

# ASPECTS OF THE CONTROVERSY ABOUT GALILEO'S TRIAL (FROM DESCARTES TO JOHN PAUL II)

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## 1 Galileo's Trial: Historical Aftermath and Reflective Commentary

In 1633 the Inquisition condemned Galileo as a heretic and banned his *Dialogue on the Two Chief World Systems*. His alleged heresy was twofold, namely to believe that the earth revolves around the sun and that the Bible is not a scientific authority. The condemnation was the outcome of a trial occasioned by the book's publication in 1632 and the climax of a dispute started in 1613, when he had criticized the biblical objection to Copernicanism in a letter to Benedetto Castelli. The controversy involved at least two issues, as one may glean from the just-mentioned heresies stated in the Inquisition Sentence [Favaro 1890-1909, vol. 19, p. 405]. One was the cosmological issue of the behavior of the terrestrial globe in physical reality; the other was the methodological (but also theological) question of the relationship between science and the Bible.

While the 1633 condemnation ended the original controversy, it ignited a new one which continues to our own time. The subsequent controversy is embodied in two distinct but interrelated clusters of source materials, which I call the *historical aftermath* and the *reflective commentary*.

The *historical aftermath* of the original episode consists of other events directly stemming from it and often involving the Church. The most immediate development following the 1633 condemnation was the reaction of Catholic thinkers, who were forced to adjust their thinking, behavior, or rhetoric to the new reality created by Galileo's condemnation; Descartes' feeling of devastation combined with a creative re-orientation of his natu-

ral philosophy is only the most famous and spectacular case of such an adjustment.<sup>1</sup> The latest episode in this aftermath occurred in the period 1979-1992, with a series of speeches and actions by Pope John Paul II [1979; 1992] which many [for example, Sharratt 1994] interpreted as a “rehabilitation” of Galileo; but the pope was also engaged in a bold attempt to reverse the traditional interpretation (that the affair illustrates the conflict between science and religion) by claiming that the original episode really shows the *harmony* between them.

The *reflective commentary* about the original episode consists of all kinds of interpretations, evaluations, and pronouncements that have been advanced in the past 350 years. For example, John Milton was perhaps the first to stress the issue of free speech when in the *Areopagitica* he recalled his meeting with Galileo in Florence thus: “there it was that I found the famous Galileo, grown old a prisoner to the Inquisition, for thinking in astronomy otherwise than the Franciscan and Dominican licensers thought” [Milton 1644, p. 35]. And in 1953, Albert Einstein, writing the Foreword to an English translation of the book which occasioned the trial, stressed the theme of enlightened rationality versus ignorant dogma: “a man is here revealed who possesses the passionate will, the intelligence, and the courage to stand up as the representative of rational thinking against the host of those who, relying on the ignorance of the people and the indolence of teachers in priest’s and scholar’s garb, maintain and defend their position of authority” [Einstein 1953, p. vii].

Although the literature on the affair is enormous, neither the historical aftermath nor the reflective commentary has ever been studied systematically. This is not meant to deny that almost all books on the original episode contain some account of the aftermath or of alternative interpretations; indeed, some of these accounts are very good and are guiding to some extent my own inquiry.<sup>2</sup> Nor do I mean to deny that there are excellent studies of particular episodes of the subsequent controversy; on the contrary, I am utilizing and building on them.<sup>3</sup> However, the full story of the aftermath has never been told, and the rich variety of reflections have never been collected or catalogued, let alone critically examined. My current project is to research and write such a critical history of the Galileo affair from 1633 to 1992.

<sup>1</sup> See Gaukroger [1995] and Descartes’ letters to Mersenne; for a more general and nuanced account, see Heilbron [1999].

<sup>2</sup> See, for example, Brandmüller [1992], Fantoli [1996], Feldhay [1995, pp. 13-25], and Langford [1966].

<sup>3</sup> See Baldini [2000], Beretta [1999], Borgato [1996], Brandmüller and Greipl [1992], Favaro [1891a; 1891b; 1891c], Galluzzi [1993; 1998], Gebler [1879, pp. 330-40], Hall [1980], Lerner [1998], Maffei [1975; 1987], Monchamp [1892; 1893], Motta [1997], Pagano [1984, pp. 10-26], Pepe [1996a; 1996b], Segre [1989; 1997; 1998], Simoncelli [1992], Tabarroni [1983], and Wallace [1996, pp. 392-96].

