Istituto e Museo
di Storia della Scienza

How they make me suffer...

A short biography of Galileo Galilei

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Translated by Anna Teicher

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How they make me suffer,
those who go in search of the highest good,
but have so far failed to find it,
because, my brain tells me,
it is not in the place where they are seeking.

(Galileo, *Against wearing the Gown*)

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This biography started out as a Galilean journey through Tuscany. However, to list a number of places linked to Galileo and to arrange them simply as stages in a tourist itinerary, divorced from the events that conditioned his life and necessarily shaped his character, would be easy, but without purpose. It would also be lacking in respect towards a figure only too well-known and exploited, even commercially, whose image has been reproduced on coins, banknotes, medals, advertisement boards and stamps of all countries, and whose name has been used for scientific instrument firms, space probes, transmitters, underwater computers, ballpoint pens, private radio and television stations, and even – ironically enough – for glasses for the long-sighted. Everybody speaks of Galileo, too much and often at second hand.

We have therefore sought to construct above all an intellectual and biographical journey, in which streets, monuments, works of art, villas and gardens take their place in the story of a life of such complexity as his and the evolution of a mind of such power. Our intention has been to enrich the image of Galileo through the places connected with him and to free him from the commonplace. Whether or not we have succeeded remains to be seen.

Birth and early life and education 1564-1580

On February 15, 1564 Galileo was born in Pisa, the son of Vincenzo Galilei, a music teacher who came from Florence, and Giulia Ammannati, from a Pescia family that had moved to Pisa years earlier. He was born at the residence of his uncle, Leone Ammannati, a house belonging to the church of S. Andrea Forisportam, as emerges from his birth certificate drawn up on February 19 in the Baptistery of Pisa.

View of Pisa during the game of the Battle of the Bridge. Engraving by Anton Francesco Lucini, after a drawing by Stefano della Bella, Rome, Giangiacomo Rossi, 1649 (Biblioteca Nazionale, Florence, N.A. Cartelle, 11,27).

Vincenzo Galilei was obliged to move to Florence, perhaps to engage in some commercial activity in tandem with his work as a musician, leaving his family in Pisa in the care of his friend Muzio Tedaldi, who was later to marry Giulia's niece. The young Galileo began his education at the public school in Pisa, probably between 1569 and 1574. The school appointed for three-year periods masters of writing, grammar and arithmetic, obliging them by contract to find suitable accommodation for teaching and, according to a document in the State Archives of Pisa, to teach 'all equally, the poor citizens as well as the rich.' Galileo may have learned here the first elements of Greek, as Antonio Leonardi da Castiglione, a master of grammar

Vincenzo Galilei, *Dialogo della musica antica et della moderna*, in Fiorenza, appresso Giorgio Marescotti, 1581 - Frontispiece

during his years as a pupil, was one of the few to be employed as *magister literarum graecarum*.

Towards the end of 1574 Galileo moved to Florence to join his father. He remained there for some years, extending his studies of 'the humanities, Greek and

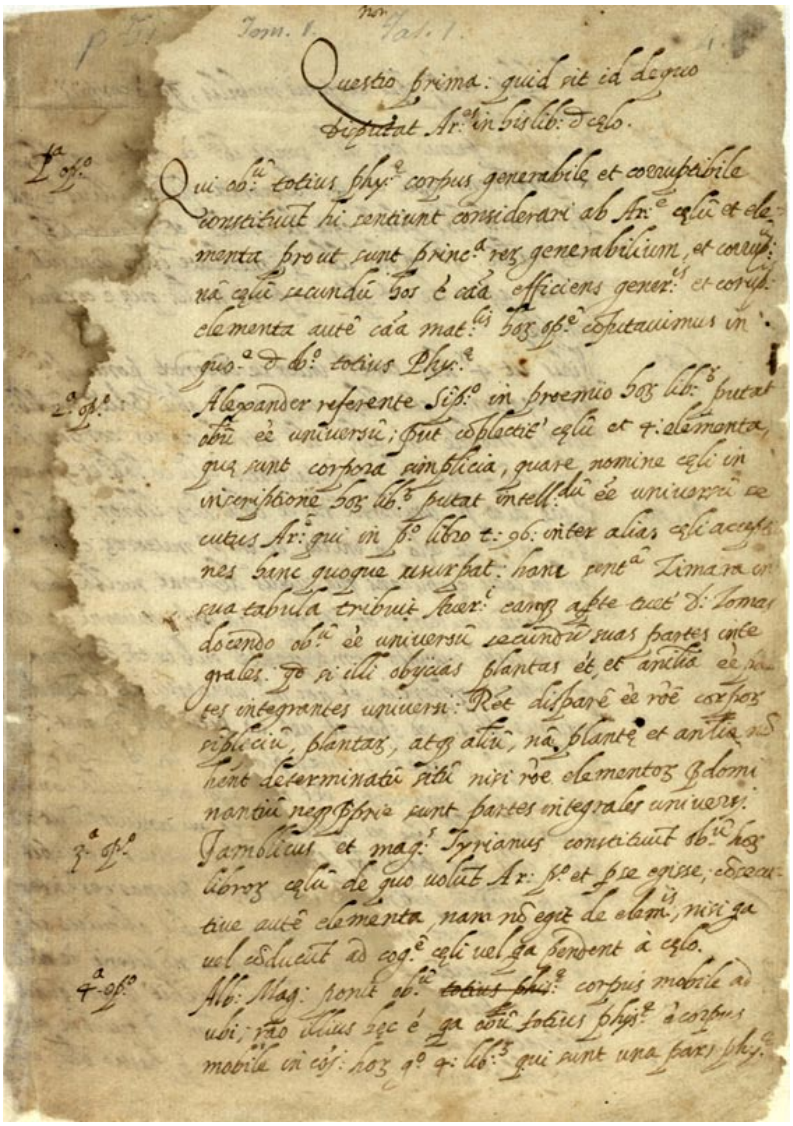
Valerio Spada, *Veduta della città di Firenze dal muricciuolo del prato de' padri di San Francesco al Monte*, 17th century (Biblioteca Nazionale, Florence, N.A. Cartelle, 10, 5)

dialectics', as well as drawing and music (he was, it seems, a good lute player). According to Niccolò Gherardini, a biographer who in truth knew little about Galileo's youth, he was sent 'to the school of a teacher of grammar, a very undistinguished man, who taught in his own house located in the Via de' Bardi.' The Galilei family possibly lived in that nearly, since, at the foot of a letter from Muzio Tedaldi to Galileo's father, we find the statement 'consigned to Pier Francesco Lapini, living across from the Torrigiani hill', behind the Palazzo de' Mozzi in the Oltrarno, adjoining the Via de' Bardi.

Vallombrosa Abbey. Detail of a fresco by Giovanni Stradano, 16th century (Villa Pazzi al Parugiano, Prato)

Galileo then continued his studies with the Vallombrosan monks - whether in the monastery of Vallombrosa or in the community of Santa Trinita, as Viviani states, we do not know - and entered the order, it seems, as a novice. Dating from this period are several notes in his hand relating to Aristotelian logic, probably reflecting tuition modelled on that of the Jesuits in the *Collegio Romano*. His father however did not allow him to complete the course of study, 'on the pretext', the Vallomb-

rosan Abbot Diego Franchi insinuated, 'of taking him to Florence to treat a severe eye condition.' This was in 1578. In 1580 Galileo returned to Pisa to enroll at the university as *artista*, that is, student of medicine and philosophy, living once again under the wing of Muzio Tedaldi as a guest in his house.



Autograph manuscript of Aristotle's *De Caelo* dating from Galileo's youth (Biblioteca Nazionale, Florence, Ms. Gal. 46, c. 4r).

University studies 1580-1589

Even as a newly enrolled student, Galileo showed a certain contempt for academic life which was to continue and which intensified when he became a teacher himself. This attitude was to inspire the biting *Capitolo contro il portar la toga* [Against wearing the Gown] (1590), in which his reaction against the requirement to dress as befits a 'doctor' (that is, to wear a gown) is a vehicle for a none-too-veiled criticism of the working method of those

> who go in search of the highest good,
> but have so far failed to find it,
> because…
> it is not in the place where they are seeking.

His judgment of a certain type of scholar, not merely of his dress, was severe. Against a concept of knowledge that he saw as the unthinking repetition of a tradition, Galileo advanced an opposing view:

> he who seeks to find a thing
> must use his imagination,
> and play with invention, and guess.

Interior of Pisa Cathedral. Tempera on paper, 19th century (Opera della Primaziale Pisana, Pisa).

Galileo indeed had been gifted with imagination since boyhood. According to Vincenzo Viviani, a young pupil of his and later his biographer, Galileo in 1583, while observing in the Cathedral of Pisa the oscillation of a lamp, now conserved in the Camposanto, had asked 'whether the times of oscillation between two points, for large, medium and small arcs, were the

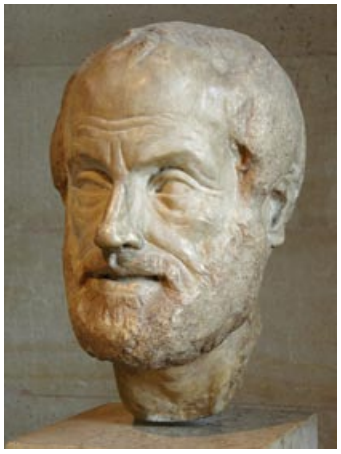
Galileo observing the lamp in Pisa Cathedral, 19th century (Domus Galilaeana, Pisa, Misc. Favaro, XIX, 3)

same.' He had in fact deduced the constant period of a pendulum, which he established by measuring the oscillations against the beating of his own pulse, employing the sense of rhythm he had developed in studying music. This story may be a product of Viviani's eulogistic frame of mind. What is certain is that Galileo anticipated the application of the pendulum in medicine (to establish a patient's pulse rate as a sign of changes in bodily temperature), but then utilised it – an indispensable instrument, thanks to the precision of its measurements – to determine the laws of motion.

Votive lamp (Camposanto, Pisa, Aulla Chapel)

Moreover, Galileo's curiosity was not satisfied by the teaching of medicine and philosophy provided at the university by such professors as Andrea Cesalpino, Girolamo Borro, Francesco de' Vieri (known as Verino Secondo) and Francesco Buonamici, tied as they all were, notwithstanding their different views and abilities, to the Aristotelian tradition or, in the case of followers of an enervated Platonism by then reduced to sterile dispute, obliged to conform to that tradition by the Statutes of Cosimo I. According to Vincenzo Viviani's account, which was not entirely detached or objective, Galileo's mind was not one that could 'easily assent to mere maxims and opinions of ancient or modern writers, when he could, through discussion, reason and experiment, satisfy himself.' Consequently, in his refusal to submit to a dogmatic, non-critical concept of science, he attracted the hostility of many 'fierce defenders' of Aristotelianism. Here was a beardless young student taking a stand in opposition to the age-old, rock-hard certainties of the Doctors.

Portrait of Andrea Cesalpino. Oil on canvas by A. Battista Ricci, 16th century (Pisa University, Rettorato)



Marble bust of Aristotle. Roman copy of the 1st or 2nd century of a bronze by Lysippus, now lost (Musée du Louvre, Paris)

Bored with arid Aristotelian studies, the young Galileo soon turned to geometry, in which he saw the basis for the laws of music and perspective. This move was against the will of his father, who had counted on his son becoming a physician and being able to support the family. Galileo's first teacher of geometry was Ostilio Ricci, court mathematician and tutor to the Grand Duke's pages, under whose guidance he read the entire volume of Euclid's *Elements*, 'keeping texts of the followers of Hippocrates and Galen close at hand … so as quickly to cover the copy of Euclid with them when his father approached.' Galileo was also absorbed in reading Archimedes. His medical studies were neglected and subsequently, with his father's reluctant agreement, abandoned.

