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*The Role of Musical Analogies in Newton's Optical and Cosmological Work*¹

Niccolò Guicciardini

The ancient link between music and cosmology met with some success in the Renaissance and early modern era. A complex range of factors led to the resurfacing of the Neo-Pythagorean myth of the harmony of the celestial spheres. The importance of the notion of harmony and of musical theories on consonance during the scientific revolution has been emphasized by historians such as Claude Palisca, Daniel P. Walker, Penelope Gouk, Paolo Gozza, Floris Cohen, and Benjamin Wardhaugh.² This is a complex and far from linear history which cannot be regarded simply as a form of passive adherence to Pythagoreanism. And while the topic cannot be explored in the present paper, mention should nonetheless be made of the fact that the late fifteenth and early sixteenth centuries witnessed what came to be described as an “untuning of the sky.”³ This consisted in the progressive

¹ I thank my colleague Richard Davies for assistance with language. Thanks also to Michel Blay, Michela Malpangotto, Alain Albouy, and to the other seminar participants at the Observatoire de Paris for their comments on a preliminary version of this paper.

² Claude V. Palisca, *Humanism in Italian Renaissance Musical Thought* (New Haven: Yale University Press, 1985); Daniel P. Walker, *Music, Spirit and Language in the Renaissance* (London: Variorum, 1985); Penelope Gouk, *Music, Science and Natural Magic in Seventeenth-Century England* (New Haven: Yale University Press, 1999); Paolo Gozza, ed., *Number to Sound: The Musical Way to the Scientific Revolution* (Dordrecht: Kluwer, 2000); Floris H. Cohen, *Quantifying Music: The Science of Music at the First Stage of the Scientific Revolution, 1580–1650* (Dordrecht: Reidel, 1984); Benjamin Wardhaugh, *Music, Experiment and Mathematics in England, 1653–1705* (Aldershot: Ashgate, 2008).

³ For a study of the complex interactions between music theory, philosophy, and mathe-

collapse of the belief, held by some Renaissance thinkers, concerning the possibility of interpreting non-musical phenomena such as the structure of the heavens, that of the human body, the medicinal virtues of drugs, and architecture in terms of musical harmonies. This belief was gradually replaced over the course of the late fifteenth, sixteenth and seventeenth centuries by the view of harmony typical of mechanical philosophy, which saw it as a phenomenon to be studied in terms of the vibration of bodies and the physiology of hearing.

As in the case of alchemy, Isaac Newton occupies a problematic position in this context. Scholars of Newtonian alchemy in the 1970s and 1980s engaged in a lively debate: for some, Newton shared the mystical ethos of natural magic which was a defining feature of, say, the Paracelsian tradition; according to others, Newton's alchemy was nothing but rational proto-chemistry.⁴ Only recently has the interpretation of Newtonian alchemical manuscripts led to more balanced and better contextualized readings.⁵

It should be said that it is far from easy to define just what we mean by Neo-Pythagoreanism. Not only does this category resist pigeon-holing, but the leading figures we can include in the Neo-Pythagorean tradition often

maternal practice in the Renaissance, see Ann E. Moyer, *Musica Scientia: Musical Scholarship in the Italian Renaissance* (Ithaca: Cornell University Press, 1992).

⁴ The early studies carried out in the 1670s and 1680s on Newton's alchemy and Pythagoreanism owe much to books such as Frances A. Yates, *Giordano Bruno and the Hermetic Tradition* (London: Routledge and Kegan Paul, 1964); and Daniel P. Walker, *Spiritual and Demonic Magic from Ficino to Campanella* (London: Warburg Institute, 1958). On the early debate concerning Newton, alchemy, and magic, I refer the reader to a number of works. On Newton's alchemy, see the groundbreaking Betty J. T. Dobbs, *The Foundations of Newton's Alchemy, or "the Hunting of the Greene Lyon"* (Cambridge: Cambridge University Press, 1975); Karin Figala, "Newton as Alchemist," *History of Science* 15 (1977): 102–37; and Figala, "Zwei Londoner Alchemisten um 1700: Sir Isaac Newton und Cleidophorus Mystagogus," *Physis* 18 (1976): 245–73. On Newton's adherence to the myth of an ancient wisdom, see the pioneering paper by James E. McGuire and Piyo M. Rattansi, "Newton and the 'Pipes of Pan,'" *Notes and Records of the Royal Society* 21 (1966): 108–43; and for a critical appraisal Paolo Casini, "Newton, gli Scolii classici: presentazione, testo inedito e note," *Giornale Critico della Filosofia Italiana* 60 (1981): 7–53, translated in *History of Science* 22 (1984): 1–58. The author is deeply indebted to the above-mentioned works that form an indispensable background for the results presented in this paper.

⁵ For an overview, see William R. Newman, "The Background to Newton's Chymistry," in *The Cambridge Companion to Newton*, ed. I. Bernard Cohen and George E. Smith (Cambridge: Cambridge University Press, 2002), 138–73; and Newman, "What Have We Learned from the Recent Historiography of Alchemy?" *Isis* 102 (2011): 313–21. For a different view see Brian Vickers, "The 'New Historiography' and the Limits of Alchemy," *Annals of Science* 65 (2008): 127–56; and the reply from Newman, "Brian Vickers on Alchemy and the Occult: A Response," *Perspectives on Science* 17 (2009): 482–506.

interpreted it in contrasting ways (suffice it to recall the polemical exchange between Robert Fludd and Kepler). For the sake of convenience, we might want to set out from the description of the “Pythagorean view” provided by Charles H. Kahn, who argues that Pythagoreanism may be traced back to two “clusters of ideas.”⁶ The first is presented in Plato’s *Phaedo*, *Epinomis*, *Republic* and *Phaedrus*; it concerns the immortality of the soul, the transmigration of souls, and the possibility of purifying oneself and attaining liberation from the cycle of rebirth by completely separating soul from body. The second cluster is presented in another great Platonic dialogue and concerns cosmogony. In *Timaeus* one is presented with the notion that the world soul is structured according to musical harmonies, while the body of the cosmos is based on the five perfect solids.⁷ As is well known, the *Timaeus* was often read as a Pythagorean dialogue. Proclus, in his highly influential commentary on Euclid—which Kepler often cited—opted for geometry, rather than arithmetic, as the chief Pythagorean mathematical doctrine and interpreted Euclid as a Platonist who had given pride of place to the Platonic five perfect solids.⁸ Some Christian authors, from antiquity down to the seventeenth century, mused on the idea that the Universe and man are the outward expression of the nature of the Creator who has forged them according to mathematical (arithmetical and/or geometrical) proportions and musical harmonies. The names of Cusanus and Kepler come immediately to mind. I will leave the first cluster aside in this paper. But let us turn to the second cluster of ideas presented through the mythological language of the *Timaeus*. This would seem like a more promising direction, which might enable us to view Newton as a late spokesman for the myth of celestial harmonies that had been revamped in the Renaissance.

