Maurice A. Finocchiaro

Trials and Tribulations of the Modern View of the Universe:

Copernicanism, Galileo, and the Church

In 1543, Copernicus elaborated quantitatively the geokinetic view of the universe. In 1589-1609, Galileo pursued it indirectly, through his new physics. After his telescopic discoveries, in 1609-1615, Galileo re-assessed it as more probable than geocentrism. In 1616, the Catholic Church condemned the doctrine and banned Copernican books. In 1632, Galileo's *Dialogue* robustly defended it. In 1632-1633, the Roman Inquisition re-censured it by trying and condemning Galileo. For the past four centuries, the Church has gradually assimilated it. These developments imply valuable lessons, about whether science and religion are incompatible, and how Galileo is a model of rationality.

Until the early sixteenth century, almost all scientists and philosophers believed that the earth stood still at the center of a finite universe. By the end of the seventeenth century, most of them had come to believe that the earth is a planet rotating daily on its own axis and revolving yearly around the sun, in an infinite universe. This transition from a geocentric and geostatic view of the universe to a heliocentric and geokinetic view is perhaps the most significant intellectual transformation in human history. It was a slow, gradual, and complex process that started with Nicolaus Copernicus in 1543 and climaxed with Isaac Newton in 1687. One of the key figures in this Copernican Revolution was Galileo Galilei (1564-1642). He made such significant contributions to physics, astronomy, and scientific methodology that scientists like Albert Einstein and Stephen Hawkins have gone so far as to nickname him "Father of Modern Science."[1] Moreover, Galileo had the misfortune of being tried and condemned by the Roman Inquisition, and thus was the protagonist of what some label "the greatest scandal in Christendom."[2]

This essay aims to highlight this story; discuss the main issues; and suggest possible lessons. The so-called Galileo Affair serves as a focus; that is, my account is structured in terms of the background, details, aftermath, and significance of Galileo's trial.

Pursuit (1543-1609)

In 1543, the Polish astronomer Nicolaus Copernicus published his epoch-making book *On the Revolutions of the Heavenly Spheres*. In it, Copernicus updated an idea that had been advanced as early as Pythagoras in ancient Greece, but had been almost universally rejected: that the earth does not stand still at the center of the universe with all the heavenly bodies revolving around it, but rather moves by rotating on its axis daily and revolving around the sun yearly.

In its essentials, Copernicus's idea turned out to be true, as we know today beyond any reasonable doubt, after five centuries of increasingly accumulating evidence. At the time, however, the situation was very different. In fact, Copernicus's accomplishment was to give a new argument in support of the old idea: he demonstrated that the known facts about the motions of the heavenly bodies could be explained in quantitative detail if one assumes that the sun is at the center and the earth moves.

This explanation is simpler and more coherent than the geostatic one. However, the argument is a hypothetical one, namely based on the claim that *if* the earth were in motion *then* the observed phenomena would result; but from this it does not follow with logical necessity that the earth is in motion. This does indeed provide a reason for preferring the geokinetic idea, but it is not a decisive reason. It would be decisive only in the absence of reasons for rejecting it. In short, one has to consider counter-arguments, and there were plenty of them.

The earth's motion seemed philosophically and epistemologically absurd because it contradicted direct sense experience; in fact, neither Copernicus nor anyone else could see, feel, or otherwise perceive the earth's motion. From the perspective of the science of physics, the motion of the earth seemed mechanically impossible because the available laws of motion (stemming from Aristotle) implied that bodies on a rotating earth would, for example, follow a slanted rather than vertical path in free fall, and would be thrown off by centrifugal force. From the viewpoint of astronomy, the earth's motion seemed to be false because it had consequences that could not be observed; for example, terrestrial and heavenly bodies would have to have similar physical properties; the planet Venus would have to exhibit phases similar to those of the moon; and the fixed stars would have to undergo a yearly shift in their apparent position, called annual stellar parallax. Finally, the earth's motion seemed theologically heretical because it contradicted the words and the traditional interpretations of Scripture. Copernicus was aware of all this. I believe that these were the reasons why he delayed publication of his book until he was about to die.