## 2 Toward a Critical History of the Galileo Affair (1633-1992)

One aspect of this investigation is that it represents a distinctive approach to the critical interpretation of the original episode. That is, if besides collecting and interpreting the reflective accounts, we evaluate them from the viewpoint of their supporting documentation and logical coherence, then such critical examination will enable us to formulate a critical interpretation of the original episode which avoids their weaknesses and incorporates their strengths. However, it is not part of the present study to explicitly articulate a critical interpretation of the original affair (1613-1633), although I would want to do that later in another project; from that viewpoint, the present study would be an excellent preparation. The focus now is the subsequent controversy (1633-1992), whose fascination rivals that of the original one; from the viewpoint of the present study, the critical understanding of the original episode is only a salient by-product.

A major issue to be addressed is the question of the relationship between science and religion. This ought to come as no surprise given that the 1633 trial of Galileo is the classic illustration of this problem. However, I give my own twist to this traditional approach.

Because the affair involved a clash between one of the founders of modern science and one of the world's great religions, it has traditionally been seen as an example of warfare between science and religion.<sup>4</sup> This interpretation is initially plausible, but I am not sure it is ultimately correct. For the documents show that many churchmen were on Galileo's side and many scientists were critical of him. Thus, it seems that there was a split within both science and religion, and the real conflict was between a conservative and a progressive attitude. At any rate, the dialectic between conservation and innovation would seem to be a key issue to explore.

However, although the dialectic of conservation and innovation emerges as a major issue to be explored, the interaction between science and religion does not evaporate, for at least two reasons. First, the interaction between science and religion remains an important element at the surface of the original episode; for even if this surface interaction can be understood in terms of the dialectic of conservation and innovation underlying it at a deeper level, the surface interaction is not thereby denied; in short, I would be explaining it, not explaining it away. More importantly, the science versus religion question is even more crucial for the subsequent controversy; for whatever may have been the deeper truth about the original episode, in the subsequent three and one half centuries that episode came to be discussed primarily from the point of view of the science-religion question and became a universal symbol of that problem. Since the focus of this project is the subsequent controversy, the exploration of the

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<sup>4</sup> See, for example, Comte [1835], Draper [1875], Popper [1956], and White [1896, vol. 1, pp. 130-52].

relationship between science and religion will be essential. Thus, the projected study may be said to promise to provide a critical history of the science-religion controversy in modern Western culture, as seen from a very particular angle, the angle of the Galileo affair, the perspective of the controversy about his 1633 trial.

This project will also address the issue of the nature of cultural myths and their interaction with documented facts. This issue emerges in many ways, one of which is the following. There is in the Vatican Secret Archives a collection of documents containing the original Inquisition files about the trial. These documents have now been in print for more than a century; but they were essentially unknown until the beginning of the 19th century and essentially unavailable until their publication in the latter part of the century. This means that for about two centuries after the trial, only a few facts about it were public knowledge, but the details were unknown; thus, views about the original episode were often exercises of the imagination elicited by tidbits of facts but fueled primarily by the mental state of the writer, social conditions, and political circumstances. On the other hand, even after the publication of the Inquisition proceedings, some myths persisted and new ones were created. This occurs not only among the uneducated popular masses but also among the intellectual elites; for example, the above mentioned quotation from Einstein indicates that he shared the myth of Galileo as the heroic defender of reason against dogma (although Einstein deserves the credit of being aware that he is espousing a myth).

To summarize this aspect of my project, I can say that I have formulated four main working hypotheses which I plan to test in the course of my inquiry: (1) that the science versus religion issue is more important for the subsequent than for the original controversy; (2) that this issue is a surface feature of the whole affair, and as such it is not the most fundamental issue, but neither can it be explained away; (3) that the clash between conservation and innovation is a key and deeper feature of the original episode; and (4) that underlying the subsequent controversy, a key and deeper feature is the phenomenon of the power and ubiquity of cultural myths (among the elites as well as the masses) and their interaction with facts (as established by scholarly documentation and research).

Next, there is the historiographical or meta-historical potential of the source material. In fact, the literature on Galileo's trial has few, if any, rivals in regard to its bulk, variety, and ramifications. The only comparable cases are episodes such as the trial of Socrates, the Copernican Revolution, and the French Revolution. And compared to the case of Socrates, the Galileo case has the advantage that better documentation is available; and compared to the cases of these revolutions, it has the advantage of greater specificity. Now, these other cases have sometimes been studied from the viewpoint of what we can learn from the relevant literature about the nature and improvement of the art of historical inquiry. The same cannot be said for the Galileo affair, although there do exist some relevant discussions. Thus,

I believe it is time to systematically explore the literature on the affair from this point of view.