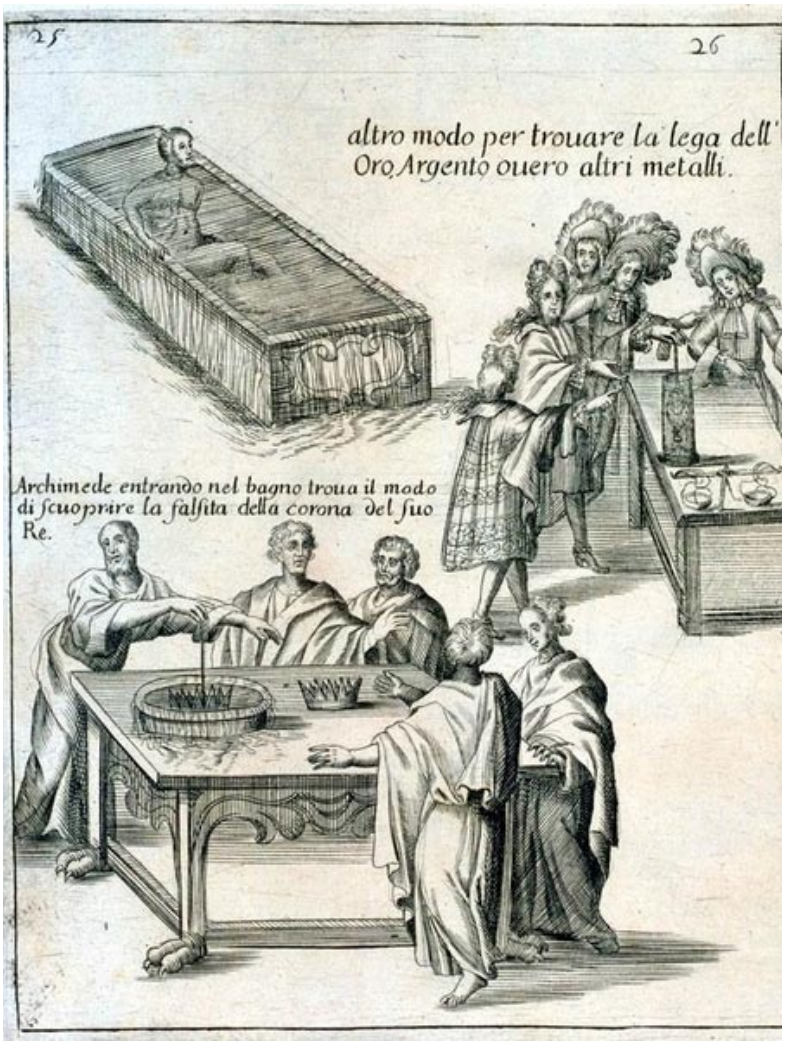
Raphael, *The School of Athens*, 1509-1510. Detail with the figure of Euclid (Musei Vaticani, Vatican City, Stanza della Segnatura)

Thus in 1585 Galileo returned to Florence, equipped with his newly acquired knowledge of geometry, leaving university without having taken a degree although in a position to have done so. The precise reason for this is unknown but, given the circumstances, the decision is unsurprising.

Dating from this second Florentine phase is *The Little Balance*, a fruit of Galileo's studies of Archimedes that was never published but that

Small hydrostatic balance (Istituto Museo di Storia della Scienza, Florence, Collezioni Medicee)

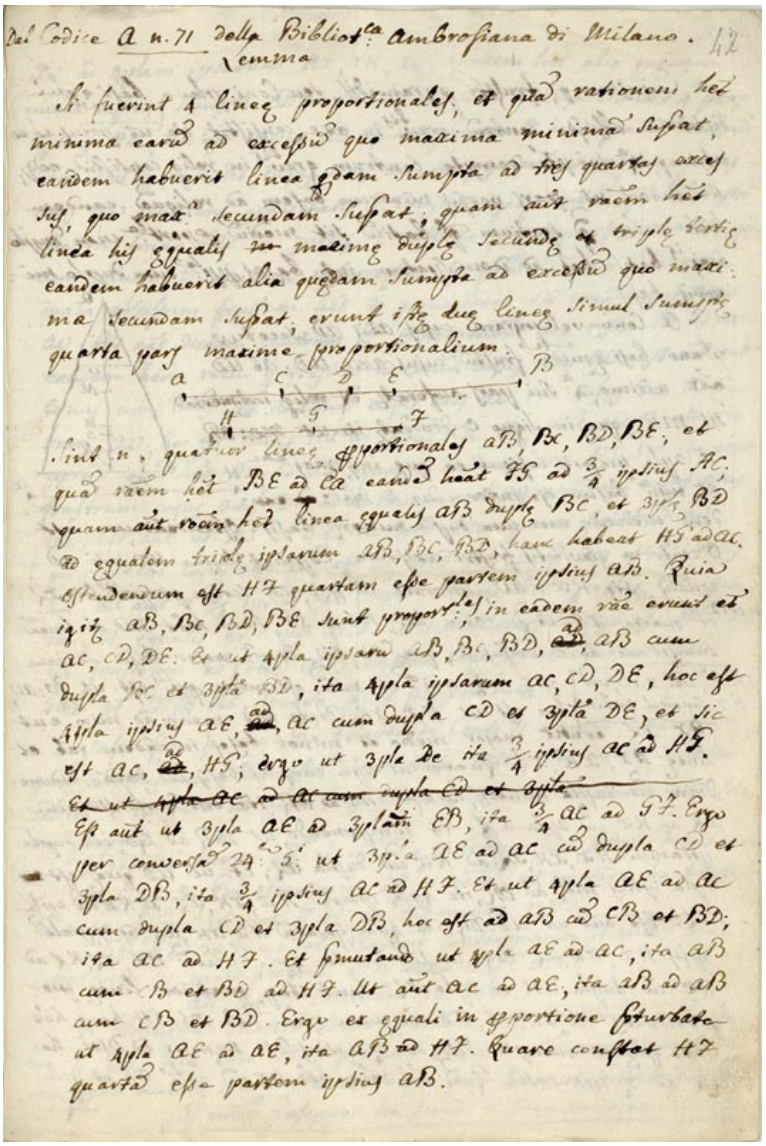
has survived in the autograph manuscript. Starting from the description, handed down by Vitruvius, of the trick played on the tyrant Hiero by a goldsmith who replaced some of the gold in his crown with silver (a deception unmasked by Archimedes 'using the medium of water'), Galileo realised that the way to 'determine the mixture of two metals precisely' was to use 'the medium of a balance.' The balance could be employed to measure the weight of the substances first in air, then in water –that is, in media of unequal density - thus making it possible to determine their different specific weights, in accordance with Archimedes' laws of hydrostatics.



Archimedes in his bath (Cornelius Meyer, *Nuovi ritrovamenti divisi in due parti con tre tavole in lingua latina, francese et ollandese*, in Roma, nella stamperia di Gio. Giacomo Komarek Boemo, alla Fontana di Trevi, 1696)

A development of the thought of Archimedes, who had considered the centre of gravity of planes, is also found in the *Theorems concerning the Centre of Gravity of Solids*, probably dating from this period, although published only in 1638 as a part of the *Discorsi e dimostrazioni matematiche intorno a due nuove scienze* [Discourses and Mathematical Demonstrations concerning Two New Sciences]. His studies on the centre of gravity of solids, considered simply as points and thus geometric elements, demonstrate not only the young Galileo's already high level of mathematical knowledge but also his remarkably youthful deviation from Aristotelian physics, which was centred on the 'quality' of bodies and indifferent to their 'quantity.' It was indeed in the work of Archimedes that Galileo, like many of his contemporaries, found the basis for this application of mathematics

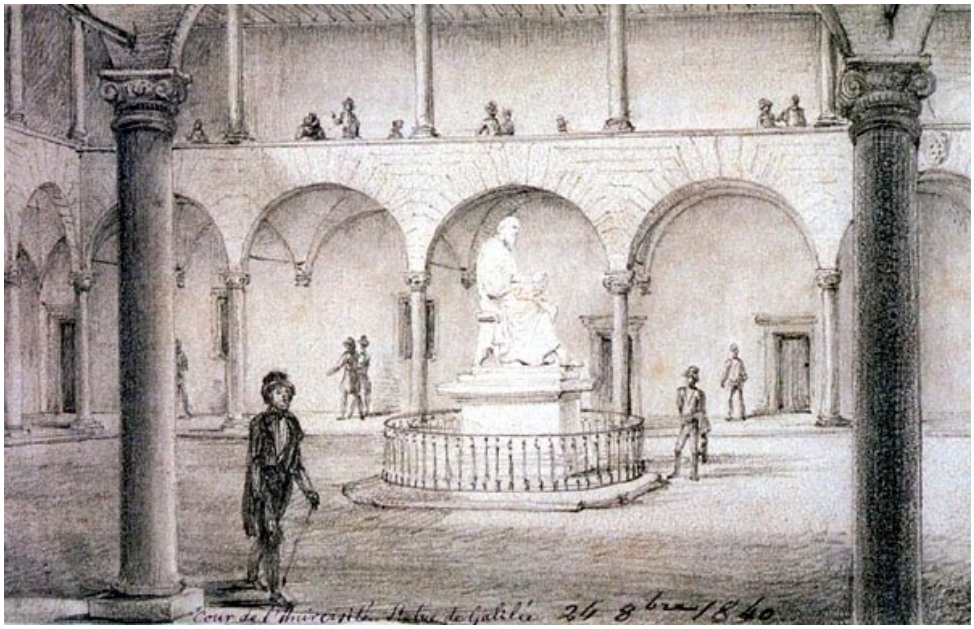
to physics, which was soon to engage him in vigorous opposition to the old methods of the scholastic tradition.



One of the theorems on the centre of gravity of solids, copied by Giovambattista Venturi (Biblioteca Nazionale, Florence, Ms. Gal. 84, c. 42r)

In 1589 Galileo left Florence, to return for good only after many years of university teaching, first in Pisa, then in Padua.

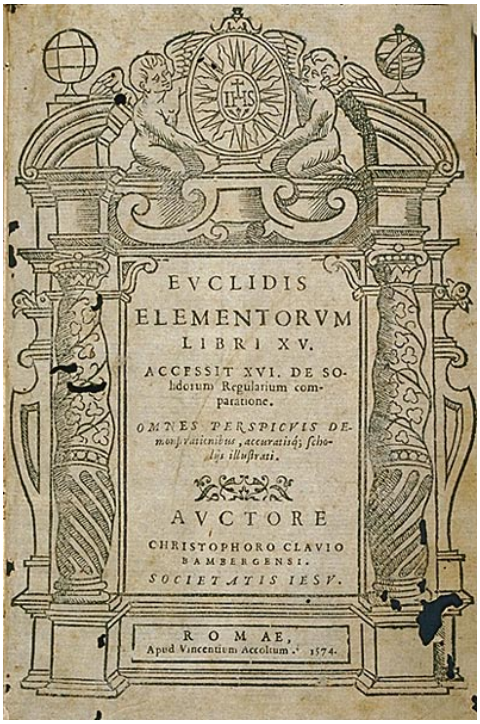
First teaching positions 1589-1592



The courtyard of Pisa University with statue of Galileo. Drawing by M.lle De la Morinière, 19th century (Private collection, Pisa)

Galileo returned to his native city when, after having repeatedly failed to find a university position, he obtained the Chair of Mathematics at the University of Pisa, thanks to the support of Guidobaldo del Monte and his powerful brother, Cardinal Francesco Maria. Here he earned enough to live on and was also able to make a useful contribution to the depleted resources of his family.

Unlike his predecessors, Galileo did not include the subject of astrology in his courses, but in all three years of teaching he read Euclid (the first and fifth books of the *Elements*). This early enthusiasm however soon cooled. Guidobaldo wrote to him, in reply to some complaint about his low salary, saying, 'I am not entirely happy, because I would like to see you more content and treated better, in keeping with your merits.' Galileo repeatedly absented himself from his teaching duties and was even fined for this, which reduced his modest salary still further.



Euclid, *Elementorum libri XV...*, auctore Christophoro Clavio, Romae, apud Vincentium Accoltum, 1574 - Frontispiece.

The academic milieu was the same that he had abruptly abandoned some years before and was certainly not favourable to the development of his research, which for some time had been concerned with the motion of falling weights. The ever-laudatory Viviani describes his 'repeated experiments, made from the top of the Leaning Tower of Pisa in the presence of other teachers and philosophers and the entire student body', in which Galileo demonstrated the falsity of 'very many conclusions of Aristotle himself', to whom the concept of specific weight, central to Galileo's interpretation of the phenomena of motion, was unknown.

Galileo conducting his experiment on falling bodies from the Leaning Tower of Pisa in the presence of the Grand Duke. Tempera on plaster by Luigi Catani, 1816 (Palazzo Pitti, Florence, Quartiere Borbonico or Nuovo Palatino, room 15)

Whether or not the experiments in dropping weights from the Leaning Tower actually took place (and it is plausible given that other researchers in this field are known to have conducted such experiments), it is the case that Galileo's theories on motion were already in conflict with some cardinal points of Aristotelian physics

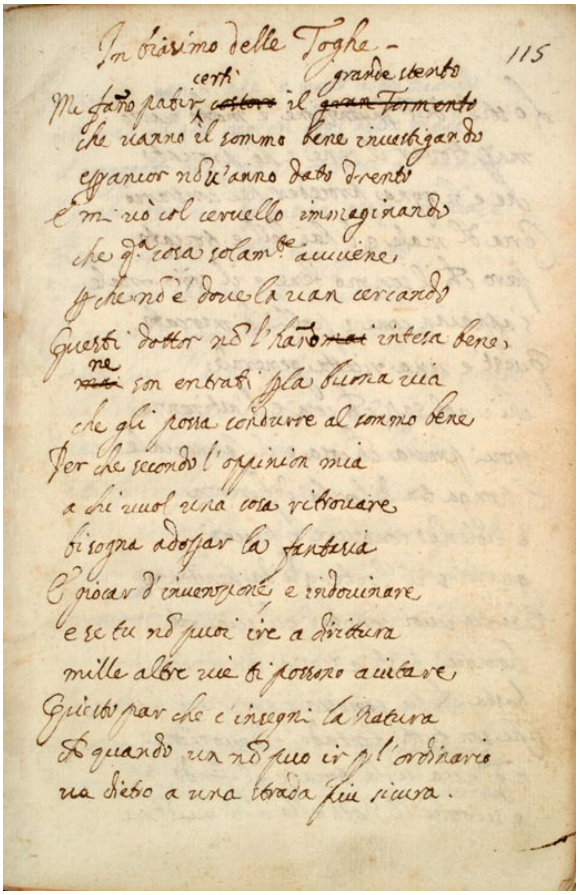
relating to the concepts of velocity, gravity and the void, which, inserted in a new theoretical system, assumed connotations different from those familiar in the traditional system. Underlining, moreover, Aristotle's total ignorance of mathematics and geometry, a knowledge of which is indispensable to 'distinguish the true from the false', Galileo stood in open conflict, as regards scientific method, with the followers of Aristotle at the University of Pisa, some of whom, formerly his teachers, had now become his colleagues.

