and intelligible providence. Creation is the work of the divine Wisdom and is assumed consequently to be potentially comprehensible.

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44. *Mysterium Cosmographicum*, p. 224-225 :
Iova Sator Mundi, nostrumque aeterna potestas,
Quanta tua est omnem terrarum fama per orbem ?
Gloria quanta tua est ? Coeli quae dedita supra
Moenia, concussis volat admirabilis alis.
Agnoscit puer et spreto satur ubere, balbis
te dictante struit valida argumenta labellis :
Argumenta, quibus tumidus confunditur hostis
Contemptorque tui, et contemptor iuris et aequi :
Ast ego, quo credam spacioso Numen in orbe :
Suspiciam attonitus vasti molimina coeli,
Magni opus Artificis, validae miracula dextrae ;
Quinque uti siderios normis distinxeris orbes,
Quos intra medius Lucisque animaeque Minister
Qua lege aeterni cursus moderetur habenas,
Quas capiat variata vices, quos Luna labores,
Sparseris immenso quam plurima Sidera campo.
[…]
Iova Sator Mundi, nostrumque aeterna potestas,
Quanta tua est omnem terrarum fama per orbem ?

45. Sachiko KUSUKAWA, *The Transformation of Natural Philosophy. The Case of Philip Melanchthon*, Cambridge, Cambridge University Press, 1995, p. 1-6, 188.

In a third instance of a *mysterium*, Kepler's insight into the cosmographical utility of the ellipse as a geometrical means of accounting for celestial physics is inspired. The ellipse integrates rectilinear (contrary) and curvilinear (continuous) principles of motion, and in doing so upends Aristotle's assumption of the opposition of the incorruptible, uniform and regular circular motion of the eternal heavens with corruptible, non-uniform, and contrary motions of the sublunary world. In the *mysterium* of the ellipse Kepler posits a reconciliation of these two contrary species of motion by his demonstration that the rectilinear opposition of the two foci defines the curvilinear path of celestial motion.

The resolution of the opposition between the two species of corruptible and incorruptible motion is critical to abandoning circles and uniform spherical motion understood by Aristotle, Ptolemy, and even Copernicus as definitive of celestial motion. In effect Kepler implies the way forward for mysterious unification of celestial and terrestrial physics — the fourth *mysterium*. He may also have contributed further, in some equally mysterious fashion, to the glories of Baroque architecture when one considers, for example, Balthazar von Neuman's design for the Basilica of Vierzehnheiligen — a vision of heaven brought down to earth. As an observer one has the illusion of being able to reach up and almost touch the cherubs' toes.[46] According to William Kyer West, "Kepler's work seems to have set the stage for the introduction of the true ellipse, rather than just oval figures, into architecture."[47]

The disclosure of the underlying geometrical uniformity of non-uniform celestial motion according to the Area Law underscores the significance of the *mysterium* of the ellipse in motion — this is no mathematical contrivance merely to "save the appearances", but rather a mathematical representation of the actual path of motion : Ἀιτιολογήτος, a "celestial physics". And finally, the harmonic relationship between the squares of the planets' periodic times and the cubes of the radii of their orbits — the "Third Law" discloses the *mysterium* of Music, perhaps Kepler's most cherished discovery. In the *Harmonies* Kepler offers a demonstration of the providential nature of the *musica mundana* : "[…] that in order to secure this harmonic arrangement, those very planetary eccentricities which any planet has as its own, and no others, had to be set up."[48]

46. Ofer GAL, Raz CHEN-MORRIS, *Baroque Science*, Chicago, The University of Chicago Press, 2013, esp. chap. 6 on "The Emergence of Baroque Mathematical Natural Philosophy : the archaeology of the inverse square law" — with thanks to Maria Avxentevskaya of the Max Planck Institute for this reference. See also John HENDRIX, *The Relation Between Architectural Forms and Philosophical Structures in the Work of Francesco Borromini in Seventeenth-Century Rome*, Lewiston, Queenston, Lampeter, The Edwin Mellen Press, 2002, p. 41.
47. William KYER WEST, "Problems in the Cultural History of the Ellipse," *Technology and Culture*, 19, 4 (1978), p. 712.
48. J. KEPLER, *Harmonies of the World*, chap. 9.

To conclude, a glimpse forward towards Isaac Newton is almost *de rigueur*. In his discussion of Kepler's Laws of Motion in the chapter on Absolute Mechanics in his *Philosophy of Nature*, G.W.F. Hegel remarks that

> these laws are among the most beautiful to be found in the natural sciences […] a [philosophical] comprehension of them is consequently of the greatest interest […]. To Newton is ascribed the glory of having discovered the law of universal gravitation. Kepler's glory has been obscured by Newton who has obtained for himself, in the general opinion, the greater part of the glory due to Kepler. […] Newton's merit, of course, is that his form of the law possesses great advantages for mathematical treatment.[49]

Especially beautiful is Kepler's deep persuasion of this union of terrestrial and celestial physics. This lies at the very heart of the notion of *mysterium* as a theologically inspired approach to the conversion of astronomy into cosmographical celestial physics — a New Astronomy based upon physical causes.

49. G.W.F. HEGEL, *Philosophy of Nature*, transl. A.V. Miller, Oxford, Oxford University Press, 1970, p. 74. Job Kozhamthadam argues that Kepler's discovery of the basic quantitative laws that describe planetary motion placed the heliocentric cosmology of Copernicus on a sound mathematic basis and paved the way for Newton's work in the next century. Job KOZHAMTHADAM, *The Discovery of Kepler's Laws. The Interaction of Science, Philosophy, and Religion*, South Bend, Ind., University of Notre Dame Press, 1994. Bernard Cohen is more complimentary towards Newton when he argues that "Kepler deserves credit for having been the first scientist to recognize that the Copernican concept of the earth as a planet and Galileo's discoveries demanded that there be one physics — applying equally to the celestial objects and ordinary terrestrial bodies. But alas […] the major aim of Keplerian physics remained unachieved, and the first workable physics for heaven and earth derived not from Kepler but from Galileo and attained its form under the magisterial guidance of Isaac Newton" (I. Bernard COHEN, *The Birth of a New Physics*, Garden City, N.Y., Anchor Books, 1960, p. 151).