Finally, my approach involves the principled and judicious avoidance of one-sidedness, and so the project would do justice to both sides (Galileo and the Church); of course, few would question that this is a worthy goal, but it is easier said than done. My approach also uses both historical and philosophical techniques: that is, empirical research to gather some of the data (namely, texts containing the reflective commentary); textual analysis to understand the intellectual content of such comments; historical interpretation to situate them contextually; historiographical reflection to classify them and derive useful lessons for the art of historical inquiry; and philosophical criticism to evaluate their evidentiary accuracy and logical coherence and derive useful lessons about general issues.

### 3 Strands and Substrands

So far I have been sketching the project I am working on. The project is ongoing, and I am far from the end. So, I am in no position to advance definite conclusions or give the full details of the story. What I want to do instead is to add some details and refinements to the sketch presented so far.

At a very general level one can distinguish, as I have, two aspects in the story of the controversy about Galileo's trial, namely the historical aftermath and the reflective commentary. One refinement is to say that the historical aftermath should be conceived as having four parts: first, actions by the Church aimed to repeal the censures against the Copernican doctrine and books; second, Church actions aimed to "rehabilitate" Galileo or apologize for his persecution; third, intellectual developments pertaining to the trial's key issue of demonstrating the reality of the earth's motion; and fourth, intellectual developments pertaining to the trial's key issue of clarifying the non-scientific authority of the Bible. It also appears that the reflective commentary should be subdivided into at least three parts: first, serious, more or less scholarly accounts of the documents, facts, or issues of the trial; second, brief or impressionistic, but revealing and significant, accounts by many classic authors (Descartes, Milton, Pascal, Arnauld, Leibniz, D'Alembert, Voltaire, Comte, John Henry Newman, Bertrand Russell, Bertold Brecht, etc.); and third, other comments, often not individually significant but only collectively so, found in general histories of science, astronomy, philosophy, literature, and the Church, in dictionaries and encyclopedias, in explicitly fictional writings, and in popular media.

We thus have the two major strands of the historical aftermath and the reflective commentary, and they subdivide into the seven substrands just introduced. You may have noticed that the last substrand of the reflective commentary is really a miscellaneous group that may require further refi-

nement; but there is no space here to discuss any further the reflective commentary, let alone to further refine the miscellaneous literature. Instead, I want to focus on the aftermath.

I have just sketched that it has four main substrands. It will now be useful to group these four substrands into two pairs, which I call the ecclesiastic aftermath and the intellectual aftermath. I will begin with the ecclesiastic aftermath.

The two main substrands of the ecclesiastic historical aftermath correspond, in a sense, to the two main phases of the original episode. These were the earlier proceedings of 1615-1616 resulting in the Decree of the Congregation of the Index against Copernican books, and the later proceedings of 1632-1633 consisting of Galileo's being put on trial by the Congregation of the Holy Office and resulting in his condemnation through a formal sentence and abjuration. Of course, these two aspects of the story are related, but it is useful at the moment to stress their differences. One involves the censoring of books and ideas, the other the condemnation of a person. The Church departments are different. Moreover, and more importantly, whereas the Church's so-called "rehabilitation" of Galileo has not come about and remains a controversial matter, its retraction of the anti-Copernican censorship was completed in the last century. To be sure, this retraction was a slow, gradual, and itself painful process, and so it may be useful to highlight that history.

#### 4 Ecclesiastic Aftermath: Book Censorship

In 1616, at the conclusion of the first phase of the Galileo affair, the Decree of the Index prohibited three books and prescribed a general prohibition. The three books were Copernicus' *Revolutionibus*, Paolo Foscarini's *Letter on the Pythagorean Opinion*, and Diego de Zuniga's *Commentary on Job*. Moreover, the decree explicitly prohibited "all books that teach the same doctrine". In 1619, in a curious turn of events, the Index banned Kepler's *Epitome of Copernican Astronomy* [cf. Bucciattini 1995]. In 1633, the sentence against Galileo included the banning of his *Dialogue*, and so the book was included in a formal decree of the Index the following year. The net effect of these prohibitions was that for the next two centuries, in regard to the motion of the earth, Catholics were allowed only to engage in a so-called "hypothetical" discussion.