Galileo's *Against wearing the Gown* emphasizes the difference between appearance and substance, between dressing the part of a scientist and really being one. It came naturally to him as a frequenter of the taverns of Pisa,

> at Bertuccie, at the Porco, at Sant'Andrea,
> at Chiassolino or at Malvagia,

to conclude by comparing men to flasks. Some, at first glance so unappealing that not even a second-hand dealer would want them, actually contain excellent wine.

> The others, who wear those delicate gowns,
> if you feel them, are nothing but wind,
> or cosmetics or perfumed water,
> or are old flasks good to piss in.



Copy of the *Capitolo contro il portar la toga* (Biblioteca Nazionale, Florence, Ms. Magl. VII, 358, c. 115r). The interlinear corrections are attributed to Galileo.

In 1592 Galileo left Pisa for Padua and it is clear that this was a forced move. From that time on, the weakness of his ties with Pisa is made clear in the sporadic and insignificant nature of his contacts with the city. Even when, some twenty years later, he was appointed Chief Mathematician at the University of Pisa, he asked to be dispensed from teaching and was readily granted his request, on the strength of the fame he had acquired meanwhile during his years in Padua through the construction of instruments such as the compass, and in particular the telescope, which had made possible the new astronomical discoveries of 1609-1610. In Pisa Galileo demonstrated these discoveries from the Torre della Verga d'Oro, in the presence of the grand-ducal family, and he was given the title of Chief Mathematician and Philosopher to the Grand Duke. This allowed him to live in Florence without financial difficulties.

The Tower of the Verga d'oro in Pisa seen from the side of the church of S. Nicola. Engraving by Bartolomeo Polloni (*Raccolta di 12 vedute della citta di Pisa*, disegnate, incise ed illustrate da Bartolommeo Polloni, 1834).

Padua and Florence 1592-1608

Padua (Francesco Valesio, *Raccolta di le più illustri et famose città di tutto il mondo*, [Venezia, c. 1579].

After the disappointments of his initial period in Pisa, the eighteen years that Galileo spent in Padua represented a significant change for him both professionally and privately, although his financial problems were not solved and indeed worsened when the death of his father in 1591 increased the burden of supporting his family. He had been appointed to the Chair of Mathematics at the University of Padua, again thanks to Guidobaldo del Monte's circle, and was giving much time to private teaching as well, forming a group of pupils many of whom were to remain lifelong friends.

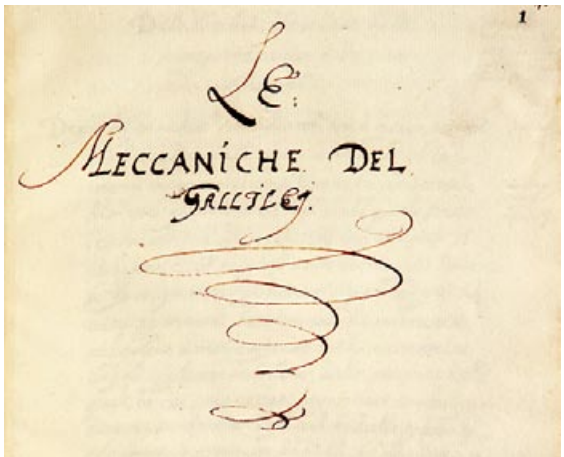
The universities of Pisa and Padua were of more or less equal status and the professors were often the same in each; they migrated from one centre to the other, laden with their baggage of peripatetic physics which, both in Tuscany and in the Veneto, it was difficult to free from the mindset of metaphysics. Outside the walls of the academic world, the cultural ferment and the presence of important intellectual figures made Padua a centre of study and exchange of ideas totally unlike suffocating, provincial Pisa. Galileo was an active member of academies and cultural circles, not only in Padua but also in Venice, where he was in contact with prominent scientists and men of letters such as

Galileo's wooden desk in the Sala dei Quaranta of the Palazzo del Bo', site of Padua University.

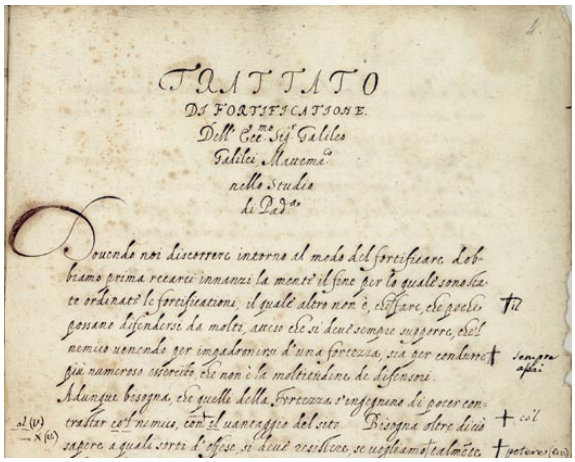
Paolo Sarpi and Giovanfrancesco Sagredo. Galileo's bond with Sagredo was such that he subsequently immortalised him as one of the interlocutors in the *Dialogo sopra i due massimi sistemi del mondo* [Dialogue concerning the Two Chief World Systems] and in the *Discourses and Mathematical Demonstrations concerning Two New Sciences*. Galileo also entered into a relationship with Marina Gamba, a Venetian woman by whom he had three children, Virginia, Livia and Vincenzo, without however marrying her.

Galileo in the presence of Paolo Sarpi. Etching by Carlo Raimondi, 1838 (*Fiori d'arti e di lettere italiane per l'anno 1839*, Milano, Bravetta, 1839)

Occasional requests for opinions on applied mechanics inevitably led him to study the theoretical aspects of this discipline, which he then made the subject of a university course on the *Quaestiones mechanicae* [Questions of Mechanics] of the pseudo-Aristotle. Galileo gathered together the fruits of his studies, broadening the knowledge acquired during his years in Pisa, in *Le mecaniche* [Mechanics], a treatise written in various versions, presumably between 1593 to 1602, but circulated only in manuscript form until its posthumous publication in 1649. Basing himself on the working of machines such as the pulley, the winch, the lever scales and the lever, he

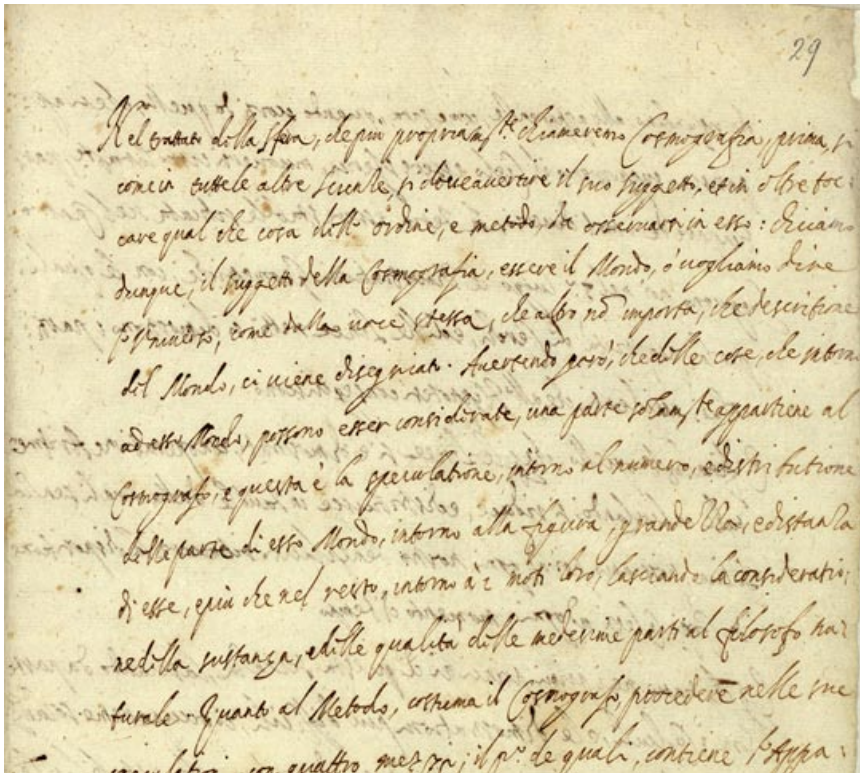


Frontispiece of a copy of *Le mecaniche*, 17th century (Biblioteca Nazionale, Florence, Ms. Gal. 72, c. 1r)



First page of a copy of the *Trattato di fortificazione*, 17th century (Biblioteca Nazionale, Florence, Ms. Gal. 31, c. 4r)

formulated the definitions of gravity, the momentum of falling bodies and the centre of gravity, thus establishing the foundations of his physics as applied to mechanical work. While Aristotle was the subject of his public lectures, his private teaching centred on the *Mechanics*, together with the art of warfare, as attested by the *Breve instruzione all'architettura militare* [Brief Introduction to Military Architecture] and the *Trattato di fortificazione* [A Treatise on Fortification]. Apart from the subjects he taught, the phenomena of motion continued to occupy the centre of his interests. Although he had abandoned his previously announced idea of writing a treatise, Galileo had made progress towards formulating not only the law of the constant period of the oscillations of the pendulum, but more importantly, the law of falling bodies, using instruments he constructed himself, such as the inclined plane. His studies during this period provided precious groundwork for the future, when in old age he attempted a systematic explanation of the knowledge he had acquired on so-called local motion. But already in these earlier years his work, although in embryonic form, dangerously threatened the concept of an Earth positioned at the centre of the universe, to which all falling bodies are attracted.

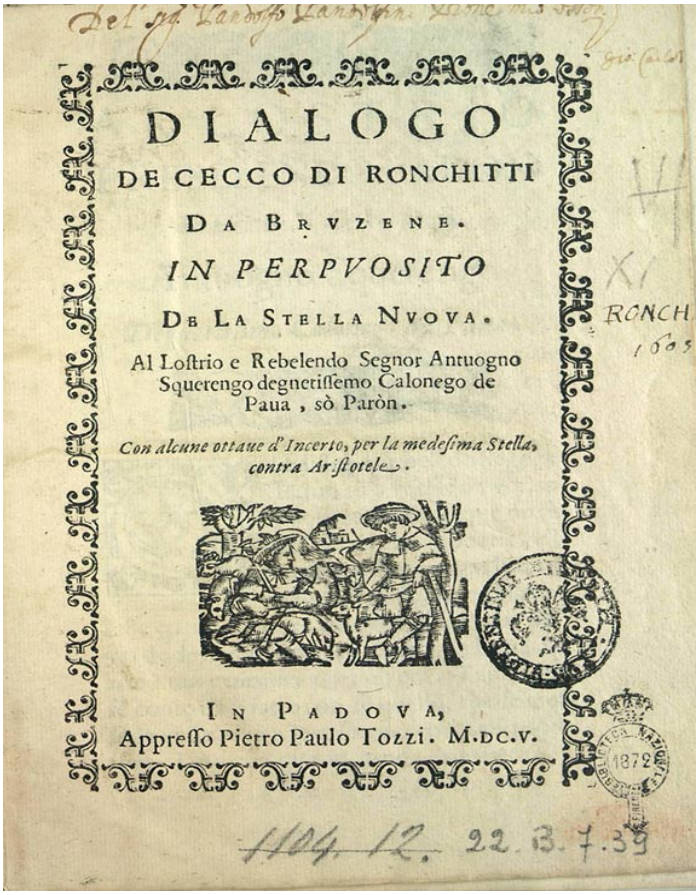


First page of a copy of the *Trattato della sfera*, probably owned by a pupil of Galileo's (Biblioteca Nazionale, Florence, Ms. Gal. 47, c. 29r)

His teaching duties obliged him to hold courses in cosmography based on the Ptolemaic system. Evidence of this is his *Trattato della sfera ovvero cosmografia* [Treatise on the Sphere, or Cosmography] (also published posthumously in 1656), which was the text he used to teach this subject. And yet two letters, one to Jacopo Mazzoni and one to Kepler, both dating from 1597, unequivocally attest to how Galileo already considered 'the opinion of the Pythagoreans and of Copernicus… much more probable than that of Aristotle and Ptolemy', openly stating this in correspondence with his European colleagues although not yet publicly proclaiming it. Probably the discussion in the

cultural circles of the Veneto, an avant-garde milieu, had contributed to definitively formulating a hypothesis already present in embryonic form in his research on motion, which hinted at the idea that falling bodies fell toward a centre of the Earth that was not necessarily the Aristotelian centre of the universe but one of the many possible centres, in accordance with the Copernican hypothesis.

When a supernova appeared a few years later, in 1604, Galileo considered it to be a transitory 'splendour', but not, in spite of this aspect, 'a star like the rest.' This phenomenon gave him the opportunity to study more deeply the rationale of the Copernican system as against the Aristotelian concept of the incorruptibility of the heavens, according to which it was inconceivable that 'most of the comets and all such similar stars were generated in the starry skies.' The appearance of the supernova gave rise to lively debate, and, in the *Dialogo de Cecco di Ronchitti da Bruzene in perpuosito della stella nuova* [Dialogue concerning the New Star by Cecco di Ronchitti of Brugine], written under a pseudonym by the Benedictine monk, Girolamo Spinelli, there is also presumably the hand of Galileo. The heated polemic on the nature of the *nova* gave him a first taste of that 'animosity in detracting, cheating, and vilifying' which was to plague him all his life, and he would soon have to confront intrigues and deceitful manoeuvres, unyielding in the face of 'false pretences … fraudulent tricks and … bold appropriation of ideas.'