As I mentioned at the beginning of this paper, the situation is rather problematic. Certain aspects of Newton’s thought concerning sound, harmony, and musical theory would seem to be perfectly in line with the positivist view of him as a scientist removed from any mystical works, in the vein of John Dee or Fludd. Take, for instance, Newton’s early studies on the tuning of the musical scale, where he considered both just intonation and equal temperament. In these studies, as Peter Pesic observes, empirical considerations on the pleasantness of sound outweigh the kind of numerical considerations typical of the Pythagorean tradition. Evidence is provided in

⁶ Charles H. Kahn, *Pythagoras and the Pythagoreans* (Indianapolis: Hackett, 2001), 3–4.

⁷ Plato, *Timaeus*, 34c–36d, 42e–44e, 47c–47e, 52e–55c; *Epinomis*, 982e–983c; *Republic* 617a–617b.

⁸ See Dominic J. O’Meara, *Pythagoras Revived: Mathematics and Philosophy in Late Antiquity* (Oxford: Oxford University Press, 1989), 179–81, 166–75.

the manuscript “Of Musick” (1665), where Newton seems more interested in experimentally researching the way in which the human ear discerns “sweetnesse,” “harshnesse,” and “grace,” than in the abstract numerology of consonance typical of the Pythagorean tradition, even in its “moderate” Boethian version. Newton goes so far as to accept semitones and even quarter-tones, something hardly acceptable to Pythagorean music theorists, provided they are “passed over very hastily wth a larger stay upon ye concords twixt wch they are,” in which case, he claims, they “might bee delightful.”⁹ For another, better known, example of Newton’s scientific approach to sound, one might refer to the theoretical research and experimental work concerning the speed of sound propagation he published in section VIII, book II of the *Principia*.¹⁰ Other aspects of Newton’s reflections on music, however, will strike us as reformulations of themes typical of the Neo-Pythagorean tradition; so much so that Gouk, in a nuanced and perceptive analysis, has dubbed Newton a “Pythagorean magus” of sorts.¹¹ Gouk’s reading of Newton as belonging to the Neo-Pythagorean tradition has been recently endorsed by Pesic and Wardhaugh, while in his recent learned study Olivier Darrigol refers in passing to Newton’s Pythagoreanism and seems to cite Gouk’s thesis with approval.¹²

Gouk’s claim is based on two sources. The first is a passage from “An Hypothesis explaining the Properties of Light discoursed of in my severall Papers” (hereafter referred to as “Hypothesis”), in which Newton draws an analogy between the musical scale and the prismatic color spectrum (see fig. 1).¹³ This famous essay was originally written in 1672 as a reply to

⁹ C.U.L. MS Add. 4000, f. 139; edited in Peter Pesic, “Isaac Newton and the Mystery of the Major Sixth: A Transcription of His Manuscript ‘Of Musick’ with Commentary,” *Interdisciplinary Science Reviews* 31 (2006): 299–303.

¹⁰ Isaac Newton, *The Principia: Mathematical Principles of Natural Philosophy*, trans. I. Bernard Cohen and Anne Whitman (Berkeley: University of California Press, 1999), 762–78.

¹¹ Penelope Gouk, “The Harmonic Roots of Newtonian Science,” in *Let Newton Be! A New Perspective on his Life and Works*, ed. John Fauvel et al. (Oxford: Oxford University Press, 1988), 101–25; see also “Isaac Newton, Pythagorean Magus,” in Gouk, *Music*, 224–57.

¹² Pesic, “Mystery of the Major Sixth”; Wardhaugh, *Music, Experiment and Mathematics*, 120–25; Olivier Darrigol, “The Analogy between Light and Sound in the History of Optics from the Ancient Greeks to Isaac Newton, Part 2,” *Centaureus* 52 (2010): 230–41.

¹³ In the spring of 1672 Newton set out to write his “An Hypothesis Hinted at for Explaining All the Afforesaid Properties of Light” (C.U.L. MS Add. 3970, ff. 433–34, 519–28) as a reply to Hooke’s letter of 15 February 1671/2. Isaac Newton, *The Correspondence of Isaac Newton*, 7 vols., ed. H. W. Turnbull, J. F. Scott, A. Rupert Hall, and Laura Tilling [Cambridge: Cambridge University Press, 1959–77], 1:110–14). He later reworked and sent it, together with another manuscript sometimes called “Discourse of Observations,” to the Secretary of the Royal Society, Henry (Heinrich) Oldenburg, on 7

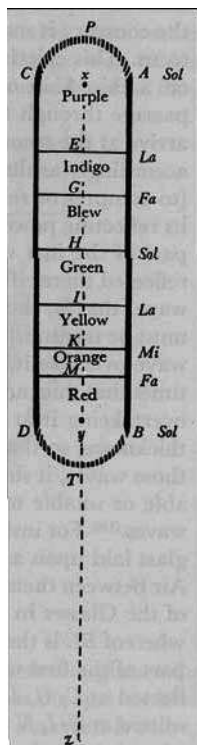


FIGURE 1. Analogy between the prismatic spectrum and the musical scale (a Dorian mode equivalent to playing the white notes on a piano keyboard from D to d), from the “Hypothesis” (1675). The reader who is not familiar with the solfège system in use in Newton’s England should ignore the notes written on the right. Source: Newton, *Correspondence*, 1, 377.

Robert Hooke, and later, in December 1675, re-elaborated and sent by Newton to Henry (Heinrich) Oldenburg, the Secretary of the Royal Society. Some of the ideas of the “Hypothesis,” including the musical scale/color spectrum analogy, are still to be found in the *Opticks*. The second text is the so-called *Classical Scholia*, most probably penned in 1693–94 and consisting of additions Newton planned to include in his second edition of the *Principia*. Here Newton refers to Pythagoras as an ancient sage who couched his knowledge of natural laws, including universal gravitation, in musical terms.¹⁴

December 1675 (Newton, *Correspondence*, 1:362–86). See also Newton to Oldenburg, 11 June 1672 (*ibid.*, 1:171–88), where some ideas of the “Hypothesis” are referred to.

¹⁴ There are several copies of the *Classical Scholia* in Newton’s hand: in the Royal Society (MS Gregory 247, ff. 6, 8–9, 10–14 *recto* and *verso*) and in the Cambridge University Library (C.U.L. MS Add. 3965.11, ff. 268r–69v, 270r, 272r, 277r–78v and 3965.17, f. 640r–640v). Two scholia found in a copy of the *Principia* belonging to Newton (now in the Cambridge University Library, Adv. b. 39. 1) have been edited in Isaac Newton, *Philosophiae Naturalis Principia Mathematica: The Third Edition* (1726), with Variant

I believe it is unwarranted to use these two sources to reach a hasty conclusion regarding Newton's Neo-Pythagoreanism. The main thesis of my paper can be summarized as follows. I will attempt to place the above two allegedly "Pythagorean" loci in context. I will claim that what Newton had in mind in the first case was an analogy between hearing and vision, rather than an analogy between musical and natural phenomena, whereas in the second case he depicted Pythagoras as concealing his knowledge of gravitation theory behind musical analogies, without any commitment to a conception of the world as ordered according to musical harmonies.