The gradual unbanning of these books may be sketched as follows [cf. Mayaud 1997]. In 1620 the Index issued the corrections to Copernicus's book promised in 1616. With the stipulated passages deleted and others appropriately changed, the book could be read. In 1744, Galileo's *Dialogue* was republished for the first time with the Church's approval, as the fourth and last volume of his collected works; in the volume the text of the *Dialo-*

*gue* had to be preceded by the Inquisition's sentence and Galileo's abjuration of 1633 and by a supposedly neutralizing introduction.<sup>5</sup> In 1757, upon request from Pope Benedict XIV, the Congregation of the Index dropped from the forthcoming edition of the *Index* the prohibition of "all books teaching the earth's motion and the sun's immobility", and so the new edition of the *Index* the following year no longer listed as an entry this general prohibition; but it continued to include the five previously prohibited books by Copernicus, Foscarini, Zúñiga, Kepler, and Galileo. In 1820, the Inquisition gave the imprimatur to an astronomy textbook by a professor at the University of Rome named Giuseppe Settele that presented the earth's motion as a fact, thus overruling the objection of the chief censor in Rome, the master of the sacred palace. In 1822, the Inquisition decided that in the future this official must not refuse the imprimatur to publications teaching the earth's motion in accordance with modern astronomy; but a decision about removing from the Index the five particular Copernican books was postponed. In 1833, while deliberating on a new proposed edition of the Index, Pope Gregory XVI decided that it would omit the five books, but that this omission would be accomplished without explicit comment; thus, the 1835 edition of the Index for the first time omitted from the list Copernicus's *Revolutionibus*, Galileo's *Dialogue* and the other three books. This was the final and complete retraction of the censorship begun in 1616. Here, the only thing I would want to add to this strand of the story is just a few footnotes about the abolition of the Index itself. In 1912, Pope Benedict XV abolished the Congregation of the Index as a separate department of the Church and made book censorship one of the tasks of the Congregation of the Holy Office (namely the Inquisition). In 1966, the very institution of a list of prohibited books was abolished when the supreme Congregation for the Doctrine of the Faith (the new name of the Inquisition) decreed that the book censorship now under its jurisdiction no longer has the force of ecclesiastical law, but only the status of moral advice. So much for the first substrand of the ecclesiastic aftermath.

## 5 Ecclesiastic Aftermath: The Person Galileo

In regard to the condemnation of Galileo-the person, the history of its ecclesiastic aftermath is more elusive, complex, and controversial. The climax, though not the conclusion, of this strand of the story is an episode that has unfolded during our own lifetime, having begun in 1979 and having had a formal conclusion in 1992. This is what some [e.g., Sharratt 1994] have

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<sup>5</sup> I say "supposedly" because that introduction argues that the world view contained in the Bible is different from the Ptolemaic system, as well as from the Copernican one; see Calmet [1744] and cf. Mayaud [1997].

called the rehabilitation of Galileo by pope John Paul II, while others [Beltrán 1998] have described it as an attempted Galileo-based self-rehabilitation by the Church, and still others [Benítez 1999] as a new myth about Galileo.<sup>6</sup> I shall call it simply the pope's alleged rehabilitation of Galileo, and summarize it as follows. It began very promisingly in 1979 at the Einstein centennial speech to the Pontifical Academy of Sciences and in 1980 with the announcement of the creation of the Vatican Commission on Galileo; but the end result was very disappointing because the process was formally concluded in 1992 at a meeting of the Pontifical Academy when the pope made a speech accepting a report by cardinal Paul Poupard, and that report [Poupard 1992] is little more than a disguised reaffirmation of the Church's traditional apologetic line.

Another important recent episode is still unfolding and is more or less contemporaneous with John Paul's alleged rehabilitation, but it pertains to a development that goes back more than half a century.<sup>7</sup> In 1941, to mark the 300th anniversary of Galileo's death, which would come in 1942, the Pontifical Academy of Sciences commissioned mons. Pio Paschini to write a book on Galileo's life and work and their historical background and significance. Paschini completed his book manuscript in 1944 and submitted it for approval. During the following year, various ecclesiastic authorities (the Pontifical Academy of Sciences, the Vatican Astronomical Observatory, and the Holy Office) judged Paschini's manuscript to be unsuitable for publication, on the grounds that it was too favorable to Galileo and too critical of the Jesuits and of the Church. After various initial appeals, Paschini abandoned hope of having his work published, and he remained silent about it for the rest of his life. He died in 1962, and then his legal heir undertook an effort to have the manuscript published. At this time the Church thought it was a good idea to publish the book, partly to celebrate the 400th anniversary of Galileo's birth in 1964, and partly to have an intellectual foundation for some of the deliberations at the Second Vatican Council; in fact, in some of the published documents of that Council, there are footnote references to Paschini's book.