DIALOGO
DE CECCO DI RONCHITTI
DA BRVZENE.
IN PERPVOSITO
DE LA STELLA NVOVA.
Al Loſtrio e Rebelendo Segnor Antuogno Squerengo degnetiſſemo Calonego de Paua, sò Paròn.
Con alcune ottaue d'Incerto, per la medeſima Stella, contra Ariſtotele.
IN PADOVA,
Appreſſo Pietro Paulo Tozzi. M.DC.V.
RONCH 1605
1872
1604. 12. 22.3.7.39

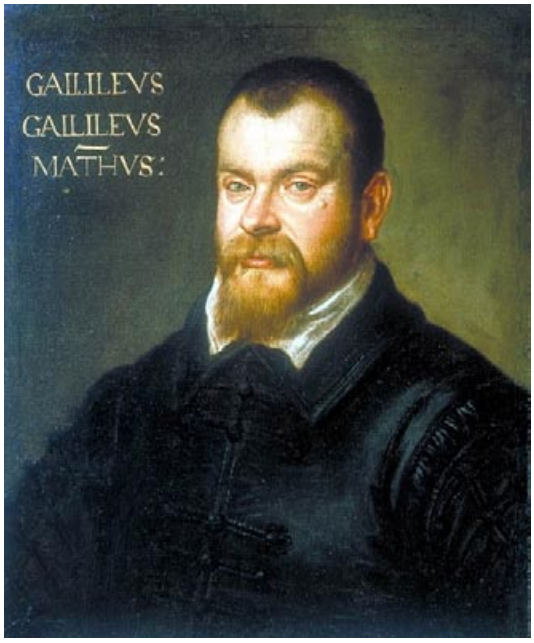
Girolamo Spinelli, *Dialogo de Cecco di Ronchitti da Bruzene in perpuosito de la stella nuova, al lostrio e rebelendo segnor Antuogno Squerengo degnetissemo Calonego de Pava, so Paron, con alcune ottave d'incerto, per la medesima stella, contra Aristotele*, in Padova, appresso Pietro Paulo Tozzi, 1605 - Frontispiece

Model of Galileo's thermoscope (Istituto e Museo di Storia della Scienza, Florence)

Watercolour frontispiece of a copy of the *Compasso geometrico e militare*, 17th century (Biblioteca Nazionale, Florence, Ms. Gal. 37, c. 3r)

Teaching was not Galileo's only activity in Padua. He continued to pursue his theoretical studies and worked tirelessly on their practical application, even setting up a workshop at his home, entrusted to the mechanic Marcantonio Mazzoleni. Here, in this home laboratory, instruments of various kinds were tried out. More than once, similar devices made their appearance in the laboratories of other scientists (or would-be scientists), arousing the anger of Galileo, who considered them his own inventions. Such was the case of the thermoscope (a rudimentary thermometer), constructed by Santorre Santorio, an Istrian doctor who had moved to Padua, and, even worse, that of the geometric and military compass, claimed as his own by Baldassarre Capra (a sinister figure whose dishonesty had already been made plain on the appearance of the *nova* in 1604) in his *Usus et fabrica circini cuiusdam proportionis* [Use and Construction of the Proportional Compass], which was no more than a plagiarism in Latin (filled, moreover, with errors) of Galileo's *Operazioni del compasso geometrico e militare* [Operations of the Geometric and Military Compass], published in 1606. A furious Galileo, 'overcome by amazement, indignation and distress', was obliged to appeal to the *Riformatori* of the University of Padua, who enjoined Capra to destroy every copy of his book and, since some copies, dispersed abroad, could not be found and had remained in circulation, to print and disseminate a *Difesa contro alle calunnie et imposture di Baldesar Capra* [Defence against the Calumnies and Impostures of Baldassare Capra].

'The best eighteen years of my life': thus was Galileo to remember his time in Padua. There he had sown the seeds of everything he was to harvest in the future, ranging from statics to dynamics, to mechanics, to cosmology, facilitated by that 'splendid and generous … Republic' which, while obliging him to 'give public service' - that is, to teach in order 'to ensure the good use of public money' - nonetheless left him free to investigate whatever field most appealed to him. It was the Venetian Republic that disentangled him from his first difficulties of a legal nature, preventing any credence being given or follow-up made to the accusations of a former employee who, having 'seen Galileo in his room drawing up various horoscopes for various people', denounced him to the local Inquisition for involvement in astrological practices.



Portrait of Galileo. Oil on canvas by Domenico Tintoretto, 1605-1606 (National Maritime Museum, Greenwich)


Giambologna's *Appennino* in the garden of the Villa of Pratolino. Engraving by Stefano della Bella (Bernardo Sansone Sgrilli, *Descrizione della regia villa, fontane, e fabbriche di Pratolino*, in Firenze, nella Stamperia granducale, per i Tartini e Franchi, 1742).

Despite his new close ties in the Veneto, Galileo had always remained in contact with Florence, where his mother, now a widow, had continued to live, probably with her sister Virginia and the latter's husband, Benedetto Landucci, in the neighbourhood of the Church of the Carmine, where in time she would be buried. Every summer Galileo returned to Tuscany, and in 1605, at the wish of the Grand Duchess Christine of Lorraine, he began to teach mathematics to Prince Cosimo de' Medici. Galileo was a guest of the Court at the Villa of Pratolino in 1605, (a stay which saw him 'confined to his bed by a tertain fever'), and at the Villa of Artimino in 1608. His regular correspondence with such prominent figures as Belisario Vinta, Secretary of State of the Grand Duchy of Tuscany, shows that his contacts with the Court were far from sporadic. The time was now ripe for a definitive return home.

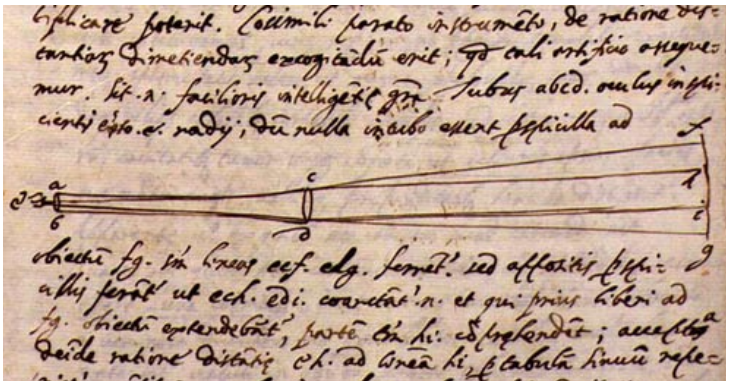
The Medici Villa of Artimino. Engraving by Giuseppe Zocchi (Giuseppe Zocchi, *Vedute delle ville e d'altri luoghi della Toscana*, Firenze, appresso Giuseppe Allegrini, stampatore in Rame, 1744)

Astronomical discoveries and return to Florence 1609-1610

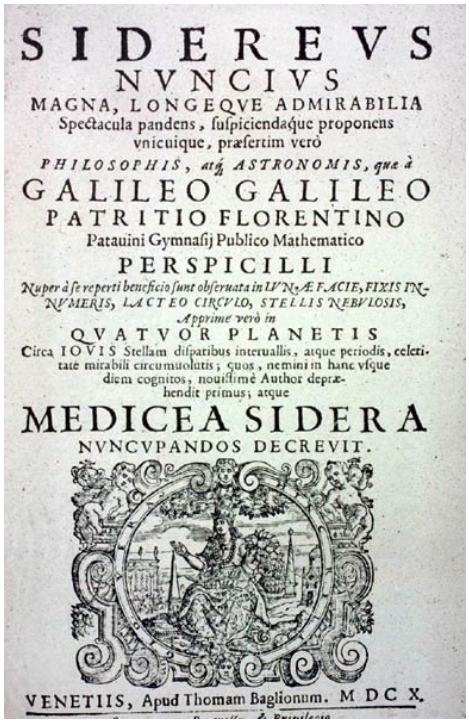
In popular imagination the name of Galileo is connected with the invention of the telescope. His last year in Padua was, indeed, filled with events linked to the construction of this instrument, public demonstrations in the presence of the Venetian nobility and even of the Doge, together with enquiries from well-known

Galileo showing his telescope to the Seigniory of Venice (Bozzetto). Oil on wood panel by Guglielmo De Sanctis, pre-1867 (Museo di Roma, Palazzo Braschi, Rome)

figures all over Europe. There were however also the assertions of various people who claimed to have invented it themselves, as well as bitter, insinuating comments. The telescope, in fact, already existed before Galileo built his first version, probably in 1609, nor did he ever make any particular claim to be its inventor. But it was only through his inventive genius that it was perfected and made more powerful, emerging from the world of mere curiosities, and leaving behind the cabinet of wonders, or in Galileo's own words, 'the little studio of some curious lit-



Autograph copy of the *Sidereus nuncius*. Design of the telescope (Biblioteca Nazionale, Florence, Ms. Gal. 48, c. 9r).


SIDEREVS
NVNCIVS
MAGNA, LONGEQVE ADMIRABILIA
Spectacula pandens, suspiciendaque proponens
vnicuique, præsertim verò
PHILOSOPHIS, atq; ASTRONOMIS, quæ à
GALILEO GALILEO
PATRITIO FLORENTINO
Patauini Gymnasij Publico Mathematico
PERSPICILLI
Nuper à se reperti beneficio sunt obseruata in LVNÆ FACIE, FIXIS IN-NVMERIS, LACTEO CIRCVLO, STELLIS NEBVLOSIS,
Apprime verò in
QVATVOR PLANETIS
Circa IOVIS Stellam disparibus interuallis, atque periodis, celeritate mirabili circumuolutis; quos, neminem in hanc vsque diem cognitos, nouissimè Author deprehendit primus, atque
MEDICEA SIDERA
NVNCVPANDOS DECREVIT.
VENETIIS, Apud Thomam Baglionum. M DC X.

Galileo, *Sidereus nuncius*, Venetiis, apud Thomam Baglionum, 1610 – Frontispiece

tle man', on the same level as 'a petrified crab, a dried chameleon, a fly or a spider preserved in a piece of amber' or those 'little things which for their age, rarity or whatever were considered extraordinary.' The telescope became in all respects a scientific instrument. And this was not all. In the hands of Galileo, the 'eyepiece' or 'giant reed' as it was then called, 'ceased to be aimed only at 'the church of Santa Giustina in Padua' or toward 'those who went in and out of the church of San Giacomo di Murano', as described by the Venetian senator Antonio Priuli, amazed at the first demonstration. It was instead pointed at the sky. Tenaciously and methodically, Galileo began to observe the aspect and movements of the heavenly bodies, hitherto seen only by the naked eye, with unimaginable results that were to provoke a cataclysm in the conception of the cosmos, the world and mankind.

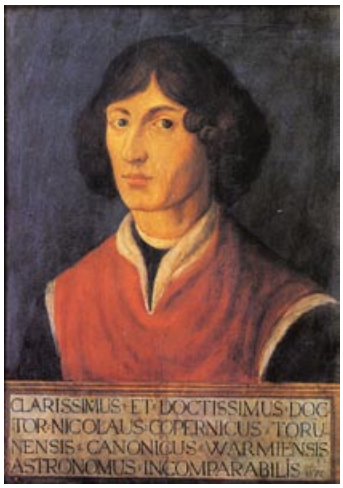
Autograph copy of the *Sidereus nuncius*. The moon drawn by Galileo as seen through his telescope (Biblioteca Nazionale, Florence, Ms. Gal. 48, c. 28r).

In 1610 *The Starry Messenger* was published in Venice. This starry messenger bore amazing news in the astronomical field, reporting in detail the results of the telescopic observations conducted daily and recorded in full detail. Galileo had studied the Moon and had failed to find the 'even, smooth, clean' surface, 'uniform and exactly spherical', that was commonly believed to distinguish the celestial bodies, finding its surface instead 'uneven, rough, full of cavities and protrusions, no less than the face of the Earth itself, from which it differs in regard to chains of mountains and the depth of valleys.' Aiming the telescope at Jupiter, he had seen four satellites orbiting around it. He had found in cosmic space myriads of stars, invisible to the naked eye, which constituted the nebulae and the Milky Way. Galileo himself described these discoveries as 'so many and with so many important consequences, that, considering what they add and what is necessarily changed in the science of the celestial movement', it could

be said 'that in great part this science has been given new life and drawn out of the shadows.' But what were these 'important consequences'? What 'shadows' would be swept away? It is clear that the results of these observations corroborated the thesis of a Copernican universe as opposed to the Aristotelian-Ptolemaic structure universally accepted up to that point. The idea of a Moon similar to the Earth refuted the Aristotelian theory of the different nature of the celestial bodies. Furthermore, conceiving of the Moon as a satellite orbiting around a centre, which was the Earth, suggested that the latter, being made of the same substance, might behave in the same way, orbiting in turn around a centre of its own. The observation of an enormous quantity of stars never before seen cast doubt on the small size of the Ptolemaic universe and, without denying its finite nature, substituted for the restricted covering of the sky a great sidereal space of Copernican origin. It had also become obvious that the 'four stars moving around Jupiter… were tracing a circle around the Sun', all of them moving 'together with Jupiter.' They were, that is, Jupiter's satellites, and revolved contemporaneously with the planet, a phenomenon whose impossibility had always been viewed by the Ptolemaics as proof of an earth-centred system. Once it had been demonstrated that this was by no means impossible, the same thing could

Polychromatic stucco bas-relief picturing Jupiter and the Medicean planets (Museo di Storia Naturale di Firenze, Florence - Sezione di Zoologia "La Specola" - Tribuna di Galileo, intrados of the entrance arch to the apse).