No doubt, Newton appears to be rather fascinated by the possible relation between results regarding the tuning of the musical scale and the subdivision of the prismatic spectrum; and in the *Classical Scholia* he refers reverently to Pythagoras as a wise man who possessed knowledge of the theory of gravitation. Still, this does not make Newton a Neo-Pythagorean or a spokesman for the union between musical harmonies and the structure of the cosmos along the lines of Plato's *Timaeus*, even if certain sections of the Newtonian corpus certainly appear to suggest that their author embraced the concept of the harmony of the cosmos and nature, especially where he refers to the "analogy of nature" as a guiding principle in his research on the perception of light and sound.¹⁵

We should note right from the start that in the mid-1680s Newton realized that the universe cannot straightforwardly be described as "harmonic." While it is certainly governed by mathematical laws, these engender phenomena which are subject to deviations from any laws that might help describe them in mathematically simple terms. Most notably, Kepler's "harmonic" third law of planetary motion has to be adjusted for two bod-

Readings, 2 vols., ed. Alexandre Koyré and I. Bernard Cohen (Cambridge: Cambridge University Press, 1972), 2:803–7. An English translation of the *Classical Scholia* with an extensive commentary can be found in McGuire and Rattansi, "Newton and the 'Pipes of Pan,'" 108–43; for an edition and commentary on the Latin text see Casini, "Newton, gli Scolii classici." A thorough edition with variants can be found in Volkmar Schüller, "Newton's *Scholia* from David Gregory's Estate on the Propositions IV through IX Book III of his *Principia*," in *Between Leibniz, Newton, and Kant: Philosophy and Science in the Eighteenth Century*, ed. Wolfgang Lefèvre (Dordrecht: Kluwer, 2001), 213–65. David Gregory first anonymously summarized the content of Newton's *Classical Scholia* in the "Praefatio" to *Astronomiae Physicae & Geometricae Elementa* (Oxford: Theatro Sheldoniano, 1702).

¹⁵ Shapiro notes this in Isaac Newton, *The Optical Papers of Isaac Newton*, vol. 1, *The Optical Lectures, 1670–1672*, ed. Alan E. Shapiro (Cambridge: Cambridge University Press, 1984), 547. See Newton's "Hypothesis," C.U.L. MS Add. 3970, f. 544r = Newton, *Correspondence*, 1:376; and Newton to John Harrington, 30 May 1698, in *ibid.*, 4:275.

ies in gravitational interaction and has to be abandoned for more than two bodies. One of the great achievements of the *Principia* is the proof that Kepler's laws hold only approximately for the planets orbiting the sun. As Newton wrote in a preliminary version of his *Principia* in 1684:

By reason of the deviation of the Sun from the center of gravity, the centripetal force does not always tend to that immobile center, and hence the planets neither move exactly in ellipses nor revolve twice in the same orbit. Each time a planet revolves it traces a fresh orbit, as in the motion of the Moon, and each orbit depends on the combined motions of all the planets, not to mention the action of all these on each other. But to consider simultaneously all these causes of motion and to define these motions by exact laws admitting of easy calculation exceeds, if I am not mistaken, the force of any human mind.¹⁶

Newton's cosmos, moreover, is subject to the progressive dissipation of motion (or kinetic energy, as we would say nowadays). In the universe Newton describes in his *Principia* neither the planetary system nor the star system has any stability. The ideas of the mathematical complexity and dissipation of the motion of the heavens upheld by Newton after the mid-1680s do not easily square with the concept of "celestial harmony." This notion of instability is important for Newtonian theology and Newton's view of the relation between God and nature. The latter, far from being mathematically perfect, as Neo-Pythagoreans would have it, depends upon God's providence to maintain its stability. Were it not for God's constant intervention, or "reformation," the fate of the universe would be chaos and the progressive deterioration of "uniformity."¹⁷ For a Pythagorean like Kepler, God is the craftsman who has created the world as harmonious artefact: the world reveals geometrical and musical perfections. For a unitarian like Newton, the world would be unstable and doomed to corruption, were it not for God, the powerful restorer, who continuously reveals His existence by providential intervention.

¹⁶ "De motu sphaericorum corporum in fluidis" (December 1684?), Add 3965.7, f. 46v. Isaac Newton, *Unpublished Scientific Papers of Isaac Newton: A Selection from the Portsmouth Collection in the University Library Cambridge*, ed. A. Rupert Hall and Marie Boas Hall (Cambridge: Cambridge University Press, 1962), 256, 281. Page numbers refer to Latin and English translations, respectively, the latter altered along the lines suggested by Curtis Wilson and George Smith.

¹⁷ See Isaac Newton, *Opticks, or a Treatise of the Reflections, Refractions, Inflections & Colours of Light*, rev. ed. (New York: Dover, 1979/1952), 402.

As already noted above, it can hardly be denied that Newton was rather fascinated by the idea that musical harmonies are concealed within optical phenomena. Through a problematic enumeration of the colors of the spectrum, he isolated seven of them—exactly the number of notes on the musical scale. In his Lucasian lectures (*Lectio I* [1670]) Newton identified only five colors, but then around 1672 (*Opticae pars II* [1672]), through the addition of orange and indigo, he reached the number seven, a result which appears to have been in part designed to draw an analogy between light and sound.¹⁸ In the eleventh lecture of his *Opticae pars II* (late 1672) Newton recounts how by observation “everything appeared just as if the parts of the image occupied by the colors were proportional to a string divided so it would cause the individual degrees of the octave to sound.”¹⁹ This idea can also be found in the “Hypothesis,” both in the draft of 1672 and in the version sent to Oldenburg in 1675. Newton (see figure 1) superimposed a monochord to the color spectrum projected by a glass prism and claimed that the seven colors appear in correspondence with the division of the monochord into seven notes. In the *Optica* Newton considered both an equal tempered scale and a scale tuned according to just intonation, and admitted that “such quite minute differences” between the two scales “can produce errors hardly visible to the keenest judge.”²⁰ Newton concluded that the best fit is given by choosing the “Dorian mode.” This particular “mode,” or scale, is obtained by playing the white notes on a piano keyboard from D to d. This mode has a particularly pleasing mathematical symmetry since the scale is a palindrome proceeding by a tone, a semitone, a tone, a tone, a semitone, a tone.²¹ Gouk and Pesic claim that with this analogy between the color spectrum and the musical scale Newton was paying homage to Pythagoreanism. But if we take account of the context in which this daring analogy was first proposed, we shall soon realize that Newton set out from a “mechanical” hypothesis regarding the analogy between auditory and visual perception, which he later played

¹⁸ Newton, *Optical Lectures*, 50, 542, 546.

¹⁹ *Ibid.*, 543.

²⁰ *Ibid.*, 545. A detailed study of Newton’s observations on the subdivision of colors in the spectrum and of the correspondence between colors and the scale is David Topper, “Newton on the Number of Colours in the Spectrum,” *Studies in History and Philosophy of Science* 21 (1990): 269–79.