Now in 1979-1980, at about the same time that the Pope was starting his alleged rehabilitation, the original manuscript of Paschini's book began to be examined by various scholars, and to be compared to the published book. They have discovered that the published version contains so many and such significant emendations that it must be regarded as an adulteration of the original. In fact, in 1964 when the Church re-examined the publication of Paschini's book, the Pontifical Academy of Sciences charged Jesuit father Lamalle with reviewing and revising the manuscript. Thus the published book is a Jesuit version of Paschini's manuscript. An interesting

<sup>6</sup> See also Segre [1997] and Finocchiaro [1999].

<sup>7</sup> For more details, see *Atti del Convegno* [1979], Blackwell [1998, 361-66], Fantoli [1996, 503-5, 523-28], and Simoncelli [1992].

irony of this story is that Paschini's published book is also the one most frequently referred to in pope John Paul's various speeches and essays, and it is intriguing that in the period 1979-1992 two developments were occurring simultaneously: the alleged rehabilitation of Galileo and the second phase of the Paschini episode. Here the uncharitable interpretation would be to say that in three and one-half centuries the Galileo affair has undergone a metamorphosis from censoring science books to censoring history-of-science books.

The history of this strand of the subsequent Galileo affair is by no means limited to recent events. In fact this aspect of the story began immediately after his death, when questions were raised about whether a convicted heretic like him has the legal right to have his will executed and to be buried on consecrated ground. These issues were decided in his favor, but not the question whether it was proper to build an honorific mausoleum for him in the church of Santa Croce in Florence. This was initially vetoed by the Church in 1642, but it was brought about a century later in 1737, since which time his body has been buried in such a mausoleum across from Michaelangelo's tomb [cf. Galluzzi 1993; 1998].

I believe this strand of the story would have to include the story of the publication of the special Vatican file containing the manuscripts of the original trial documents.<sup>8</sup> As late as 1780, Giovanni Targioni Tozzetti, a history-of-science pioneer, who was the first to publish many important documents of 17th century Italian science, reported with disappointment having been told that there were no documents pertaining to Galileo's trial in the Archives of the Holy Office. This was indeed true, for the trial documents were not kept in the relatively obvious place where Tozzetti inquired (namely the Inquisition Archives), but rather in the Vatican Secret Archives, befitting their special status and significance. This was discovered in 1810 when, by order of Napoleon, the file was taken to Paris, as part of the emperor's decision to transfer there all archives of the Vatican, the Inquisition, and other Church congregations in Rome; for the next seven years the Church tried unsuccessfully to retrieve the file; in 1817 she gave up, having concluded that it had been lost or destroyed; but it finally re-surfaced in Vienna in 1843 and was promptly delivered back to Rome. This kind of attention received by the file soon led to its publication. Partial editions were first printed by Epinois [1867], and then the complete dossier was published by Berti [1876; 1878], by Gebler [1877], and by Epinois [1877]. These Vatican documents and many others were then included in the National Edition of Galileo's collected works published in 1890-1909; as a result the discussion of the affair moved to a relatively higher plane.

<sup>8</sup> For more details, see Barbier [1811; 1812; 1814a; 1814b], Delambre [1821, vol. 1, pp. xix-xxxii], Favaro [1887a; 1887b; 1887c], Gebler [1879, pp. 319-29], Marini [1850, pp. 143-53], Mercati [1926-1927], and Pagano [1984, pp. 10-26].

## 6 Intellectual Aftermath: The Earth's Motion

This will have to suffice here and now for the second substrand of the ecclesiastic aftermath. Moving on to the intellectual aftermath, I have already mentioned that it also has two substrands, consisting of intellectual developments pertaining to the trial's two key issues of demonstrating the reality of the earth's motion and clarifying the non-scientific authority of the Bible.

The key scientific claim that led to Galileo's trial and for which he was condemned was the proposition that the earth moves with daily axial rotation and annual heliocentric revolution. The condemnation thus ignited a scientific controversy which of course had existed since Copernicus's *Revolutionibus* in 1543, but which now took a more intense and more definite form –more definite because it now focused on whether the earth moves and whether this motion can be proved or disproved experimentally by either terrestrial or astronomical evidence, and more intense because scores of books were published, new experiments devised and performed, new arguments invented, and old arguments re-hashed.