Detail of a 15th century miniature portraying Claudio Tolomeo (Biblioteca Medicea Laurenziana, Florence, Ms. Pl. 30, 1, c. 1r).



Portrait of Niccolò Copernico. Oil on canvas by an unknown painter, 1676 (Uniwersytet Jagielloński, Kraków)

be true of the Earth, which might very well revolve around the Sun, accompanied by its satellite the Moon. Among all these discoveries, that of Jupiter's satellites was thus the one with the greatest impact. And it was not by chance that Galileo, who had long been seeking the protection of a prince in order to continue his studies without having to teach, named them the *Medicean Stars*, dedicating them to the House of Medici and to Cosimo II in particular, his former pupil, who had now become the Grand Duke of Tuscany.

Preparatory study by Stefano della Bella for the antiporta of the 1656 Bolognese edition of Galileo's works. Galileo is portrayed in the act of showing the Medicean stars (the satellites of Jupiter) to the personifications of Optics, Astronomy and Mathematics (Gabinetto Disegni e Stampe degli Uffizi, Florence, n. 8042 F).

The publication of *The Starry Messenger* provoked an explosion among the more or less orthodox scientists and Aristotelians, in an atmosphere of malice, denial, envy, false refutation and spiteful gossip (as well, it should be said, as some enthusiastic praise). Galileo's colleague, Cesare Cremonini, though inclined to be friendly, had no wish to put the telescope to his eye. He was a priest in the tradition of that Aristotelian rationalism which, some centuries previously, had been unprejudiced and independent, but was by now in decay. His outlook brought him into trouble with the Inquisition, without however preventing him from denouncing in his turn Bernardino Telesio's *De rerum natura* [On the Nature of Things]. As regards the telescope, he proclaimed, between a sneer and a reprimand, that to 'look through those lenses … confounded his very mind.' This brought to an end his contribution to the

debate on new scientific developments. The Bohemian doctor and astrologer, Martin Horky, was not much better, although he did publish a pamphlet. He denied the existence of Jupiter's satellites, strong in the assumption that no-one had ever seen them, and attributed Galileo's false discovery of them to kaleidoscopic effects of the lenses and above all to his thirst for money. Having gone beyond the limit of decency, he was dismissed by those who had supported him in the polemic and was advised to leave Italy by Kepler to whom he had turned in search of protection. Another suggestion was that the planets, each of which wore a particular colour, were already seven, a number whose sacredness no-one could doubt: seven, like the metals existing in nature, seven, like the vital parts of the human organism. How could these four extraneous bodies be allowed to discompose perfection?

Unassailable arguments aside, Galileo's opponents could do little in the face of the evidence, especially when Kepler, using a telescope given him by Galileo himself, confirmed the sighting of Jupiter's satellites. The *Medicean Stars* had the desired effect, and the Grand Duke of Tuscany summoned Galileo to Florence, as Chief Mathematician to the University of Pisa and to the Grand Duke himself. Galileo expressly requested that he might also be given the title of Philosopher, 'professing … to have spent more years studying philosophy than months studying pure mathematics.' The salary was excellent, the prestige enormous, and there was no obligation to teach. The discontent and protests of Galileo's Paduan friends against his leaving were of no avail.

Portrait of Cosimo II de' Medici. Oil on canvas by Justus Sustermans, post-1623 (Gallerie Fiorentine, Florence)

Chief Mathematician and Philosopher to the Grand Duke of Tuscany 1610–1611

Portrait of Galileo. Engraving by Francesco Villamena (*Opere di Galileo Galilei*, Bologna, per gli heredi del Dozza, 1656)

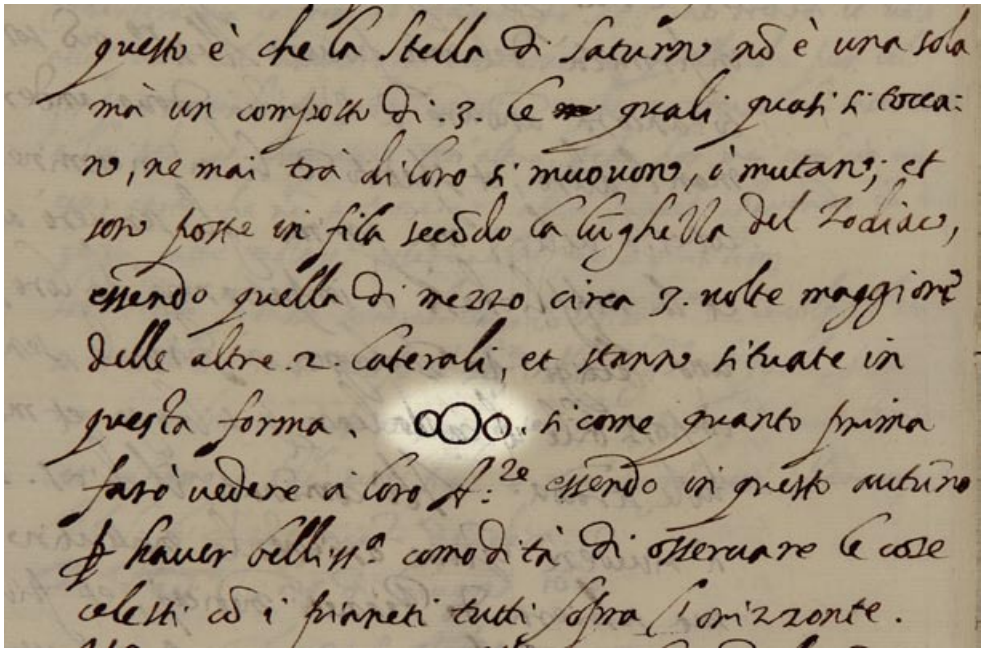
In Florence, Galileo's search for a house from which he could continue to make telescopic observations reveals how totally absorbed he now was in his astronomical studies. In 1610 he sang the praises of a house with 'an elevated terrace that reveals the whole sky all around.' And in fact a letter was addressed to him a little later 'in Porta Rossa, at the Tower of the del Meglio', but there is no other evidence of his having resided in this quarter. Instead, he was frequently to be found living in the hills around Florence, more suitable to his work and his fragile health, always afflicted by the damp, heavy, mentally oppressive air of Florence. Viviani was to note with hindsight:

Galileo at court. Oil on canvas by Cesare Augusto Detti, 1878. The present location of the work is unknown.

'It seemed to him that the city was in a certain way the prison of speculative minds, and that the freedom of the countryside was the book of nature, always open to the man who, with the eyes of the mind, loved to read and study it.' Galileo was the guest of Antonio de' Medici in his villa at Marignolle, and also stayed at the Villa delle Selve near Lastra a Signa, put at his disposal by his friend Filippo Salviati.

Jovilabe (Istituto e Museo di Storia della Scienza, Florence)

Whether the villas of his friends were responsible or not, Galileo's progress in astronomy during this period was remarkable. Continuing his observations of Jupiter's satellites, he succeeded, with the aid of instruments such as the *jovilabe*, in establishing with remarkable exactitude their periods of revolution as viewed from the Earth, and he sensed that he had to correct his calculation of their positions, taking into account the terrestrial orbit around the Sun. For seafarers, new possibilities for measuring longitude were opened in this way, and Galileo was to try several times to sell his discovery to the maritime powers, first to Spain and subsequently to the States General of Holland. The 'longitude business' however did not succeed: the complicated and prolonged negotiations always came to nothing.



Three-bodied Saturn drawn by Galileo in a letter to Belisario Vinta dated July 30, 1610 (Biblioteca Nazionale, Florence, Ms. Gal. 86, c. 42v)

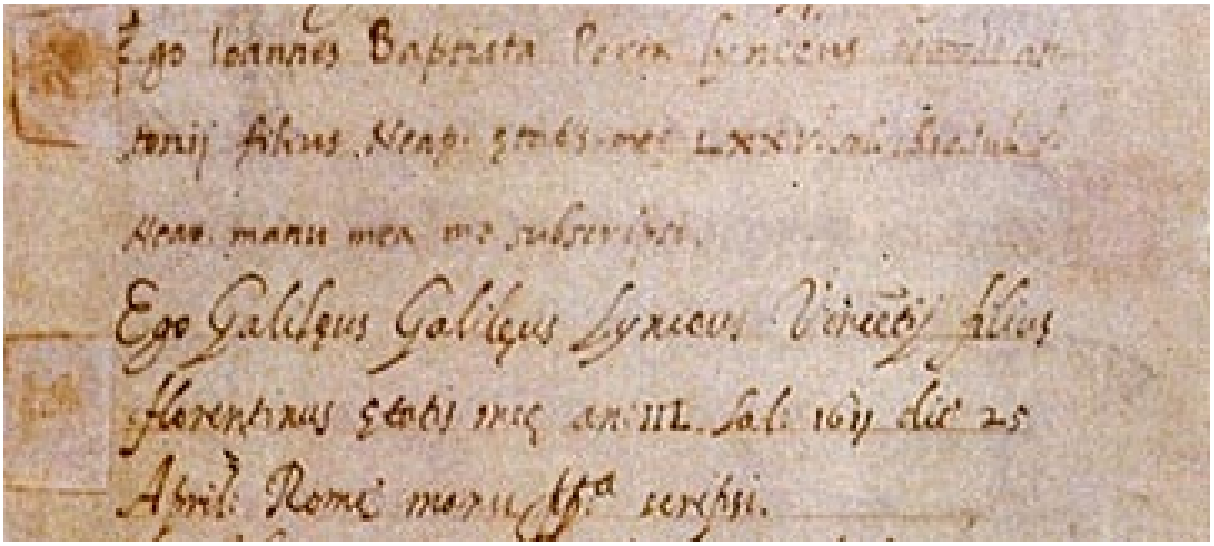
Not satisfied to rest on this new discovery, Galileo extended his observations to Saturn and Venus. His telescope was not powerful enough to allow him to distinguish the ring around Saturn, a planet that he first thought was composed of three distinct parts, then of three lobes joined together. But it did reveal to him that the planets do not shine with a light of their own, and did allow him to demonstrate 'by means of reason', observing their phases, that 'Venus necessarily moves around the Sun, and Mercury too', a further proof of the unsustainability of the geocentric hypothesis.

Polychromatic stucco bas-relief picturing the phases of Venus (Museo di Storia Naturale di Firenze, Florence - Sezione di Zoologia "La Specola" - Tribuna di Galileo, intrados of the entrance arch to the apse)

In the spring of 1611 Galileo requested and received the Grand Duke's permission to go to Rome, to expound his discoveries in detail to the Jesuit scientists of the *Collegio Romano*. Initially convinced that Galileo's discoveries were to be explained as optical illusions, astronomers such as Cristoforo Clavio and Odo van Maelcote now fully acknowledged the credibility of Galileo's telescopic observations and even expressed their compliments. But they always refrained from the least consideration of the implications in the philosophical field as regards the structure of the universe, thus putting into practice the advice given to Galileo by his Paduan friend, Paolo Gualdo, who warned him – a portent, as it were, of what was soon to happen - that 'many things can be said in dispute which it is unwise to declare to be true, especially when you have universal, long-established opinion against you.' Galileo was received by Pope Paul V, who showed his esteem by refusing to allow the scientist to kneel before him. He was welcomed with all honours by the Academy of

Portrait of Federico Cesi. Oil on canvas attributed to Pietro Fachetti, 1610-1612 (Academy of the Lincei, Palazzo Corsini, Rome)

the Lincei, whose founder, Federico Cesi, had been seduced by that 'mountainous, cavernous, sinuous, watery moon', that 'horned Venus', and that 'triple Saturn of his.' With such a warm welcome, Galileo convinced himself that he had won everybody over to his side, excepting the immovable Peripatetics, 'more partial to Aristotle than Aristotle himself would have been.' But under the ashes, fire was smouldering. The first protests arose within the Jesuit Order, and the Inquisition ordered information to be gathered on Galileo and his imprudent association in Padua with Cesare Cremonini, then under investigation on many charges.