²¹ On musical theories in antiquity see Andrew Barker, *Greek Musical Writings*, vol. 2, *Harmonic and Acoustic Theory* (Cambridge: Cambridge University Press, 1989). For an introduction to temperament see James Murray Barbour, *Tuning and Temperament: A Historical Survey* (1951; repr., East Lansing: Michigan State College Press, 1972). The English context is studied in Benjamin Wardhaugh, *Music, Experiment and Mathematics*.

down. Indeed, Newton quite early on in his life showed a strong interest in perception, especially visual perception, an interest that was related to broad-ranging questions and anxieties of his concerning the relationships between soul and body.²²

In his "Hypothesis" (both in the draft of 1672 and in the final version of 1675) Newton is interested in perception, and especially in the analogies between hearing and vision, on which he had already dwelt in 1665–66. Indeed, as Pesic has shown, as early as 1665 Newton had examined the relations between visual and auditory perception by focusing on the physical effects of vibrations on optic and acoustic nerves, making them pleasant or unpleasant. Further, the analogy between hearing and vision, and the theory according to which visual sensation is carried by vibrations of a "pure transparent liquor passing from the eye to the sensorium," can be found in the 1666 manuscript "Of Colours."²³ Newton's working hypothesis concerning perception is that the sense organs are stimulated by material bodies which excite vibrations in an elastic medium contained in the nerves. These ether-vibrations are transmitted to the sensorium. Newton claims that since both sound and light are perceived through the propagation of the vibrations of the ethereal "animal spirit" found in acoustic and optical nerves, it is only natural to ask oneself whether any analogy exists between the two forms of perception. For instance, in his 1672 "Hypothesis" Newton writes that light corpuscles, by hitting the retina, produce "vibrations" in the ether which cross the optic nerve and reach the brain, where they "affect the soule with a sensation of various colours according to their various proportions, something after the manner that various sounds are produced by various proportions of the vibrations of the Air."²⁴ Might the origins of musical consonance shed light on those of "the harmony of some colors"? Still, in 1675, in the version sent to Oldenburg, Newton examines this hypothesis, which he formulates with great caution:

... as the harmony & discord of Sounds proceed from the proportions of the aereall vibrations, so may the harmony of some colours, as of Golden & blew, & the discord of others, as of red & blew proceed from the proportions of the æthereall. And possibly

²² See the commentary in James E. McGuire and Martin Tamny, *Certain Philosophical Questions: Newton's Trinity Notebook* (Cambridge: Cambridge University Press, 1983), 216–40.

²³ See Newton, "Of Musick," C.U.L. MS Add. 4000, f. 138, and C.U.L. MS Add. 3975, ff. 19–20; discussed in Pesic, "Mystery of the Major Sixth," 292, 299–300.

²⁴ C.U.L. MS Add. 3970.3, f. 528v.

colour may be distinguished into its principall Degrees, Red, Orange, Yellow, Green, Blew, Indigo, and deep violett, on the same ground, that Sound within an eighth is graduated into tones.²⁵

As early as 1672, in his optical lectures, which deal with the analogy between the musical scale and the color spectrum at length, Newton surmised that the “affinity” between “the outermost purple and red” is “analogous to the concordances of sounds” found between the “ends of the octave (which can in a way be considered as unisons).”²⁶ The same idea is present in the draft of the “Hypothesis” composed in 1672, where Newton wrote,

To which end I would suppose the vibrations causing the deepest scarlet to be to those causing the deepest violet as two to one; for so there would be all that variety in colours wth wch in the compasse of an eighth is found in sounds & the reasons why the extreames of colours Purple & scarlet resemble one another would be the same that causes Octaves (the extreames of sounds) to have in some measure the nature of unisons.²⁷

Newton, however, soon realized that he had to downplay the above analogy by noting that the ratio 2 to 1 for the extreme colors of the spectrum (the “deepest violet” and the “deepest scarlet”) did not occur. Indeed, in an “Observation” in his draft “Hypothesis” Newton obtains a ratio greater than 3 to 2 (a fifth) but smaller than 5 to 3 (a major sixth in just intonation): his preferred estimate is the ratio 14 to 9.²⁸ Note that $14/9 \approx 1.56$ is a value in-between a fifth and a sixth. The fifth is $3/2 = 1.5$, the major sixth in Pythagorean intonation corresponds to a ratio $27/16 \approx 1.69$, while in just intonation it is $5/3 \approx 1.67$.

But how could Newton determine the “bigness,” “depth,” or “thickness” (or as we would say, the wavelength) of the vibrations? One should note that Newton, with the word “bigness,” denoted both amplitude and wavelength, the assumption being that these two magnitudes are correlated

²⁵ Newton, *Correspondence*, 1:376.

²⁶ See *Opticae pars II* (late 1672), in Newton, *Optical Lectures*, 544–46.

²⁷ C.U.L. MS Add. 3970. f. 528v; cited by Shapiro in *ibid.*, 546n.

²⁸ The ratio for the extreme colors of the spectrum was found to be “greater than 3 to 2 & lesse then 5 to 3. By the most of my observations it was 9 to 14 [read 14 to 9].” C.U.L. MS Add 3970, f. 521v; discussed in Pesic, “Mystery of the Major Sixth,” 296; Shapiro in Newton, *Optical Lectures*, 547n.

in such a way that a larger amplitude is associated with a longer wavelength. Therefore, the reader should be warned that my usage of terms such as “frequency” and “wavelength” below is anachronistic. As Michel Blay and Olivier Darrigol show, for Newton wavelength was not a purely mathematical characteristics of the ether waves; rather, he understood it as correlated to the “strength,” magnitude,” or “vigour” of a ray. Since red is “stronger” than blue, presumably because it is carried by bigger corpuscles, the waves associated with red are “bigger” in both amplitude and wavelength than those associated with blue.²⁹ It is through his celebrated study of “rings” (see figures 2 and 3) that Newton managed to match each color to the wavelength of the ethereal vibration associated with it, as I shall briefly explain below.

In the early 1670s Newton had the intuition to study mathematically the formation of interference patterns in thin films, a phenomenon already observed by Robert Boyle and Hooke, by adopting an experimental approach that was most suited for quantification. Newton placed a spherical lens upon a flat glass surface in such a way as to create a thin layer of air between the two pieces of glass (figure 3). When the sun shone on this device from above, he noticed the formation of colored rings. When monochromatic light is used in this experiment, clearly spaced-out rings emerge, as shown in figure 2.

Through a simple calculation, Newton showed how thickness d of the layer of air between the two glass surfaces was a function of diameter D of the rings ($d \approx D^2/8R$), where R is the radius of the spherical lens (see figure 3). This formula enabled Newton to show how the rings would form at integral multiples of an elementary thickness of the layer of air. The conclusion he reached was that this elementary length coincides with the length of the “pulse” of a vibrating ethereal medium. For example, in the case of yellow the length of the pulsation would be $1/80,000$ of an inch.

We should bear in mind that Newton was a corpuscularist, although he proposed corpuscularism in a guarded manner—if I may put it so—as

²⁹ See Newton, *Correspondence*, 1:376. See Michel Blay, “Une clarification dans le domaine de l’optique physique: *bigness* et promptitude,” *Revue d’Histoire des Sciences* 33 (1980): 215–24. Here refer to Darrigol, “Analogy,” 234. Newton draws a comparison between the “small bodies” composing the rays of light impinging on “refracting or reflecting superficies” and stones hitting the surface of water in “Mr Isaac Newtons Answer to Some Considerations upon His Doctrine of Light and Colors,” *Philosophical Transactions of the Royal Society of London* 88 (1672): 5087, reprinted in I. Bernard Cohen and Robert E. Shofield, eds., *Isaac Newton’s Papers and Letters on Natural Philosophy* (Cambridge: Cambridge University Press, 1958), 119.