For example, in 1651 Jesuit Giovanni Battista Riccioli claimed that the Inquisition had been right and wise in condemning Galileo. Riccioli argued that this was so chiefly because neither the Ptolemaic nor the Copernican, but rather the Tychonic, system was the correct one, and so Galileo was scientifically wrong in holding that the earth moves. And the Jesuit made a comprehensive examination of all the arguments to support his scientific choice. He even invented a new geostatic argument based on Galilean ideas, a Galilean argument against Galileo, so to speak. Riccioli accepted the law of acceleration of falling bodies, and he also took at face value the passage on semicircular fall in the *Dialogue*, where Galileo says that on a rotating earth a body falling freely from the top of a tower would follow a circular path in absolute space defined by the semicircle whose diameter is the line from the earth's center to the point of release. Riccioli's reasoning was that the earth cannot rotate because if it did, a body falling freely from the top of a tower would in reality be following the Galilean semicircular trajectory, and motion along this trajectory is uniform (as measured from center of the semicircle); but observation reveals that the motion of falling bodies is accelerated. In 1665, this argument engendered a subcontroversy that involved Alfonso Borelli and a mathematics professor at Padua named Stefano degli Angeli; before subsiding four years later, this dispute had spawned at least eight books.<sup>9</sup>

Riccioli is only one of the most significant examples of this strand of the story in the period between the trial in 1633 and Newton's *Principia* in 1687, significant because Riccioli's *Almagestum Novum* is a monumental

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<sup>9</sup> See Angeli [1667; 1668a; 1668b; 1669], Borelli [1668], Riccioli [1668; 1669], Zerilli [1668]; for more details see Galluzzi [1977] and Koyré [1955].

work impressive for its erudition and its high mathematical and scientific competence in selected areas. During this period much heat and some light was added to the controversy on the earth's motion in books by such authors as Descartes, Mersenne, Pierre Gassendi, Libert Froidmont, Jean Baptiste Morin, Gilles de Roberval, Ismaël Boulliau, Jacques Grandamy, John Wilkins, Alexander Ross, Scipione Chiaramonti, Giovanni Barenghi, Giorgio Polacco, Christopher Scheiner, Iohannes Herbinus, and a certain Mademoiselle Dumée.<sup>10</sup>

The controversy did not die out with Newton's *Principia* for the following reason. In my view this work did soon settle the issue by providing a demonstration of the earth's motion that convinced all competent thinkers. But the Newtonian proof was an indirect one. The search for direct evidence of the earth's motion continued. I would thus include in this strand of the story the discovery of aberration of starlight by James Bradley in 1729, the discovery of stellar parallax by Friedrich Bessel in 1838, and the invention of Foucault's pendulum in 1851.

One of the most interesting episodes in this strand is the attempt to detect and measure whether falling bodies undergo an eastward deflection from the vertical. Recall that one of the Aristotelian objections to terrestrial rotation was that if the earth were rotating, bodies in free fall would be left behind and thus would land westward from the point of release; and since observation reveals that bodies fall vertically, it follows that the earth does not rotate. In the *Dialogue* Galileo answered this objection by arguing that if the earth were rotating, the horizontal motion which a body would have before being released would be conserved, and it would combine with the downward motion during the fall to bring the body exactly under the point of release without deviation, so that we would observe the same thing as we would on a motionless earth. This reply is correct as a first approximation, but Galileo himself gives various hints elsewhere in the book to the effect that on a rotating earth falling bodies would advance forward horizontally as they fall, thus being deflected eastward; the basic reason for this is that on a rotating earth a body at the top of a tower is moving horizontally with a faster linear speed than the base of the tower, due to the fact that the geocentric circumference at the top of the tower is longer than that at the base by an amount which is a function of the height of the tower. Following up on such hints, in 1789-1792 an Italian priest and mathematician named Giambattista Guglielmini [1789; 1792; 1994] computed the amount of such an eastward deviation, devised some experiments to detect it, and confirmed the predictions. The predicted deviation is of course very small; for a height of about 160 feet used by Guglielmini, the deviation was calcula-

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<sup>10</sup> I have been unable to find out anything about this Mademoiselle Dumée than the one sentence in Montucla's *Histoire des Mathématiques* [1799-1802, vol. 2, p. 300] to the effect that in 1680 she published a book defending the earth's motion entitled *Entretiens sur le Système de Copernic*.

ted to be about  $2/3$  of an inch. Thus all kinds of precautions had to be taken and devised, involving such things as the mechanism of release; stopping microscopic pendular vibrations before release; minimizing disturbances from outdoor traffic, winds, and temperature; averaging out the spread of deflections from one trial to another; etc.