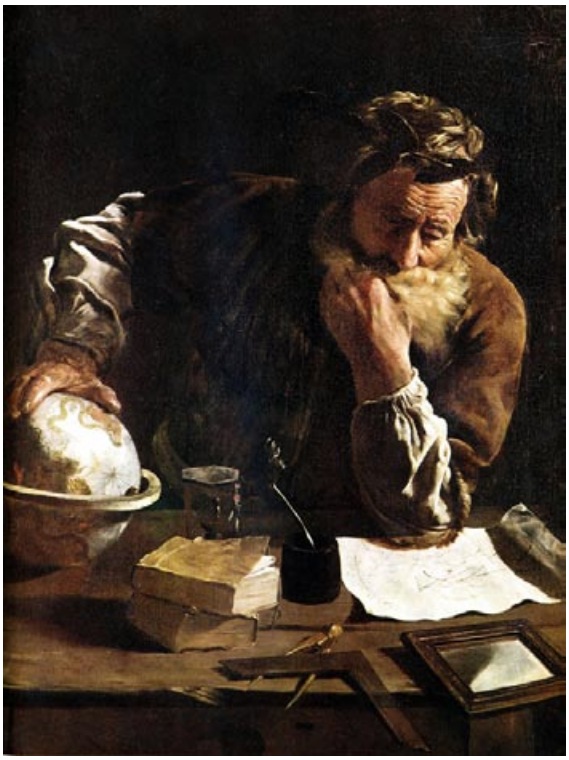


Autograph entries by Giambattista Della Porta and Galileo in the original register of the Academy of the Lincei (Biblioteca Apostolica Vaticana, Vatican City, Ms. Vat. Lat. 9684, c.4)

Water and Sun 1611-1613

On the Aristotelian front, open warfare was now declared, no holds barred. The target was not simply the theories, but also Galileo himself, suggesting that what was at play was personal envy and that a powerful element in this was, to quote Benedetto Castelli, 'those avidly desired thousand *scudi*', the salary, that is, of the Chief Mathematician. In Florence, between 1611 and 1613, Lodovico delle Colombe mounted a full challenge on floating bodies, spiced with official meetings, convened and then abandoned, and public experiments designed to lend it a compelling theatricality. Did the floating or failure to float of bodies in water depend on their individual forms, as the Aristotelians maintained, or on their different specific weights, as Galileo claimed? Yet again, it was Aristotle against Archimedes. To settle the issue

Raphael, *The School of Athens*, 1509-1510. Detail showing the figure of Aristotle (Musei Vaticani, Vatican City, Stanza della Segnatura)



Archimedes. Oil on canvas by Domenico Fetti, 1620, (Gemäldegalerie Alte Meister, Dresden)

rapidly, Galileo published the *Discorso intorno alle cose che stanno in su l'acqua o che in quella si muovono* [Discourse on Bodies on or in Water], which went into a second edition. It was followed by two replies from adversaries and two counter-replies written by Galileo in collaboration with Benedetto Castelli, the second of which was signed by Castelli alone in 1615. Over and above the individual issues, the conflict was once more between a mathematical approach to physics, between 'pluming the wings with

the feathers of mathematics, without which it is impossible to rise even an arm's measure above the earth', and a descriptive, dogmatic procedure lacking in method. This had been felt by one of Galileo's opponents, Giorgio Coresio, who warned his readers against a philosophy that was 'new, full of radical change, and represented all things in the universe under different faces', unintentionally painting a picture worthy of the most ardent supporter.

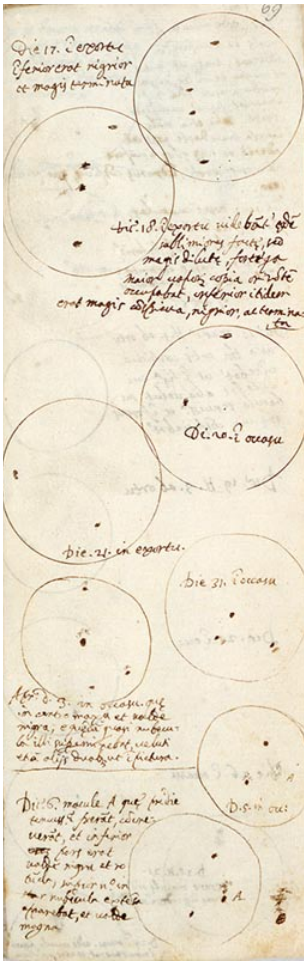

DISCORSO
AL SERENISSIMO
DON COSIMO II.
GRAN DVCA DI TOSCANA
Intorno alle cose, che Stanno in sù l'acqua, ò che in quella si muouono,
DI GALILEO GALILEI
Filosofo, e Matematico della Medesima ALTEZZA SERENISSIMA.
IN FIRENZE,
Appresso Cosimo Giunti. M DCXII.
Con licenza de' Superiori.

Galileo, *Discorso intorno alle cose che stanno in su l'acqua o che in quella si muovono*, in Firenze, appresso Cosimo Giunti, 1612 – Frontispiece

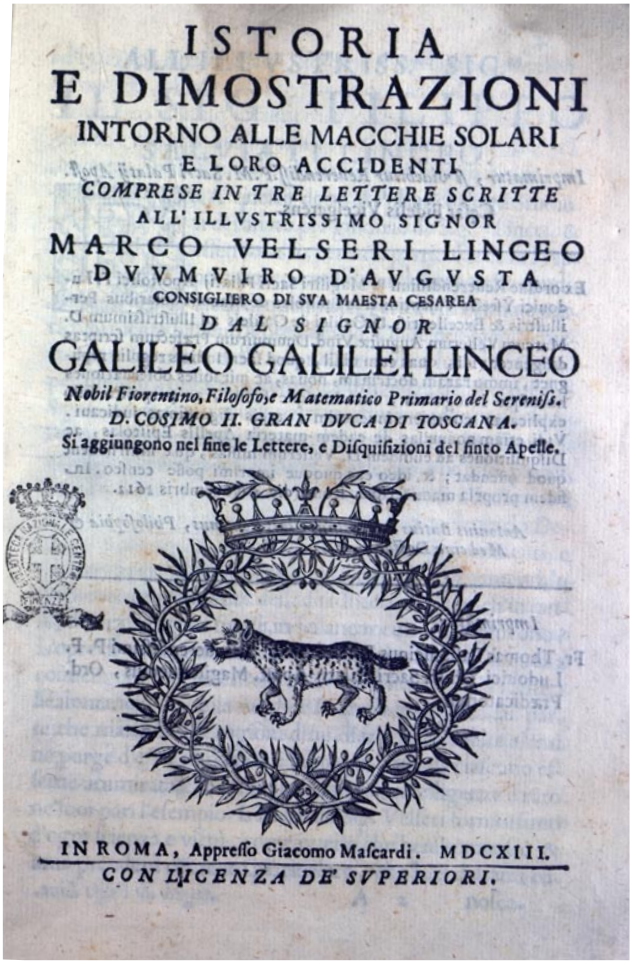
At the same time, a question regarding the Sun also sparked controversy. In this dispute, Galileo was pitted against a figure of much higher standing than the provincial Aristotelians, the Swabian Jesuit, Christoph Scheiner, professor of mathematics at Ingolstadt. Under the pseudonym Apelles - alluding to the Greek painter who hid behind his own paintings to observe unseen the reactions of those looking at them – Scheiner, in three letters written to the Augsburg banker, Mark Welser, who had them published, announced the discovery of a phenomenon he described as 'almost incredible': sunspots. Were they alterations of the Sun? No, the Sun was known to be inalterable.

Portrait of Christoph Scheiner. Oil on canvas by Christoph Thomas Scheffler, 18th century (Stadtmuseum, Ingolstadt)

Although the arguments he employed to demonstrate this were indeed dependent on telescopic observations, the gist of the matter was that a Jesuit, jealous custodian of tradition, would hardly have dared to cast doubt on the incorruptibility of the heavenly bodies. A sun with spots on it was almost offensive. Accordingly, those spots must have been stars, situated between the Earth and the Sun, deceptively appearing to the eye to be part of its surface. Galileo accepted Welser's challenge to take a stand,



Galileo's drawings and notes on spots observed on the sun's surface (Biblioteca Nazionale, Florence, Ms. Gal. 57, c. 69r)



Galileo, *Istoria e dimostrazioni intorno alle macchie solari e loro accidenti…*, in Roma, appresso Giacomo Mascardi, 1613 - Frontispiece

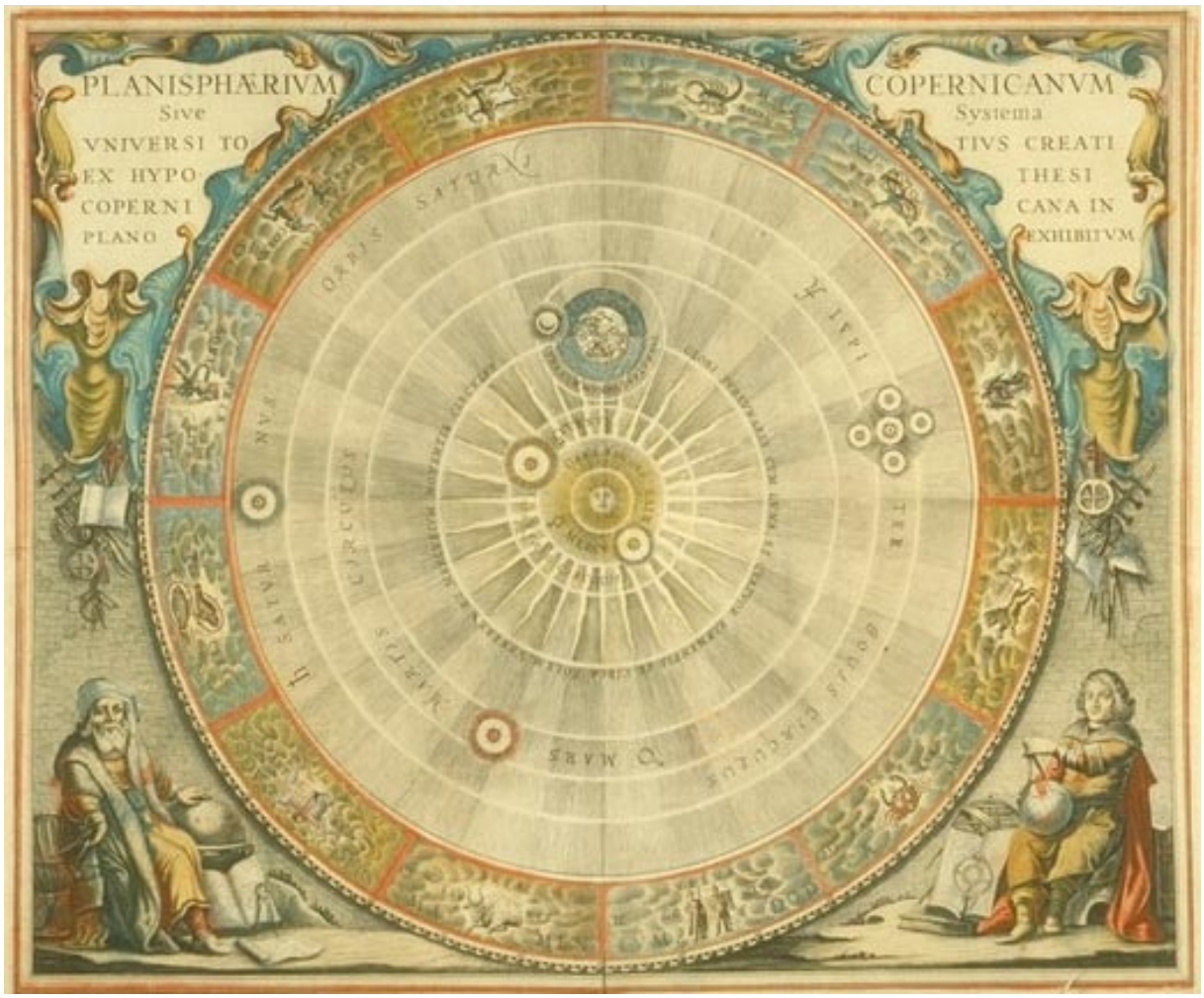
and in 1613, with the support of the Academy of the Lincei, he published his *History and Demonstrations concerning Sunspots and their Phenomena*. In this text he refused to acknowledge Scheiner's stars, reassigning them their role of solar corruptors, continually disappearing and reappearing like a kind of cloud near the surface of the Sun, which probably drew them in a rotary motion around its axis.

Unusually prudent as to the true nature of sunspots, certain of knowing more what they were not than what they really were, Galileo nevertheless showed no humility in his general view of his adversaries' work. A few scientists and too many men, by now accustomed to recoil from 'every tiny little alteration' in the sky, appeared to him to be slaves of the education imposed on them and psychologically prisoners

Ptolemaic planisphere (Andreas Cellarius, *Harmonia macrocosmica seu atlas universalis et novus totius universi creati cosmographiam generalem et novam exhibens*, Amstelodami, apud Ioannem Ianssonium, 1661)

of a concept of the world dominated by ancestral fears. 'I fear that our attempt to measure the whole with our own poor means leads us into strange fantasies, and that our particular hatred of death makes fragility hateful to us.' Here the use of the first person was obviously a euphemism for the third. Rising above this kind of scientific infancy, Galileo flourished his own idea of knowledge, which consisted not of 'penetrating the true and intrinsic essence' of each individual natural phenomenon, leaping inconclusively from one to another, but of collocating their causes within a general world system, linking them and explaining one by another. In this way the study of sunspots had led him, step by step, to affirm the similarity of heavenly and terrestrial bodies and to hypothesise the rotation of the Sun around its own axis, a rotation that was transmitted to the bodies near it.