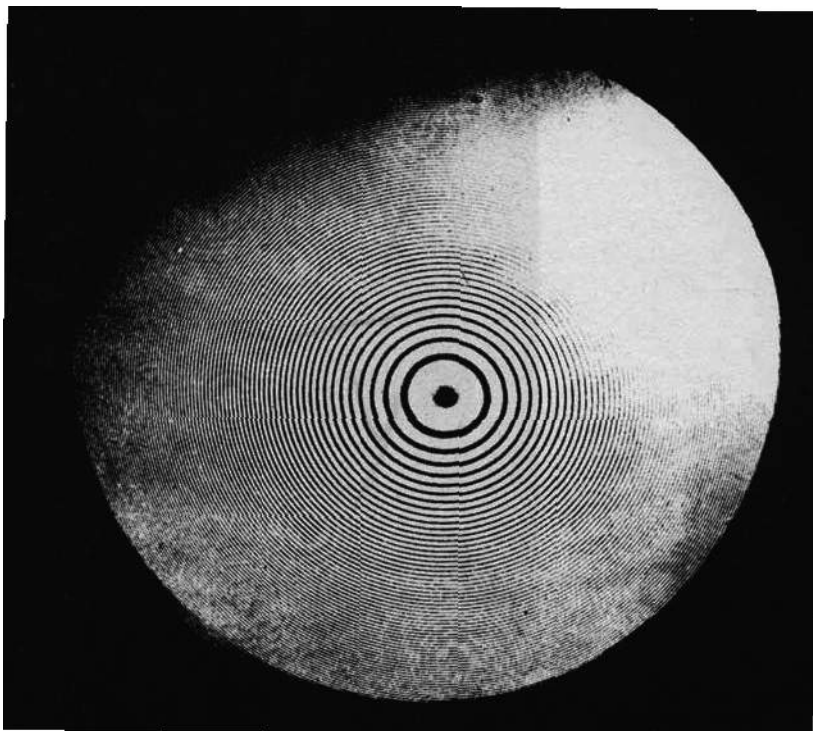


FIGURE 2. Rings produced by monochromatic light striking Newton's experimental device, as described in this article. Source: author's photograph.

far as the nature of light was concerned. Still, in the 1670s he combined corpuscularism with the idea of luminous ethereal waves. According to Newton, the phenomena Hooke had observed in the case of thin films (soap bubbles, mica, etc.) and described in his *Micrographia* could be explained by attributing periodic properties to light, an idea which supporters of the wave theory ought to have found it easier to justify than did Newton himself. According to Newton, when corpuscles meet the surface separating two transparent media with different refractive indexes, they send vibrations through the optical ether, which explain the periodicities observed in interference phenomena such as the formation of Newton's rings. What is noteworthy here is that Newton associated a wavelength of the ether vibration with each color. In the 1690s Newton avoided committing himself to the hypothesis of the ether, and he reformulated this ingenious idea of a

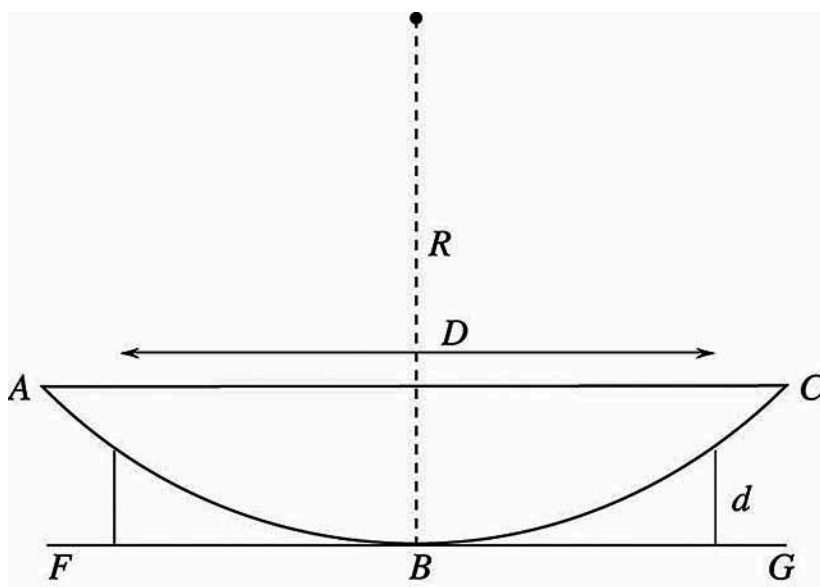


FIGURE 3. A spherical lens ABC with radius R is placed on a flat glass surface FBG . When it is lit from above, colored rings are formed (see fig. 2). D is the diameter of one ring. Newton calculated the thickness d of the layer of air between the lens and the glass plate in function of D . Source: Compomat s.r.l. ©Niccolò Guicciardini.

combination of corpuscular and periodic properties of light by elaborating his theory of “fits of easy reflexion and easy transmission.” According to this theory, light rays find themselves in periodic “constitutions or states” whereby they are either reflected or transmitted by transparent media. Newton called these periodic dispositions of the rays the “fits of easy reflexion and easy transmission,” and the space interval between these dispositions the “interval of the fits”: he claimed that this interval is characteristic of each color. Very much like his 1670s ether theory, this new hypothesis accounted for the formation of rings. The theory of fits was published by Newton in book II, part. III, props. 12–20 of the *Opticks*.³⁰

³⁰ For a detailed explanation of Newton’s theory of the interference of light and a description of his experiments with rings, the reader should consult Alan E. Shapiro, *Fits, Passions, and Paroxysms: Physics, Method and Chemistry and Newton’s Theories of Colored Bodies and Fits of Easy Reflection* (Cambridge: Cambridge University Press, 1993), 49–97, 136–207.

In the 1670s, by resorting to his ether theory, and after briefly entertaining the hope that the ratio 2 to 1 would ensue for the elementary ether vibrations relative to red and violet, Newton ascertained experimentally that the “wavelengths” of the colors at the two ends of the prismatic spectrum are not marked by the the ratio 2 to 1 we would expect to find in the interval of an octave. As noted above, the ratio between red and violet rather appeared to be in-between $5/3$ and $3/2$, the ratio $14/9$ —which does not correspond to any consonant musical interval—being often taken as the best estimate. Newton’s subsequent experiments on interference of light via the observation of rings most often yielded the value $14/9 \approx 1.56$, which is the value cited in the *Opticks*.³¹ In other words, Newton, a careful experimental researcher and mathematician, tested a hypothesis regarding the physiology of perception and reached a problematic result.