In 1804 the eastward deviation was also confirmed in Germany by Johann Benzenberg [1804; 1845; cf. Borgato 1996]. In the meantime, more sophisticated and precise calculations had been worked out by Laplace and Gauss, working independently of each other and using different methods and principles; they predicted an eastward deviation with a value about  $2/3$  that calculated by Guglielmini [cf. Bertoloni Meli 1992]. As late as the first decade of the twentieth century the phenomenon continued to attract some attention, and physicist E. H. Hall [1903; 1904; 1910; cf. Borgato 1996] gave an updated sophisticated experimental confirmation of the predicted eastward deviation.

Of course, by now we are relatively far removed from the Galileo affair or even the motion of the earth, for the challenge in these latter experiments is not to prove or confirm something which is unquestioned, but rather to measure with a very high level of precision; there are even mathematical challenges, insofar as physicists now try to take into account such things as the fact that the earth's surface is not perfectly spherical, air resistance, air turbulence caused by the falling motion, the nonhomogeneous density of the balls being dropped, and even the effect of lunar gravitational attraction. On the other hand, to bring us back to the Galileo affair, it is intriguing to note that when Guglielmini first conceived his experiments, he happened to be in Rome, attached to the entourage of a powerful cardinal, and his idea was to exploit the greatest height of fall available at the time, which happened to be the dome of St. Peter's church. Thus, initially he dreamed of providing an experimental proof that Galileo was right by dropping balls from the dome's ceiling in that same church which had been the physical focus of his troubles.

## 7 Intellectual Aftermath: The Nonscientific Authority of the Bible

Once again, this is more than enough by way of illustration of the third aspect of the story I am investigating, that is, the first substrand of the intellectual aftermath. I now come to the aftermath of the other key intellectual issue of Galileo's trial, namely whether the Bible is a scientific authority. I regard this question to be primarily a methodological or epistemological one, rather than a scientific one like the earth's motion, or a purely theological question.

To this strand of the story belongs the fact, often mentioned by various writers, that eventually the Church ended up agreeing with Galileo, not

only regarding the earth's motion, but also about the principle that the Bible is an authority only on questions of faith and morals, and not in scientific investigation. The evidence usually mentioned here is Pope Leo XIII's encyclical letter *Providentissimus Deus* of 1893. Pope John Paul II, in his recent speeches on Galileo, has also stressed that he was right on this crucial theological point. Thus, part of what I want to do is to understand this transition from a situation when the cultural consensus was that Biblical assertions about natural phenomena carried weight, indeed decisive weight, and so could not be contradicted in natural philosophy, to one where the consensus is that such assertions carry no weight and can be disregarded in science. This transition is an interdisciplinary development, and so the study of it involves not only the history of science, but also the histories of philosophy, theology, and Biblical hermeneutics.<sup>11</sup>

The distinctness of this strand of the story remains even if its initial phase is interpreted differently, that is, even if it were claimed that Galileo did not elaborate the principle of independence of science from the Bible, but that he preached and practiced the use of biblical passages to support scientific claims.<sup>12</sup> For example, so the allegation would go, in the *Letter to the Grand Duchess Christina* he reinterpreted the passage on the Joshua miracle to support the earth's motion. Even so, my main point in this regard would be that part of the aftermath of the trial is the story of how it affected discussions of the issue of the relationship between science and the Bible. Here it is important to note also that the actual, potential, or perceived conflict between the Bible and Copernicanism or other scientific theories is an aspect of the situation that cannot be diluted or explained away, and provides initial credence and a distinct line of support to the thesis of a warfare between science and religion.

I must say, however, that I side with the pope [John Paul II 1979; 1992], when he regards Galileo as a precursor of the Church's current view of the independence of science from the Bible. I would criticize the opponents of this interpretation, partly on the grounds that they rely on a misreading of Galileo's *Letter to the Grand Duchess*; in the past my own criticism [Finocchiaro 1986; 1992; 1995] has involved primarily the textual analysis of this letter. I am now discovering additional support from the history of this strand of the affair. For example, this letter was not allowed to be included in the 1744 edition of Galileo's works, which did include the *Dialogue* and had the Church's imprimatur; and this suggests that the letter was seen as containing a radically progressive doctrine more dangerous than the earth's motion; the denial of the scientific authority of the Bible would be such a

<sup>11</sup> Important contributions to this aspect of the story have been made by Pesce [1987; 1991a; 1991b; 1992a; 1992b; 2000].