More and more pieces were being put together to form the mosaic, including rotation of Venus around the Sun, by then fully revealed, 'in accordance with the positions of Pythagoreans and Copernicus.' Aristotle and Ptolemy were tottering. For Galileo, contemporary philosophy had now become a 'great untuned organ' and from his superior height he looked down on the 'many organists striving in vain to bring it



Copernican planisphere (Andreas Cellarius, *Harmonia macrocosmica seu atlas universalis et novus totius universi creati cosmographiam generalem et novam exhibens*, Amstelodami, apud Ioannem Ianssonium, 1661)

into perfect tune.' He saw them failing because they had left 'untuned three or four of the main organ-pipes', which prevented the perfection of the general harmony. To be treated as a deaf organ-tuner must have been highly annoying to Scheiner, and, behind the subsequent controversy as to which of them had been first to observe the sunspots, there probably lurked other factors.

Emblem of the Jesuit Order (Luis de Alcazar, *Vestigatio arcani sensus in Apocalypsi, cum opusculo de sacris ponderibus ac mensuris*, Antverpiae, apud Ioannem Keerbergium, 1614 - Frontispiece)

This hidden rancour was to grow in time into fierce mutual contempt, so that over twenty years later Galileo, having abandoned his romantic musical metaphors, was to refer to Scheiner as 'loathsome animal', 'pig and malevolent ass', 'contemptible little man', 'miserable wretch', whose 'childish babblings' it was a waste of time to pursue. In comparison, the lack of an ear for music was a trifling matter. The controversy with Scheiner officially inaugurated Galileo's hostile relationship with the Jesuits, destined to weigh heavily on his studies and his life. But, as he was soon to realise, it was not only the Jesuits whom he had to guard against.

View of the Collegio Romano and the Church of Sant'Ignazio, Rome (Giuseppe Vasi, *Delle magnificenze di Roma antica e moderna*, in Roma, nella stamperia del Chracas presso S. Marco al Corso, 1747-1761)

Against the motion of the Earth 1612-1615

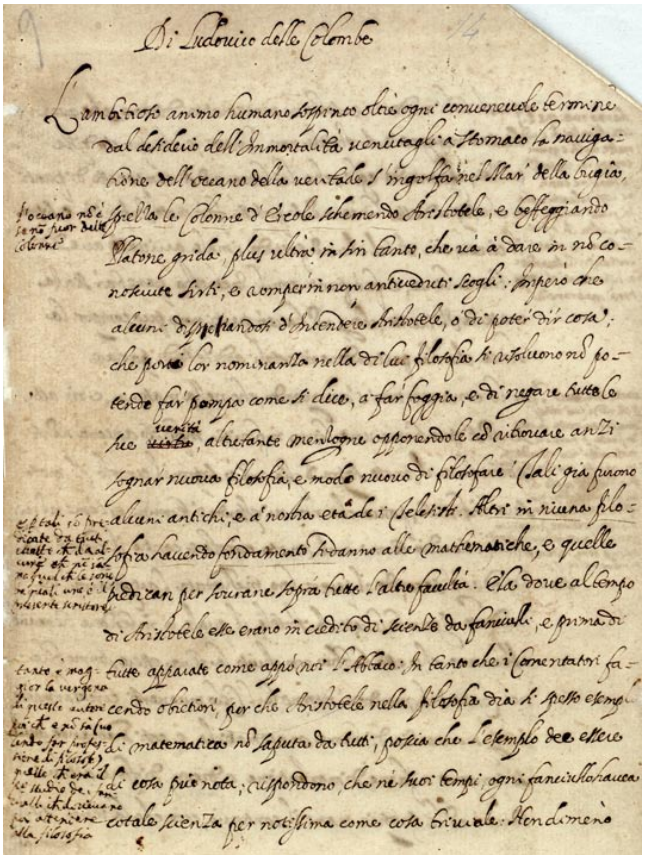
There has been in Florence an inept speaker, who has come out strongly against the motion of the Earth; but this good man is so knowledgeable about the author of this doctrine as to call him *Hypernicus*. Now may Your Excellency see from where and by whom poor philosophy is so mistreated.

In late 1612 Galileo, scornful as usual, informed Cesi that the Dominican, Niccolò Lorini, professor of Ecclesiastical History at the Studio of Florence, had written to him saying that 'the views of that Hypernicus, or whatever he is called', seem

Galileo before the Dominican Council. Oil on canvas by Friedrich Karl Hausmann, 1852 (Wallraf-Richartz-Museum, Cologne)

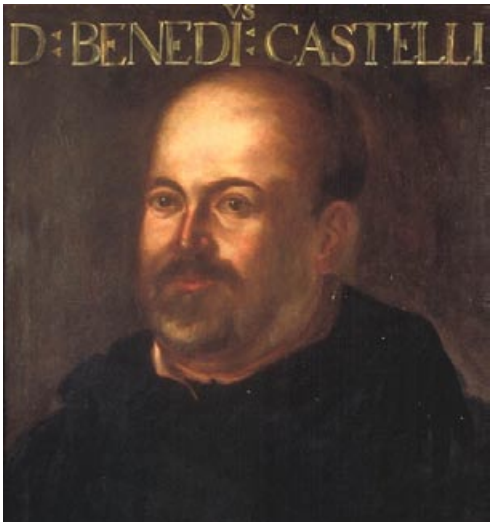
opposed to Divine Scripture. And in *mistreating poor philosophy*, Lorini was in good company. A real network of adversaries, 'a band of malign individuals envious of the virtue and merits' of Galileo were uniting, as he was warned by Lodovico Cardi Cigoli, under the guidance of the Archbishop of Florence, Alessandro Marzimedici. The instigator of this initiative was probably the already notorious Lodovico delle Colombe, who had circulated the year before a work entitled *Contro il moto della Terra* [Against the Motion of the Earth] in which, he was convinced, he 'dealt a death blow' to Copernican thought, by opposing to it every passage in Holy Scripture that would

seem to contradict it. Galileo was now thrust, in spite of himself and for the first time, onto the slippery path of comparing scientific theories and holy texts. And when the path is slippery, it is easy to slip. In the letter sent to Benedetto Castelli in late 1613, he set forth his position: nature and Holy Scripture are both the 'Divine Word'; but while nature is a language 'of things … that never transgress the terms of the laws imposed on them', Scripture is a language 'of words', a useful means of 'adaptation to the capacities of ordinary people' and requiring the mediation of an interpreter, who cannot be limited to the literal meaning, especially when the significance of the words seems to conflict with what 'reason and experiment puts before our eyes.' That is to say: nature is the true, divine language, which cannot be subject to its divulged version, good only for those unable to understand it directly. As Galileo explained elsewhere: 'Names and attributes must be accommodated to the essence of things, and not the essence to the names, because things came first, and their names subsequently.'


Di Ludovico delle Colombe

Opening page of a text by Ludovico delle Colombe, *Contro il moto della terra*, with autograph marginal notes by Galileo (Biblioteca Nazionale, Florence, Ms. Gal. 66, c. 14r).

The *Letter to Castelli* began to circulate in manuscript form and was soon widely disseminated in secret, going beyond the boundaries of the small Galilean circle. Denunciations soon arrived, and the polemic spread beyond Tuscany. Lorini again, speaking for the Fathers of the 'most religious Monastery of S. Marco' in Florence, sent a letter to the Congregation of the Index. Six weeks later another Dominican, Tommaso Caccini, who had been thundering against the Copernican perversion from the pulpit of the church of Santa Maria Novella, made a spontaneous declaration before the Inquisition.



Portrait of Benedetto Castelli. Oil on canvas. Copy from the Collezione Gioviana (Istituto e Museo di Storia della Scienza, Florence).

Oval showing the restructuring and enlargement of the Convent of San Marco (Palazzo Vecchio, Florence, detail of the courtyard ceiling by Marco da Faenza, 1556).

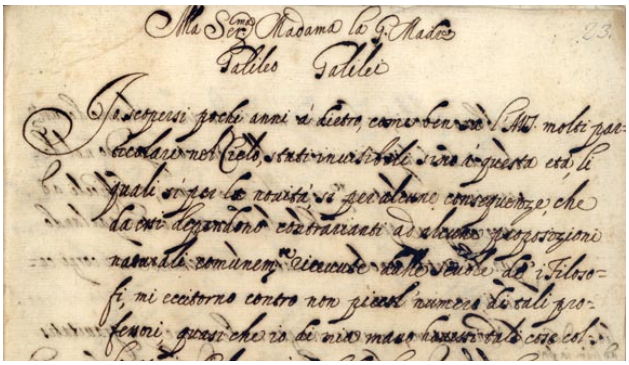
That the strings were pulled by a single puppeteer is clear from a letter sent to Tommaso Caccini by his brother Matteo to dissuade him from 'mixing himself in the affairs of others' and reprove him for having 'let himself be such a stupid fool as to stir up the doves.' This was a barely concealed allusion to the name of Delle Colombe who as usual continued to weave his plots in collusion with people of the lowest cultural level. Among the latter was the Bishop of Fiesole, Baccio Gherardini, who in a surge of geocentrism 'erupted with the greatest vehemence' against Galileo without knowing – as Galileo himself tells us – that the father of the heliocentric theory 'was not a live Florentine, but a dead German', that is, Copernicus.

Portrait of Giovanni di Paolo Rucellai: detail of the façade of the church of Santa Maria Novella, Florence. Oil on wood panel attributed to Francesco Salviati, c. 1540 (Collezione Rucellai, Florence).

There followed a trial in which several people, all of them friars, were called upon to testify. The accusations against Galileo, direct and indirect, were very serious, concerning not only the *Letter to Castelli*, of which a copy that may have been forged was sent to the Inquisition, but, more significantly, his strong, well-founded support of the Copernican system, whose very bases it was purposed to declare heretical. All this was seen by the accusers against a murky background of so-called deviant friendships, such as that with Paolo Sarpi, 'so famous in Venice for his impiety', and 'others from Germany' (the academicians of the Lincei, of German, and thus Protestant, origin) and of shocking heresies regarding the strictly theological area, attributed to people identified only as his 'disciples' or generically as 'Galileians.'

In parallel with the trial, a debate had arisen among figures of higher intellectual standing: the viewpoint of science against that of the Church. In 1615, in a letter officially addressed to Christine of Lorraine, the bigoted Dowager Grand Duchess of Tuscany, Galileo insisted on defending the independence of scientific research from religion and warned against 'barring the way to free philosophising on the world and on nature, as if everything had already been established with certainty and made clear.' The *Letter to Christine of Lorraine* (which, like the *Letter to Castelli*, prudently remained unpublished) was essentially a reply to Robert Bellarmine, the future saint, who had played a leading part in the discussion on Copernican thought. 'The supposition that the Earth moves and the Sun stands still answers to all the appearances … and is well said,' he wrote, but to maintain that the Sun 'actually' stands at the centre of the universe and does not move from east to west, while the Earth rotates

Portrait of Christine of Lorraine. Oil on canvas by Tiberio Titi, c. 1609 (Palazzo Pitti, Florence)



First page of a copy of the *Lettera a Cristina di Lorena*, 17th century (Biblioteca Nazionale, Florence, Ms. Gal. 65, c. 23r)

around it, 'is a very dangerous thing, which not only disturbs scholastic philosophers and theologians, but also endangers Holy Faith by rendering false Holy Scripture.' Bellarmine's position was based on the sophistic distinction between abstract hypothesis and truth based on the observation of nature, a position in which the Church had taken refuge since the emergence of the new cosmological theories, concerned not with the appearances of the phenomena but with the credibility of Holy Scripture, given the glaring scientific errors that were beginning to be exposed in it. By now, direct experience and Galileo's astronomical discoveries confirmed beyond doubt many mathematical demonstrations of Copernicus, exposing the falsity of Aristotle and Ptolemy's arguments regarding the movement of planets in the solar system. The path of simple theoretical confrontation thus appeared increasingly arduous. The arguments against the merely hypothetical nature of heliocentrism were too many and too hard to disprove from a standpoint not based in physics or astronomy. But the Church had other, very different, means of safeguarding its own impregnability.

Bust of Cardinal Robert Bellarmine by Bernini, 1621-1624 (Chiesa del Gesù, Rome)

Black clothing befits our times... 1615-1616

A defensive strategy based on clandestine pamphlets and covert negotiations by mediators proving insufficient, Galileo decided in late 1615 to travel to Rome again to justify his position. But for him, this meant having the truth of his theories accepted, and Rome certainly did not offer a suitable climate for this, despite

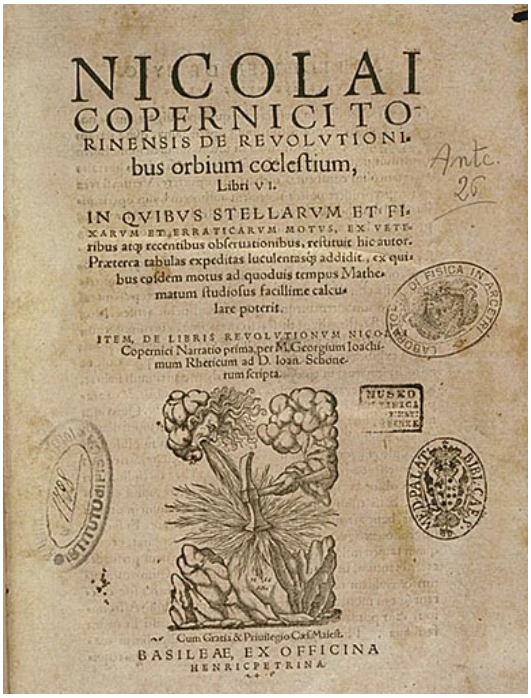
Galileo explaining his theory of the earth's motion before officials of the Inquisition. Oil on canvas by Carlo Felice Biscarra, 1859 (Castello Ducale, Aglié, Piedmont)

the apparent openings of a few years before. In Rome the atmosphere was more and more oppressive, increasingly barred to free discussion and impermeable to all innovation, a climate described by Tommaso Campanella, who knew it intimately, as 'horrendous', filled with 'ignorance and fear', a time of black mourning clothes, 'dark, nocturnal, hostile, infernal, treacherous', suggesting unnatural death. And such a climate had been the experience of many in previous years.