Galileo's attitude was at first similar. The main difference was that his central interest was physics, mechanics, and mathematics, rather than astronomy. He began university teaching in 1589. In his official position as professor of mathematics, his duties included the teaching of astronomy and physics, as well as mathematics.[3]

Although acquainted with the Copernican theory, Galileo did not regard it as sufficiently well-established to teach it in his courses; instead he covered traditional geostatic astronomy. Nor was he directly pursuing the geokinetic theory in his research. Rather his research consisted of investigations into the nature of motion and the laws in accordance with which bodies move. Here his work was original and revolutionary, for he was critical of the traditional physics of motion, and was attempting to construct a new science of how bodies move.

He soon realized that the physics he was building was very much in line with the geokinetic theory, in the sense that what he was discovering about the motion of bodies in general had the consequence of making possible for the earth to move, and rendering unlikely its rest at the center of the universe. In short, Galileo soon realized that his physical research had important consequences in the astronomical field, namely to strengthen the Copernican theory by removing the physical objections against it.

Thus, in his early career Galileo judged that the anti-Copernican arguments outweighed the pro-Copernican ones. Consequently, he neither accepted Copernicanism, nor was he pursuing it actively and directly. However, he may be described as indirectly pursuing a Copernican research program insofar as he was constructing a new physics consistent with the earth's motion.[4]

Re-assessment (1609-1615)

This situation changed drastically with the advent of the telescope. The telescopic discoveries led Galileo to a major re-assessment of the Copernican theory of the earth's motion.[5]

The telescope was first invented in Holland in 1608, but in 1609 Galileo was able to make significant qualitative improvements and to achieve sufficient magnification that could not be duplicated by others for some time (see Figure 1). Moreover, rather than merely exploiting the instrument for practical applications on earth, he started using it for systematic observations of the heavens, to learn new truths about the universe.

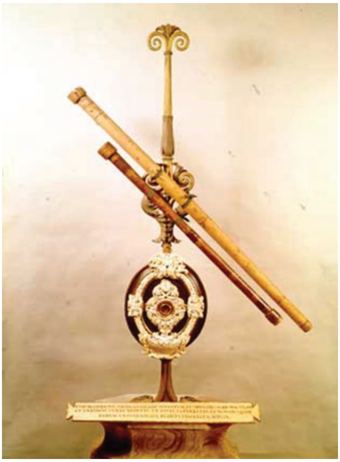

Fig. 1 Galileo's telescopes from 1609-1610, now kept at the Museo Galileo, Florence
(From: Encyclopedia Britannica Online, at https://www.britannica.com/science/physical-science/images-videos/Two-of-Galileos-first-telescopes-in-the-Institute-and-Museum/2916)

These observations led to several startling discoveries, which he published the following year in a book entitled *The Sidereal Messenger*.[6] The moon's surface is full of mountains and valleys (see Figure 2); innumerable other stars exist besides those visible with the naked eye; the Milky Way and the nebulas are dense collections of large numbers of individual stars; and the planet Jupiter has several moons revolving around it at different distances and with different periods.

As a result, Galileo became a celebrity. Resigning his professorship at Padua, he obtained a position as adviser to the grand duke of his native Tuscany and moved to Florence the same year. His official title was "Philosopher and Chief Mathematician to the Grand Duke of Tuscany."

Soon thereafter, Galileo also discovered the phases of Venus and sunspots. On the latter, he published a book in 1613, entitled *Sunspot Letters*.[7]

Although almost all of these discoveries were made independently by others, no one understood their significance as well as Galileo. The significance was threefold. Methodologically, the telescope implied a revolution in astronomy, insofar as it was a new instrument that enabled the gathering of a new kind of data, transcending the previous reliance on naked-eye observation. Substantively, those discoveries considerably strengthened the case in favor of the physical truth of Copernicanism, by refuting almost all empirical astronomical objections and providing new supporting observational evidence. Finally, this reinforcement was not equivalent to a settling of the issue, because there was still some astronomical counter-evidence (mainly, the lack of annual stellar parallax); moreover, the mechanical objections had not yet been explicitly answered and the physics of a moving earth had not yet been articulated; and the theological objections had not yet been refuted.