Newton’s adherence to the musical scale/color spectrum analogy resurfaces in his writings dating to the early 1690s, especially in drafts of what was to become his celebrated *Opticks*. Here he most often confirms the approximate ratio of $14/9$ for the extreme colors of the spectrum. He also affirms that a major sixth in just intonation would correspond to the ratio of the “wavelengths” of the vibrations for red and violet that would be “in the proportion of 5 to 3 to make the 5 principal colours red yellow green blue violet answer to the tones in a sixth major.”³² These results would seem to spoil the analogy between the color spectrum and the octave. Yet in his drafts for a projected fourth book of the *Opticks*, Newton reinterpreted his experimental results by taking recourse to a numerical operation applied to the ratios of the musical scale. This numerical operation first appears in a draft of proposition 15 and in the addition to the conclusion of book 4, part 1, obs. 8.³³ Newton was evidently pleased with this idea, so much so that he formulated it anew in book II of the *Opticks* as follows (the ratios quoted by Newton below are those of the Dorian mode according to just intonation):

But it agrees something better with the Observation to say, that the thicknesses of the Air between the Glasses there, where the Rings are successively made by the limits of the seven Colours,

³¹ Newton, *Opticks*, 210. For details, see Shapiro in Newton, *Optical Lectures*, 547n.

³² C.U.L., Ms. Add. 3970, f. 336r; discussed in Petic, “Mystery of the Major Sixth,” 296; this idea was restated in Newton, *Opticks*, 211–12.

³³ C.U.L. MS Add. 3970, ff. 363r, 344; discussed in Shapiro, *Fits, Passions, and Paroxysms*, 192 n. 123.

red, orange, yellow, green, blue, indigo, violet in order, are to one another as the Cube Roots of the Squares of the eight lengths of a Chord, which sound the Notes in an eighth, [. . .]; that is, as the Cube Roots of the Squares of the Numbers, 1, 8/9, 5/6, 3/4, 2/3, 3/5, 9/16, 1/2.³⁴

By introducing the cube roots of the squares of the Dorian mode ratios, the analogy with the octave would be preserved. For example, according to Newton's preferred measurement results, thicknesses d_1 and d_2 corresponding to deep violet and red are in a ratio $d_1/d_2 \approx 9/14 \approx 0.64$, which is close to the cube root of the square of 1/2. Namely, $(1/2)^{2/3} \approx 0.63$. The reader should note that, according to measurements accepted today, deep violet has wavelength ≈ 400 nm and red ≈ 650 nm, so that $40/65 \approx 0.62$. In his fascinating article on the subject, Pesic is certainly right in drawing attention to the trick Newton devised, for while the latter pushed things a little—considering the arbitrary manner in which he subdivided colors (in modern terms, what wavelength was chosen to define each of the seven colors of the spectrum)—he preserved the musical scale/color spectrum analogy by invoking the ratio 2/3. As is well known, this ratio played a decisive role both in the science of harmonics (it is the ratio for the fifth, which, after the octave, is the most important consonant interval) and in Keplerian astronomy (it occurs in Kepler's third law according to which the planetary periods of revolution around the sun T and their mean distances d from the sun are such that $T^{2/3} = cd$, c constant). Therefore, a Pythagorean way of thinking seems to be lurking here, since a ratio basic for the understanding of planetary orbits was invoked by Newton for preserving the analogy between colors and sounds. Dennis Sepper consequently observes that “the circle of colours would thus bear a certain analogy with the circles of planets.”³⁵ Pesic elaborates on Sepper's cautious hypothesis, and in explicit support of Gouk's interpretation of Newton as an exponent of Neo-Pythagoreanism (which he approvingly cites), he claims,

Given the great importance of the cube root of the square in Newton's astronomical work, one can readily believe that he seized on it here with pleasure, perhaps seeing an opportunity to extend his musical analogy to the cosmic scale at the same time as he used it

³⁴ Newton, *Opticks*, 211–12.

³⁵ Dennis L. Sepper, *Newton's Optical Writings: A Guided Study* (New Brunswick, N.J.: Rutgers University Press, 1994), 123.

to subsume the major sixth to the overarching octave. His reinterpretation of the data not only “agrees better with the Observation” but also sets forth a rival Keplerian “Third Law,” here for the harmonies of coloured rings, rather than of planets.³⁶

However, Newton never mentions any connection between the ratio $2/3$ (i.e. the cube root of the square) used in relation to the study of colored rings and Kepler’s third law. Nowhere, for that matter, neither in his manuscripts nor in his printed works, does he relate any laws of optics to planetary motions. Pesic’s interpretation, which would support Gouk’s reading of Newton as a defender of Neo-Pythagoreanism, cannot be ruled out, and it still stands as a fascinating interpretative hypothesis. However, it seems to me to be somewhat far-fetched, at least when applied to the years following the composition of the *Principia*: for in the winter of 1684–85 Newton had realized—as we have seen above—that planetary orbits do not obey Kepler’s laws precisely because of perturbations caused by mutual gravitational interactions.

What I am particularly keen to stress here is the fact that while no doubt fascinated by the analogy between the musical scale and the color spectrum, Newton—who stands by this view in texts as widely dispersed as the manuscripts dated to 1665, the 1672–75 “Hypothesis,” a 1685 letter to William Briggs, the 1690 preparatory manuscripts for the *Opticks* and finally the second English edition of the *Opticks* from 1717–18—displays an outlook far removed from Neo-Pythagoreanism.³⁷ His study of the analogies between the musical scale and the color spectrum was motivated by his interest in the physiology of perception in terms of the vibrations of a fluid ether contained in the “optick nerves,” a hypothetical theory that resurfaces in some of the queries at the end of the *Opticks*.³⁸ Rather than any mystical correspondences between light and musical harmony, what I believe Newton was interested in were the mechanistic theories about consonance in terms of air vibrations, and the idea of an animal spirit in the acoustic nerves as an explanation for the mechanism of hearing. What Newton attempted to do was to extend the acoustic perception theories already circulating as viable hypotheses to visual perception.

³⁶ Pesic, “Mystery of the Major Sixth,” 297.

³⁷ Newton, *Correspondence*, 2:417–18.

³⁸ See queries 13 and 14 (from the 1704 first edition of the *Opticks*) and queries 17 and 23 (from the English 1717–18 edition). Newton, *Opticks*, 345–48, 353.