<sup>12</sup> This interpretation may be found in such authors as Mallet du Pan [1784], Bergier [1788-1790], Bérault-Bercastel [1790], Feller [1797], Cooper [1838; 1844], Marini [1850], Madden [1863], "Epigrafi ed offese" [1887], and Duhem [1908].

doctrine, not its affirmation in whatever version, such as the weaker principle that the bible should be given precedence when a physical proposition has not been conclusively demonstrated.

Moreover, this strand includes developments like the following. In 1661, Honoré Fabri published under the pseudonym of Eustachio Divini a book critical of Huygens's theory of the system of Saturn. There is a passage in this book [Divini 1661, p. 49] where the presumed author reports a discussion he had had with Fabri regarding the status of Copernicanism and the Church's censures against it. Fabri is quoted as having asserted the following: because there is no conclusive demonstration of the earth's motion, the Church is entitled to give a literal interpretation of the relevant biblical passages; if a conclusive demonstration were ever discovered, the Church would then be entitled to interpret those same passages in a figurative sense; but I (namely Fabri) do not think such a conclusive demonstration will ever be found. What is happening here, in effect, is that Fabri is quoting himself to advance this view.

Today we know that such a view is the same as that found in cardinal Bellarmine's letter to Foscarini [Favaro 1890-1909, vol. 12, pp. 171-71; Finocchiaro 1989, pp. 67-69]. At that time, however, this letter was obviously not generally available. Fabri's remark was apparently taken as a semi-authoritative pronouncement because he was a Jesuit living in Rome and had the official position of confessor in St. Peter's church. At any rate, the remark received wide discussion.

For example, it was discussed by Adrien Auzout in 1665 in his *Letter to Abbé Charles* and by an anonymous writer in a review of Azout's views in the *Philosophical Transactions* of London of the same year, in an article entitled "A Further Account Touching Signor Campani's Book and Performances about Optick Glasses". Fabri's remark was also discussed by Leibniz in at least three different places: in his essay "Apologia fidei Catholicae ex recta ratione" [Leibniz 1679-1686, pp. 31-32]; in a letter to landgrave Ernst von Hessen-Rheinfals [Leibniz 1688, pp. 200-202]; and in the chapter entitled "On Error" of his *New Essays on Human Understanding* [Leibniz 1704b, p. 515]. Jean Montucla [1758, vol. 1, pp. 541-42] also discussed it in 1758 in his *Histoire des Mathematiques*, as did Joseph Lalande [1771, vol. 1, pp. 539-41] in his *Astronomie*.

Now, the gist of these discussions is as follows. They take Fabri's remark to imply that the Church's anti-Copernican censures are provisional, not permanent and absolute; this would seem to be an obvious consequence. But they also go on to infer a further conclusion, that is, given that the censures are provisional and non-absolute, so is the literal interpretation of relevant biblical passages; but if it is proper to interpret such passages non-literally at some future time, then their literal interpretation is not formally binding at the present time either; which is to say they need not be interpreted literally, and so the biblical objection to Copernicanism dissolves. I believe what is going on here is that these authors are suggesting that there

is a tension between the claim that a conclusive demonstration would force a non-literal interpretation of the Bible, and the claim that the Bible literally interpreted is ever a source of scientific knowledge; that once we accept the former claim about the effect of a demonstration, we have to reject the latter claim about the scientific authority of the Bible.

Once again, this should suffice as a sketch of this aspect of the aftermath of Galileo's trial, that is, of the second substrand of the intellectual aftermath.

## 8 Epilogue

To conclude, in 1633 the Inquisition condemned Galileo for holding that the Earth moves and that the Bible is not a scientific authority. This ended the trial whose origin dated back to 1613, involving issues of both scientific fact and methodological principle. But a new controversy began, continuing to our own day –another trial about the original trial, or a series of re-trials of Galileo, as it were. This subsequent controversy is about interpreting and evaluating the original trial and so partly reflects the original issues. But it has also acquired a life of its own, with debates on whether or not, for example, science and religion are incompatible, political expediency prevails over scientific truth, and scientific research must bow to social responsibility. The subsequent controversy has two main strands: the historical aftermath consists of events stemming from the original episode and involving actions by the Church, up through the alleged rehabilitation of Galileo by Pope John Paul II in 1979-1992; the reflective commentary consists of countless interpretations and evaluations of the original episode that have been advanced in the past 350 years. Although the literature on the affair is enormous, the full story of the aftermath has never been told, and the reflective commentary has never been systematically examined. I am currently researching the details of this story.<sup>13</sup>

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