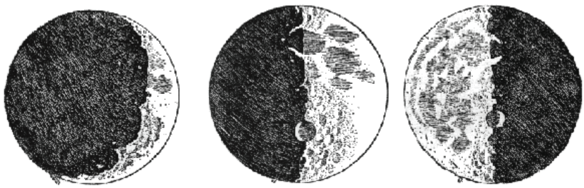

Fig. 2 Images of the appearance of the moon through Galileo's telescope, as published in The Sidereal Messenger
(From Galileo Galilei, Opere, 20 vols., ed. A. Favaro et al., Florence: Barbèra, 1890-1909, vol. 3, pp. 63, 65)

Condemnation and Prohibition (1615-1616)

Besides realizing that the pro-Copernican arguments were still not absolutely conclusive, Galileo must have also perceived the potentially explosive character of the religious objections. Thus, for a while he did not get involved. Eventually, however, he was dragged into the theological discussion.[8]

In fact, as it became known that Galileo was convinced that the new telescopic evidence significantly confirmed the truth of the geokinetic theory, he came increasingly under attack from conservative clergymen. They argued that Galileo was a heretic because he believed in the earth's motion and the earth's motion contradicted Scripture (e.g., the miracle in Joshua 10:12-13).

Thus, at one point Galileo felt he could no longer remain silent and decided to refute the biblical argument against Copernicus. To avoid scandalous publicity, he wrote his criticism in the form of long private letters, in December 1613 to his disciple Benedetto Castelli and in spring 1615 to the dowager Grand Duchess Christina.

Galileo's letters circulated widely and the conservatives got even more upset. Thus, in February 1615, a Dominican friar filed a written complaint against Galileo with the Inquisition in Rome. An investigation was launched that lasted about a year. As part of this inquiry, a committee of Inquisition consultants reported that the key Copernican theses were false in natural philosophy and heretical in theology. The Inquisition also interrogated other witnesses. Galileo himself was not interrogated, for various reasons: the key witnesses exonerated him; his letters had not been published; and his published writings contained neither a categorical assertion of Copernicanism nor a denial of the scientific authority of Scripture.

However, in December 1615, Galileo went to Rome of his own accord to see what was happening. He was able to talk to many influential Church officials and was received in a friendly manner. He may be credited with having prevented the worst, insofar as the Inquisition did not issue a formal condemnation of Copernicanism as a heresy. Instead two milder consequences followed.

In February 1616, Cardinal Robert Bellarmine, in the name of the Inquisition, gave Galileo a private warning, forbidding him to hold or defend the truth of the earth's motion; Galileo agreed to comply. And in March, the Congregation of the Index (the cardinals in charge of book censorship) published a decree which, without mentioning Galileo, made three declarations: the earth's motion was false and contradicted Scripture; a 1615 book by one Paolo Antonio Foscarini, supporting the earth's motion as true and compatible with Scripture, was condemned and permanently banned; and Copernicus's 1543 book was banned until appropriately revised

Published in 1620, these revisions amounted to rewording or deleting a dozen passages. The original wording suggested that the earth's motion was or could be physically true. The censored versions conveyed the impression that the earth's motion was merely a convenient instrument (or hypothesis) to make mathematical calculations and observational predictions.

Defense and Confirmation (1623-1632)

For the next several years, Galileo kept quiet, until 1623 when Cardinal Maffeo Barberini became Pope Urban VIII. Since Barberini was an admirer and patron of his, Galileo felt freer and decided to write the book on the system of the world conceived earlier, adapting its form to the new restrictions. This was the *Dialogue on the Two Chief World Systems, Ptolemaic and Copernican* of 1632.[9]

Galileo wrote the book in the form of a dialogue among three characters (see Figure 3) engaged in a critical discussion of the cosmological, astronomical, physical, and philosophical arguments, but careful to avoid the theological ones. Its key thesis is that the arguments favoring the geokinetic theory are stronger than those favoring the geostatic view, and in that sense Copernicanism is more probable that geostaticism. When formulated this way, the thesis is successfully established. In the process, Galileo managed to incorporate into the discussion his telescopic discoveries, his conclusions about the physics of moving bodies, a geokinetic explanation of the tides, and various methodological reflections.