Before I turn to examine the second Pythagorean crux in Newtonian thought, namely the relation between musical harmonies and astronomical laws, I wish to stress my belief that Newton's "voice" is far removed from the numerological rhetoric of men such as Dee and Fludd, and from the geometrical and musical analogies that guided Kepler's cosmogonical thought. Newton's method seems to me experimental and geared towards the explanation of optical interference phenomena (the rings) in terms of interactions between light corpuscles and the optical ether, and the physiology of hearing and vision in terms of the vibrations transmitted through the nerves. I fail to find in Newton any traces of a language consonant with, say, Rosicrucian mysticism or Marsilio Ficino's Neo-Platonism. In his outlook Newton was actually rather averse to Neo-Platonism, which he held responsible for the Nicean corruption of the Christian faith, and he was just as averse to the Jewish Kabbalistic tradition, which he tore to bits.³⁹

But let us now move on to the manuscript notes related to the project for a new edition of the *Principia* that, according to Gouk's view, prove Newton's adherence to the Neo-Pythagorean myth of the harmony of the spheres, his *Classical Scholia*.⁴⁰ In these scholia, which were probably composed in the years 1693–94, Newton claims that atomism, heliocentrism, and the gravitational theory were all known to the ancient sages, among whom Pythagoras is given pride of place. The latter he respectfully includes in his genealogy of ancient sages sprung from the wisdom of Noah and Moses. Newton embraced the myth according to which Pythagoras, Leucippus, and Democritus had inherited the foundations of this wisdom from the Phoenician Moschos. The Pythagorean tradition was thus seen to preserve certain elements of ancient Hebrew wisdom: heliocentrism and a cosmology of vacuum and atoms. In the 1690s, after having written the *Principia*, Newton started crediting the ancient pagan sages, instructed via transmission of the esoteric Hebrew tradition, with a knowledge of the laws governing celestial mechanics, which he claimed to have simply rediscovered. That the myth of the rediscovery of an ancient wisdom was deeply rooted in Newton's mind appears evident from "The Original of Monarch-

³⁹ Matt Goldish, *Judaism in the Theology of Sir Isaac Newton* (Dordrecht: Kluwer, 1998), 141–61; Michael T. Walton, "The Geometrical Kabbalahs of John Dee and Johannes Kepler: The Hebrew Tradition and the Mathematical Study of Nature," in *Experiencing Nature: Proceedings of a Conference in Honour of Allen G. Debus*, ed. Paul H. Theerman and Karen Hunger Parshall (Dordrecht: Kluwer, 1997), 43–59.

⁴⁰ See Gouk, "Harmonic Roots," 120–24; and *Music, Science and Natural Magic*, 251–57.

ies" (1693–94?), where he states that Numa was a "Pythagorean Philosopher."⁴¹ More famously, in the very opening lines of *De mundi systemate*, probably written in 1686, Newton claims that the ancients held that the Earth moves as a planet around the sun. According to Newton, the Copernican theory was taught by "Philolaus, Aristarchus of Samo, Plato in his riper years [. . .] the whole sect of the Pythagoreans [. . .] Anaximander [. . .] and Numa Pompilius." It was only after Eudoxus, Callippus, and Aristotle that "the ancient philosophy began to decline, and to give place to the new prevailing fictions of the Greeks."⁴² In an intended preface to the *Principia* written in the late 1710s, Newton attributes to the "Chaldeans," the "Ancients," the "Pythagoreans," and the "Greeks and Romans" a knowledge of universal gravitation.⁴³

In the *Classical Scholia* one reads that Pythagoras had esoterically expressed the law of universal gravitation through his talk of Apollo's lyre. In order to appreciate Newton's account of this myth, but especially his rhetoric, it is worth quoting at length from the *Classical Scholia*. Newton writes,

By what proportion gravity decreases by receding from the Planets the ancients have not sufficiently explained. Yet they appear to have adumbrated it by the harmony of the celestial spheres, designating the Sun and the remaining six planets, Mercury, Venus, Earth, Mars, Jupiter, Saturn, by means of Apollo with the Lyre of seven strings, and measuring intervals of the spheres by the interval of the tones [. . .] But by this symbol they indicated that the Sun by his own force acts upon the planets in that harmonic ratio of distances by which the force of tension acts upon strings of different lengths, that is, reciprocally in the duplicate ratio of the distances. For the force by which the same tension acts on the same string of different lengths is reciprocally as the square of the length of the string. The same tension upon a string half as long acts four times as powerfully, for it generates the Octave, and the Octave is

⁴¹ MS Keynes 146, f. 16r, edited in Frank E. Manuel, *Isaac Newton, Historian* (Cambridge, Mass.: Harvard University Press, 1963), 212.

⁴² Isaac Newton, *Sir Isaac Newton's Mathematical Principles of Natural Philosophy and His System of the World*, trans. Andrew Motte and Florian Cajori (1729/1734; repr. Berkeley: University of California Press, 1962), 549–50.

⁴³ C.U.L. MS Add. 3968.9, f. 109r-109v; in Isaac Newton, *The Mathematical Papers of Isaac Newton*, 8 vols., ed. D. T. Whiteside (Cambridge: Cambridge University Press, 1967–81), 8:459.

produced by a force four times as great. [. . .] And, in general terms, if two strings equal in thickness are stretched by weights appended, these strings will be in unison when the weights are reciprocally as the square of the lengths of the strings. Now this argument is subtle, yet became known to the ancients. For Pythagoras, as Macrobius avows, stretched the intestines of sheep or the sinews of oxen by attaching various weights, and from this learned the ratio of the celestial harmony. Therefore by means of such experiments he ascertained that the weights by which all tones on equal strings [. . .] were reciprocally as the square of the lengths of the string by which the musical instrument emits the same tones. But the proportions discovered by these experiments, on the evidence of Macrobius, he applied to the heavens and consequently by comparing those weights with the weights of the Planets and the lengths of the strings with the distance of the Planets, he understood by means of the harmony of the heavens that the weights of the Planets towards the Sun were reciprocally as the square of their distances from the Sun.⁴⁴

If we then imagine the planets as “tied” to the sun by the mythical seven strings of Apollo’s lyre, in order for the strings to vibrate in unison, a tension must be exercised on them that stands in a certain ratio to the length of the strings. The tension of the strings would then be, in Pythagoras’ mystical language, analogous to gravitation, while the lengths of the strings would stand for the distances of the planets from the sun.

The strings of Apollo’s lyre are seven, like the celestial bodies orbiting around the Earth according to the Ptolemaic system. Here we have an equivalence between the number of celestial bodies and the number of notes on the musical scale. This equivalence, however, does not hold for the Copernican system, where the number of planets orbiting around the Sun is six. One immediately realizes that in order to discern a message about the Copernican system behind the mythical tale of Apollo’s seven-stringed instrument, one must give it a rather artificial reading, since there is no literal correspondence between the number of strings and the number of planets. But there is a more disturbing discrepancy concerning the analogy between tension and gravitational force. Marin Mersenne had already shown in 1636 that in order to vibrate in unison two strings with the same

⁴⁴ Translation in McGuire and Rattansi, “Newton and the ‘Pipes of Pan,’” 115–17.

density and an equal cross section, it is necessary for their tensions to be proportional, and not inversely proportional, to the square of their length. According to Mersenne's law, the frequency f of the sound produced by plucking a string is proportional to the square root of the tension T and inversely proportional to the length l of the string, or, to use an algebraic formalism absent from Mersenne's work, $f = k(T)^{1/2}/l$ (where the constant k depends upon the physical properties of the string). This law was well known in the 1690s, since Mersenne had published it in *Harmonie Universelle* (1636–37). Newton was aware of Mersenne's work, which he cites in the *Principia*.⁴⁵ However, regardless of the exact formulation of the law (which in practice had to be slightly adjusted in order to take into consideration the stiffness of the string), he certainly understood that the lowering effect on pitch caused by an increase in the length of the string has to be compensated by an increase (and not by a decrease) in tension, in order to maintain the pitch unaltered. Therefore, no mathematically valid relation can be very easily discerned between musical harmony and the force of gravitation, which, of course, decreases with distance. In short, Newton's statement, "And, in general terms, if two strings equal in thickness are stretched by weights appended, these strings will be in unison when the weights are reciprocally as the square of the lengths of the strings," on which the analogy rests, is wrong.