From the viewpoint of the ecclesiastic restrictions, Galileo must have felt that the book did not "hold" the geokinetic theory because he was not claiming that the geokinetic arguments were conclusive; that the book was not "defending" the theory because it was rather a critical examination of the arguments on both sides; and that it was a hypothetical discussion because the earth's motion was being presented as a hypothesis postulated to explain observed phenomena.

Fig. 3 Frontispiece of Galileo's Dialogue (1632)
(From: Galileo Galilei, Opere, 20 vols., ed. A. Favaro et al., Florence: Barbera, 1890-1909, vol. 7)

However, Galileo's enemies complained that the book did not treat the earth's motion as a hypothesis (in the sense of instrument), but as a real possibility, like the uncensored and prohibited version of Copernicus's book. Additionally, they claimed that the *Dialogue* defended the earth's motion, because the pro-Copernican arguments were evaluated favorably, and the anti-Copernican arguments were criticized.

Trial and Condemnation (1632-1633)

These complaints amounted to charging Galileo with violating Bellarmine's warning and the Index's decree. These alleged transgressions were bad enough, but there was also a third charge. The book supposedly violated a special injunction issued personally to Galileo in 1616, prohibiting him from discussing the earth's motion in any way whatever; a document describing this injunction had been found in the file of the earlier Inquisition proceedings. Thus, Galileo was summoned to Rome to stand trial, which after various delays began in April 1633.[10]

At the first hearing, Galileo was asked about the events of 1616 and his *Dialogue*. He admitted receiving from Bellarmine the warning that the earth's motion could not be held or defended, but only discussed hypothetically. He denied receiving a special injunction not to discuss the topic in any way whatever. In his defense he introduced a certificate he had obtained from Bellarmine in 1616; this certificate only mentioned the prohibition to hold or defend. Galileo also claimed that the book did not really defend the earth's motion, because the favorable arguments were judged inconclusive, and so it did not violate Bellarmine's warning.

The special injunction surprised Galileo as much as Bellarmine's certificate surprised the inquisitors. Thus, it took three weeks before they decided on the next step. The inquisitors opted for some out-of-court plea-bargaining: they would not press the most serious but least provable charge (violation of the special injunction), but Galileo would have to plead guilty to a lesser but more solid charge (transgression of the warning not to defend Copernicanism) Galileo requested a few days to devise a dignified way of pleading guilty to the lesser charge. Thus, at later hearings, he stated that the first deposition had prompted him to re-read his book; he was surprised to find that it gave readers the impression that the author was defending the earth's motion, even though this had not been his intention. He attributed his error to wanting to appear clever by making the weaker side look stronger. He was sorry and ready to make amends.

The trial ended on 22 June 1633 with a harsher sentence than Galileo had been led to expect. The verdict found him guilty of a category of religious crime intermediate between the most and the least serious, called "vehement suspicion of heresy." The objectionable beliefs were the cosmological thesis that the earth moves and the methodological principle that the Bible is not a scientific authority. The *Dialogue* was banned. He was condemned to house arrest for the rest of his life. And he was forced to recite a humiliating "abjuration".

One of the ironic results of this condemnation was that, to keep his sanity, Galileo went back to his earlier research on motion, organized his notes, and five years later published his most important contribution to physics, the *Two New Sciences*.[11] Without the tragedy of the trial, he might have never done it.

Assimilation (1633-1992)

While the Inquisition's condemnation in 1633 ended the original controversy, it gave rise to a new one that continues to our own day.[12] The subsequent Galileo affair is about the facts, issues, causes, and lessons of the original.

The facts of this subsequent Galileo affair may be highlighted as follows. Some involve actions taken by the Catholic Church, such as: the partial unbanning first of Galileo's *Dialogue* and later of Copernican books in general, during the papacy of Benedict XIV (1740–1748); the total repeal of the condemnation of the Copernican doctrine (1820-1835); the implicit theological vindication of Galileo's hermeneutics by Pope Leo XIII's encyclical *Providentissimus Deus* (1893); the beginning of the rehabilitation of Galileo himself, occasioned by the commemoration of the tricentennial of his death (1942); and, most recently, the further rehabilitation of Galileo by Pope John Paul II (1979-1992).