Several interpretations of the analogy between the force of gravity and the tension on Pythagoras's monochord might be attempted in order to render Newton's statements in the *Classical Scholia* compatible with Mersenne's law. On this issue, the reader might want to consult eighteenth-century commentators such as Colin Maclaurin, or the more recent work by Sigalia Dostrovsky.⁴⁶ The latter claims that Newton's statement in the *Classical Scholia* has to be interpreted so that for "frequency" one understands a magnitude proportional to the planet's angular velocity.⁴⁷ Nothing in Newton's words seems to support the plausibility of this interpretation. The most radical point of view is that of Tito Tonietti, who claims that

⁴⁵ Marin Mersenne, *Harmonie Universelle* (Paris: Ballard, 1636–37). Mersenne, *Harmonicorum Libri XII* (Paris: Baudry, 1648), referred to in Newton, *Philosophiae Naturalis Principia Mathematica* (London: Streater, 1687), 372. Mersenne's law is cited in proposition IX of *Harmonicorum*, 2:12. See Peter Dear, *Mersenne and the Learning of the Schools* (Ithaca: Cornell University Press, 1988), 139–60.

⁴⁶ Colin Maclaurin, *An Account of Sir Isaac Newton's Philosophical Discoveries* (London: Millar, 1750), 34.

⁴⁷ Sigalia Dostrovsky, "Early Vibration Theory: Physics and Music in the Eighteenth Century," *Archive for History of Exact Sciences* 14 (1975): 211.

Newton was wrong.⁴⁸ What Newton might want to imply in the above passage is that if one halves a string, one produces the same note as that obtained by increasing the tension fourfold; or if one shortens the string to one third of its length, one produces the same note as that obtained by increasing the tension by a factor of nine, etc. ("The same tension upon a string half as long acts four times as powerfully, for it generates the Octave, and the Octave is produced by a force four times as great.") Is this the key to Newton's reading of the Pythagorean myth of Apollo's lyre as an analogy between the tension of the strings and gravitation?

Be that as it may, I believe that the musical analogy between Apollo's lyre and the planetary system should not be taken too literally, and therefore requires no strictly rigorous mathematical interpretation. In my opinion, it is Newton's intention to attribute only a metaphorical role to this analogy, and therefore it is misleading to read the *Classical Scholia* in excessively formalized terms, namely by relating Newton's statements—which are couched in a symbolic and mythological language—to Mersenne's law. I surmise that, according to Newton, Pythagoras concealed his knowledge through ciphered language by adopting the above analogy so as to enable the wise to grasp a coded message conveying a truth about the planetary system. Indeed, Newton continues the passage just quoted by warning his readers,

But the Philosophers loved so to mitigate their mystical discourses that in the presence of the vulgar they foolishly propounded vulgar matters for the sake of ridicule, and hid the truth beneath discourses of this kind [. . .] Pythagoras beneath parables of this sort was hiding his own system and the true harmony of the heavens.⁴⁹

In his Euhemeristic reading of Greek and Roman mythology, in his biblical hermeneutics of prophecies, and in his approach to alchemical literature and emblems, Newton was guided by the idea that the ancient texts needed to be deciphered according to rules known to the interpreters and ultimately decoded as statements concerning plain historical or scientific facts, rather than to be approached, as in the Renaissance Philonic tradition, as allegories of a mystical nature.⁵⁰ For those acquainted with Newton's read-

⁴⁸ Tito M. Toniatti, "Does Newton's Musical Model of Gravitation Work? A Mistake and Its Meaning," *Centaurus* 42 (2000): 135–49.

⁴⁹ Translation in McGuire and Rattansi, "Newton and the 'Pipes of Pan,'" 117.

⁵⁰ Manuel, *Historian*, 120–21; Goldish, *Judaism*, 52.

ing of pagan emblems, biblical allegories, and sacred architectural proportions, it will come as no surprise that in the *Classical Scholia* two ideas are prominent: that the ancients possessed superior scientific knowledge; and that they adumbrated factual truths in a symbolical language for which an interpretative key had to be found by following philological and iconographic rules.

With the above considerations I cannot claim that I have disproved Gouk's Pythagorean reading of the *Classical Scholia*. Historical interpretation seldom allows one to reach such razor-sharp results. My more modest claim is that, by placing these texts in a somewhat broader context, I have offered a more plausible reconstruction of Newton's intended meaning, or—as some intellectual historians would put it—of the “illocutionary force” implied in Newton's pronouncements concerning Pythagoras. I am very much in favor of conceiving historical interpretation as addressed to uncovering authorial intentions. That is why I have paid so much attention to what Quentin Skinner called the “proper emphasis and tone of an author's work”: something that can be recovered only by paying due attention both to the linguistic conventions accepted by the author and to what the author was “doing in saying what he said,” since Newton's actions vis-à-vis his contemporaries reveal the relationship he wished to establish between himself as an author and his readers and acolytes.⁵¹ Thus, I claim that the *Classical Scholia* should be viewed as evidence for Newton's adherence, at least in the 1690s, to the myth of *prisca sapientia*. According to his perspective, the musical harmonies engendered in the cosmos which the ancients spoke of must be regarded as a code to be deciphered: they are not to be understood literally. The mistaken application of Mersenne's law would appear to confirm the above interpretation. Newton seems to have interpreted the myth of Apollo's lyre as a coded message—one of the many ciphered messages hidden behind Greco-Roman mythology and the allegories of the apocalypse on which he focused in his studies of alchemy and biblical hermeneutics—not as a truth revealing the harmonies of the cosmos, something he, after the mid-1680s, did not believe in as a cosmologist and theologian.

Over the course of the sixteenth century, the Neo-Pythagorean myth of celestial harmonies that had been endorsed by many in the late Renaissance was gradually abandoned, although it was still accepted in the late 1620s

⁵¹ I refer to Quentin Skinner's employment of the theory of illocutionary acts due to J. L. Austin in “Meaning and Understanding in the History of Ideas (1969),” in *Visions of Politics*, vol. 1, *Regarding Method* (Cambridge: Cambridge University Press, 2002), 85.

by a giant such as Kepler. Newton has been associated with this “late-Renaissance” wing by Gouk and Pesic. According to their view, he upheld the idea of the harmony between music and light phenomena in the “Hypothesis,” and between music and gravitational phenomena in the *Classical Scholia*. Several aspects of Gouk’s and Pesic’s interpretation are perfectly acceptable. As they show, Newton was fascinated by the myth of an ancient lore expressing the “analogy of nature” in musical terms. However, viewing Newton as a Neo-Pythagorean natural philosopher, or even a “Pythagorean magus,” as Gouk would have it, is problematic, since this approach fails to take account of the context in which Newton engaged with these musical metaphors, a context which reveals a mentality in many ways removed from Neo-Pythagoreanism.

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