The historical aftermath also includes actions by various non-ecclesiastic actors, such as: René Descartes's decision (1633) to abort the publication of his own cosmological treatise *The World;* Gottfried Leibniz's indefatigable efforts (1679-1704) to convince the Church to withdraw its condemnation of Copernicanism and Galileo; the Tuscan government's reburial (1737) of Galileo's body in a sumptuous mausoleum in the church of Santa Croce in Florence (see Figure 4); Napoleon's seizure (1810-1814) of the Vatican file of the Galilean trial proceedings and his plan to publish its contents; the publication of those proceedings by lay scholars in France, Italy, and Germany (1867-1878); and the attempts in the middle of the twentieth century by various secular-minded and left-leaning intellectuals (e.g., Bertolt Brecht, Arthur Koestler, and Paul Feyerabend) to blame Galileo for such things as the abuses of the industrial revolution, the social

Fig. 4 Galileo's Tomb, at the Church of Santa Croce, in Florence
(From: https://upload.wikimedia.org/wikipedia/commons/3/3a/Galileo%27s_Tomb%2C_Santa_Croce.JPG)

irresponsibility of scientists, the atomic bomb, and the rift between the two cultures.

Science vs. religion?

One of the most important issues of the Galileo affair is the question of what we can learn concerning the relationship between science and religion.[13] The most common view is that the affair epitomizes the conflict between science and religion. Here, it is important to stress that this view has been advanced not only by relatively injudicious writers who have recently been widely discredited (e.g., John William Draper and Andrew Dickson White), but also by such cultural icons as Albert Einstein, Bertrand Russell, and Karl Popper. At the opposite extreme, there is the revisionist thesis that the affair really proves the *harmony* between science and religion. This harmonious interpretation does not merely deny the traditional thesis, but reverses it. Its most significant advocate is Pope John Paul II, for whom this was the key point he wanted to make in his rehabilitation of Galileo in 1979-1992.
In contrast to both the conflict and harmony theses, I claim that the trial did have both conflictual and harmonious aspects when viewed in terms of science and religion; however, these are elements of its surface structure, and its most profound deep-structure lies rather in the clash between cultural conservation and innovation. My argument is the following.

First, as already mentioned, the 1633 Inquisition sentence condemned Galileo for two beliefs: that the earth moves and that Scripture is not a scientific authority. The second issue involved a disagreement between those who (like Galileo) held and those who (like the inquisitors) denied that it is proper to defend the truth of a physical theory contrary to Scripture. It follows that there is an irreducible conflictual element in Galileo's trial, between those who believed and those who denied that there is a conflict between Scripture and science. The irony of the situation is that it was the victim who held the more fundamentally correct view. However, insofar as that Galilean non-conflictual view is the more nearly correct one, the content of that view suggests an important harmonious element in the affair.

Furthermore, both conflict and harmony exist at the level of the surface structure of the situation. If we move to a deeper cultural aspect, then we must point out that Galileo was not the only one who held there was no conflict, and that many of those who agreed with him were themselves churchmen. That is, in Galileo's time, there was a division within Catholicism between those who did and those who did not accept the scientific authority of Scripture. A similar split existed in scientific circles. A further division existed in both domains with regard to the other main issue of Galileo's trial—the proposition of the earth's motion. Thus, rather than having an ecclesiastic monolith on one side clashing with a scientific monolith on the other, the real conflict was between two attitudes criss-crossing both.

The most fruitful way of conceiving the two factions is to describe them as conservatives or traditionalists on one side and progressives or innovators on the other. The real conflict was between these two groups and attitudes. In this sense, Galileo's trial illustrates the clash between cultural conservation and innovation and is an episode where the conservatives happened to win. This conflict is one that operates in such other domains of human society as politics, art, economy, and technology. It cannot be eliminated without stopping social development; it is a moving force of human history.

Right for the wrong reasons, or model of rationality?

Another extremely important issue involves the question of what can be learned from Galileo regarding scientific methodology, and more generally regarding rationality and critical thinking.[14] One way of addressing this question is the following.

One initial response by critics of Galileo and pro-clerical apologists was to hope or try to show that he had been scientifically wrong, with regard to the earth's motion or the science of motion in general. However, slowly and gradually, the history of science established incontrovertibly that Galileo had been right on this issue. For example, in 1687, Newton completed the Copernican Revolution when he published his *Mathematical Principles of Natural Philosophy.*

The Newtonian system of celestial mechanics has several important geokinetic consequences. But the Newtonian proofs were still relatively indirect, and so the search for more direct evidence continued. In 1729, James Bradley in England discovered the aberration of starlight, providing direct observational evidence that the earth has translational motion. In 1789-1792, Giambattista Guglielmini in Italy was the first to directly confirm terrestrial rotation by means of experiments detecting an eastward deviation of falling bodies; his work was soon confirmed and refined further by other experimenters and theoreticians. In 1838, Friedrich Bessel in Germany observed the annual parallax of the fixed stars, which provides direct proof that the earth revolves annually in a closed orbit. In 1851, Léon Foucault in France invented the pendulum that bears his name and provided a spectacular demonstration of the earth's rotation.

However, long before Foucault, as it was becoming clearer that Galileo had been right in holding that the earth moves, another genre of anti-Galilean criticism or clerical apologia had been emerging. He started being charged with believing what turned out to be true for the wrong reasons, on the basis of flawed arguments, or with the support of inadequate evidence.

This type of criticism raises a crucial and valid point. That is, there is more to being right than that one's beliefs happen to be true, i.e., correspond to reality. It is also important that one's own motivating reasons and supporting arguments be right. In other words, one's reasoning is at least as important as the substantive content of one's beliefs.

However, most such anti-Galilean charges are misapplied and can be refuted. Galileo's reasoning can be successfully defended; indeed, it can be shown to be a model of rationality and critical thinking. I would argue as follows.

The Copernican Revolution required much more than Copernicus's original argument. Firstly, the geokinetic hypothesis had be supported not only with new theoretical arguments, but also with new observational evidence. Galileo's telescopic discoveries provided such novel evidence.

Secondly, the earth's motion had to be not only constructively supported with new arguments and evidence, but also critically defended from a host of powerful old and new objections. Galileo answered the observational astronomical objections by showing that the empirical consequences implied by Copernicanism were visible with the telescope, although still invisible with the naked eye. He answered the mechanical objections by articulating a new physics centered on the principles of conservation and composition of motion. And he answered the scriptural objections by arguing that Scripture is not a scientific authority, and so scriptural passages should not be used to invalidate astronomical claims that are proved or provable.

Thirdly, the defense of the geokinetic hypothesis required not only the destructive refutation of those objections, but also the appreciative understanding of their strength. Galileo was keen on this, and so in his writings we find the anti-Copernican arguments stated more clearly and incisively than in the works of Aristotelians advocating the geostatic system. Finally, Galileo also realized that his case in favor of Copernicanism was not absolutely conclusive or decisive because, for example, his telescope failed to reveal an annual parallax of the fixed stars.

In short, Galileo's reasoning exhibits several features that may be highlighted as follows. He combined intellectual theorizing with sensory observation, which is the essence of experimentation, as distinct from passive observation. He accepted the views supported by the best arguments, and was aware that it is a long and complex story to evaluate the strength of arguments; that is, he engaged in critical reasoning, not mere reasoning. He knew and understood the arguments against his own views, which is a feature we may call open-mindedness. And he was willing and able to appreciate the arguments against his own views, even when he was trying to refute them; and this may be labeled fair-mindedness.

Notes

1. Albert Einstein, *Ideas and Opinions,* trans. Sonja Bargmann (New York: Crown, 1954), 271; Stephen W. Hawking, *A Brief History of Time* (New York: Bantam Books, 1988), 179.
2. Arthur Koestler, "The Greatest Scandal in Christendom," *Observer* (2 February 1964), 21, 29; cf. Koestler, *The Sleepwalkers: A History of Man's Changing Vision of the Universe* (New York: Macmillan, 1959).
3. For Galileo's life in general, see John L. Heilbron, *Galileo* (Oxford: Oxford University Press, 2010); and Stillman Drake, *Galileo at Work: His Scientific Biography* (Chicago: University of Chicago Press, 1978).
4. For details, documentation, and references on the account sketched in this section, see Maurice A. Finocchiaro, *Defending Copernicus and Galileo: Critical Reasoning in the Two Affairs* (Dordrecht: Springer, 2010), 1-64.
5. For details, documentation, and references on the account sketched in this section, see Finocchiaro, *Defending Copernicus and Galileo*, 51-134.
6. In Galileo Galilei, *The Essential Galileo,* trans. and ed. Maurice A. Finocchiaro (Indianapolis: Hackett Publishing Company, 2008), 45-84.
7. Galileo Galilei and Christoph Scheiner, *On Sunspots*, trans. and ed. Eileen Reeves and Albert Van Helden (Chicago: University of Chicago Press, 2010); Galilei, *Essential Galileo*, 97-102.
8. For details, documentation, and references on the account sketched in this section, see Maurice A. Finocchiaro, trans. and ed., *The Galileo Affair: A Documentary History* (Berkeley: University of California Press, 1989), 47-153; and Finocchiaro, trans. and ed., *The Trial of Galileo: Essential Documents* (Indianapolis: Hackett Publishing Company, 2014), 43-105.
9. See Galileo Galilei, *Dialogue Concerning the Two Chief World Systems—Ptolemaic and Copernican*, second edn, trans. and ed. Stillman Drake (Berkeley: University of California Press, 1967); Galilei, *Galileo on the World Systems an Abridged Translation and Guide*, trans. and ed. Maurice A. Finocchiaro (Berkeley: University of California

Press, 1997); Galilei, *Essential Galileo*, 190-271. Cf. Maurice A. Finocchiaro, *Galileo and the Art of Reasoning: Rhetorical Foundations of Logic and Scientific Method* (Dordrecht: Reidel, 1980); Finocchiaro, *The Routledge Guidebook to Galileo's Dialogue* (London: Routledge, 2013).

10. For details, documentation, and references on the account sketched in this section, see Finocchiaro, trans. and ed., *The Galileo Affair,* 214-96; and Finocchiaro, trans. and ed., *The Trial of Galileo*, 114-39.
11. Galileo Galilei, *Two New Sciences*, trans. and ed. Stillman Drake (Madison: University of Wisconsin Press, 1974); and Galilei, *Essential Galileo*, 295-367.
12. For details, documentation, and references on the account sketched in this section, see Maurice A. Finocchiaro, *Retrying Galileo, 1633-1992* (Berkeley: University of California Press, 2005).
13. For details, documentation, and references on this, see Finocchiaro, *Defending Copernicus and Galileo*, 291-314; Finocchiaro, "The Copernican Revolution and the Galileo Affair," in *The Blackwell Companion to Science and Christianity*, ed. J.B. Stump and Alan G. Pudgett (Malden, MA: Wiley-Blackwell, 2012), 14-25; Finocchiaro, *Routledge Guidebook to Galileo's Dialogue,* 311-14; and Finocchiaro, "The Galileo Affair," in '*The Idea That Wouldn't Die*'*—The Warfare between Science and Religion: Historical and Sociological Perspectives,* ed. Ron Binzley and Ron Numbers (Baltimore: Johns Hopkins University Press, forthcoming).
14. For details, documentation, and references on this, see Finocchiaro, *Galileo and the Art of Reasoning, 145-79*, 343-412; Finocchiaro, *Defending Copernicus and Galileo,* 121-34, 229-50, 277-90; Finocchiaro, "A Galilean Approach to the Galileo Affair, 1609-2009," *Science and Education* 20 (2011): 51-66; and Finocchiaro, *Routledge Guidebook to Galileo's Dialogue*, 241-80, 314-27.