Concerned and distraught, the Tuscan ambassador to Rome, Piero Guicciardini, sent dispatches to Florence to inform the Court of how Galileo 'fiercely defended his opinions', how he was subject to 'extreme passion and showed little discipline and prudence in controlling it', and how that 'sky of Rome' was 'very dangerous' for him. Guicciardini warned that Rome was not a 'place in which to come and dispute about the Moon', and he was right.

Galileo before the Inquisition. Oil on canvas by Cristiano Banti, 1857 (Collezione Elena Fragni, Milan)

On March 1, 1616 in an apparently private session held at Bellarmine's home, the Congregation of the Index gave its verdict. A prohibition was placed on the *Lettera sopra l'oppinione de' pittagorici e del Copernico* [Letter concerning the Opinion of the Pythagoreans and Copernicus] by the Calabrian Carmelite, Paolo Antonio Foscarini, guilty of having attempted conciliation by finding analogies between Copernicus' theories and many passages in Holy Scripture. Suspension until corrected, 'donec corrigantur', was imposed on the *De revolutionibus* by Copernicus and the *Commentarii in Job* by Diego de Zuñiga, a Spanish theologian who had given a verse in the *Book of Job* a pro-Copernican interpretation. Although a previous opinion issued by the Inquisition's


NICOLAI
COPERNICI TO-
RINENSIS DE REVOLVTIONI-
bus orbium cœlestium,
Libri VI.
IN QVIBVS STELLARVM ET FI-
XARVM ET ERRATICARVM MOTVS, EX VETE-
ribus atq; recentibus observationibus, restituit hic autor.
Præterea tabulas expeditas luculentasq; addidit, ex quibus eosdem motus ad quoduis tempus Mathematum studiosus facillime calculare poterit.
ITEM, DE LIBRIS REVOLVTIONVM NICOLAI
Copernici Narratio prima, per M. Georgium Joachimum Rheticum ad D. Ioan. Schonerum scripta.
Cum Gratia & Priuilegio Cæs. Maiest.
BASILEAE, EX OFFICINA
HENRICPETRINA

Frontispiece of the second edition of Copernicus' *De revolutionibus orbium coelestium*, printed in Bâle in 1566 by Sebastian Henricpetri.

Portrait of Cardinal Maffeo Barberini. Oil on canvas by Caravaggio, 1598-1599 (Private collection, Florence)

Portrait of Paul V. Oil on canvas by Caravaggio, 1605 (Prince Camillo Borghese private collection, Rome)

theological consultants pressed for a sentence of *formal heresy*, the decree declared the heliocentric theory to be *false* but not *heretical*, and Galileo himself was not even mentioned. He received only a verbal caution from Cardinal Bellarmine, which he was obliged to accept. The lightness of the sentence was owing, it seems, to the intervention of the Cardinals Bonifacio Caetani and Maffeo Barberini (the future Pope Urban VIII), who were opposed to labelling as heretical the mobility of the Earth. A further factor was presumably Pope Paul V's debt to the Grand Duke of Tuscany, Cosimo II de' Medici, who had actively supported his election to the papacy, and who would have been indirectly damaged by the infliction of a severe sentence on his Chief Mathematician.

Galileo, at first optimistic, interpreted the verdict of the Congregation of the Index as aimed only at those who had seen analogies between Copernican thought and Holy Scripture. 'From the work of Copernicus himself,' he wrote in relief to Curzio Picchena, Secretary of State of the Grand Duchy of Tuscany, 'they will eliminate ten verses of the dedicatory preface to Paul III, in which he hints that he does not consider his doctrine opposed to Scripture.' But his optimism was soon to fade. When Galileo requested Car-

dinal Bellarmine to deny the false rumours circulated by his detractors that he had been forced to make a humiliating abjuration in Rome, the Cardinal's declaration was conclusive: no abjuration had been demanded of Galileo, nor had 'healthy penitence' been inflicted on him; but 'the doctrine attributed to Copernicus that the Earth moves around the Sun and the Sun stands at the centre of the world without moving from east to west' was 'contrary to Holy Scripture and in no case could be defended or held.' In the *Letter to Christine of Lorraine*, Galileo had feared the possibility that 'this particular proposition' of the *De revolutionibus* might be 'condemned as erroneous', on the grounds that this would be 'of greater detriment to the minds of men' than if the whole book were prohibited, because it would mean that 'a proposition had been proved that it was a sin to believe.'

Galileo explaining his discoveries. Oil on canvas by Théophile Gide, 19th century (Musée des Beaux-Arts, Bordeaux).

In spite of this, Galileo asked for and was granted permission to stay longer in Rome. His fighting spirit or, in the words of the increasingly agitated Guicciardini, his 'confirmed habit of taming the friars', led him, although at risk of falling 'into the deepest abyss', not only to defend the independence of scientific research but also to claim justice, rightly convinced of being the victim of those 'monkish persecutions' from which Picchena had tried to protect him. He wrote:

…to hope for the longed-for peace would, moreover, be entirely vain, both because envy is immortal, and because my enemies have found a way to torment me with impunity, by disguising themselves with simulated religion to make me appear devoid of true religion.

This reveals a bitterness equal to that experienced a few weeks earlier at a meeting with his main accuser, Tommaso Caccini, who had expressed scorn for his 'simulated repentance' and had accused him of having 'a mind filled not only with great ignorance but with poison, and devoid of charity.'

All told, Galileo returned to Florence defeated, and was compelled from then to fight secret battles with the blunted weapon of a mutilated Copernicanism, in an Italy where no one – as Sarpi lamented – could live safely without a mask to protect him. Such a device masked not only men, but also books, persistently corrected, to disguise with convenient hypotheses all the proven scientific truths that could cast any doubt on the credibility of Scripture.

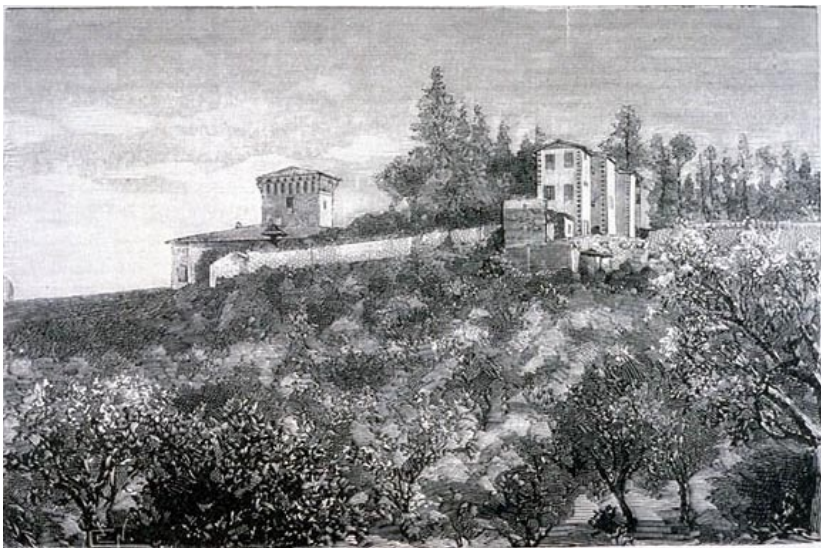
A sitting of the Inquisition. Oil on panel by Goya, 1812-1819 (Museo de la Real Academia de Bellas Artes de San Fernando, Madrid)

Comets 1617-1619

In his *Letter to Christine of Lorraine* Galileo had been over-confident in supposing that the heliocentric theory could not be suppressed. 'Closing the mouth of one man' would not be sufficient: it would be necessary to 'ban … the work of Copernicus and the writings of other authors who held the same doctrine', 'to prohibit the whole science of astronomy', to the point of stopping men from 'looking at the sky.' Today we know that he was ultimately right, but unfortunately certain historical processes last much longer than the lifetime of a man. However, some faint signals that the drops were carving a groove in the stone were soon to emerge. No longer able to deny the evidence of what was demonstrated by telescopic observation, but still refusing to countenance, as a concept 'damned', the mobility of the Earth, many Jesuit astronomers had begun to embrace a mixed system hypothesized by the Danish scientist Tycho Brahe (d. 1601), who had attempted to mediate between the Ptolemaic and the Copernican systems. This had given rise to a sort of geo-heliocentrism, whereby the Sun was held to complete one revolution around the Earth, together with all the other planets rotating around it in their turn. The Tychonic system failed to explain all the phenomena, but it did leave the Earth firmly immobile at the centre of the universe. This was enough for the Jesuits, so terrified by the idea of a mobile Earth as to overlook even the fact that, from the orthodox Catholic viewpoint, Tycho Brahe was an abominable heretic of Protestant faith. Galileo, for his part, had never taken Tycho's efforts seriously, finding in his cosmic system 'the major difficulties' that had made him 'part ways with Ptolemy.' He had even refused – difficult, decided character that he was – to have any contact with Tycho in person, never agreeing to the latter's requests for an exchange of ideas.

Tycho Brahe in his observatory at Uraniborg Castle on the island of Hven (Willem Janszoon Blaeu, Le grand atlas, ou *Cosmographie Blaviane, en laquelle est exactement descripte la Terre, la mer et le ciel*, à Amsterdam, chez Jean Blaeu, 1667).

Galileo continued to pursue his studies with discretion. In 1617 he withdrew to the country, renting a villa on the hill of Bellosguardo, where he moved with his son Vincenzo. His two daughters, both nuns, had already been living nearby for some years in the convent of San Matteo in Arcetri, also outside the city walls.



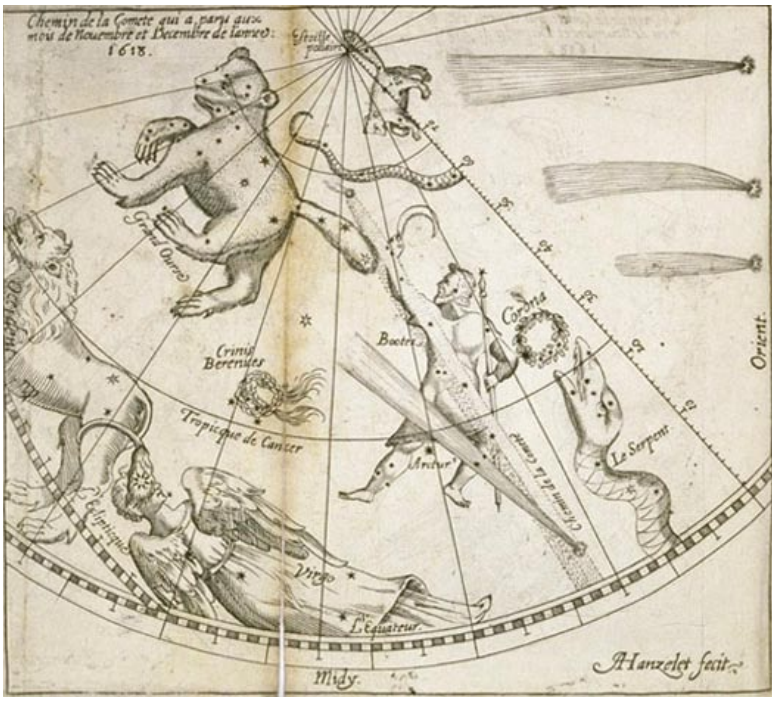
Villa at Bellosguardo, known as dell'Ombrellino (Domus Galilaeana, Pisa, Misc. Favaro 54, filza 26).

The retired residence on the Florentine hills, over which Galileo travelled on mule-back to visit his daughters, was not paralleled by a similar intellectual isolation, despite the precautions taken after the events of 1616. On the contrary, Galileo was still considered the protagonist of scientific debate, a protagonist in his own individual way, bitingly critical of the dusty scholastic philosophies and ardently defending his own working methods.

In 1618-19 an occasion for new controversy was provided by the appearance of three comets, which Galileo could not even observe directly, since he was, as often, ill and confined to his bed. This time Jesuit thought was embodied by Father Orazio Grassi, who published an anonymous treatise (*De tribus cometis anni MDCXVIII disputatio astronomica* [An Astronomical Disputation on the Three Comets of the year 1618]), to which Galileo replied in 1619 with the *Discourse on Comets*, prudently signed by his pupil Mario Guiducci, but in fact essentially his own. The discussion on the nature of comets was concerned with their collocation in the heavenly regions, their appearance when enlarged by the telescope and, above all, the curvature of their tails and their motion, which Galileo, in opposition to Grassi, believed to be rectilinear, though the observations clearly revealed an apparent deviation that called for an

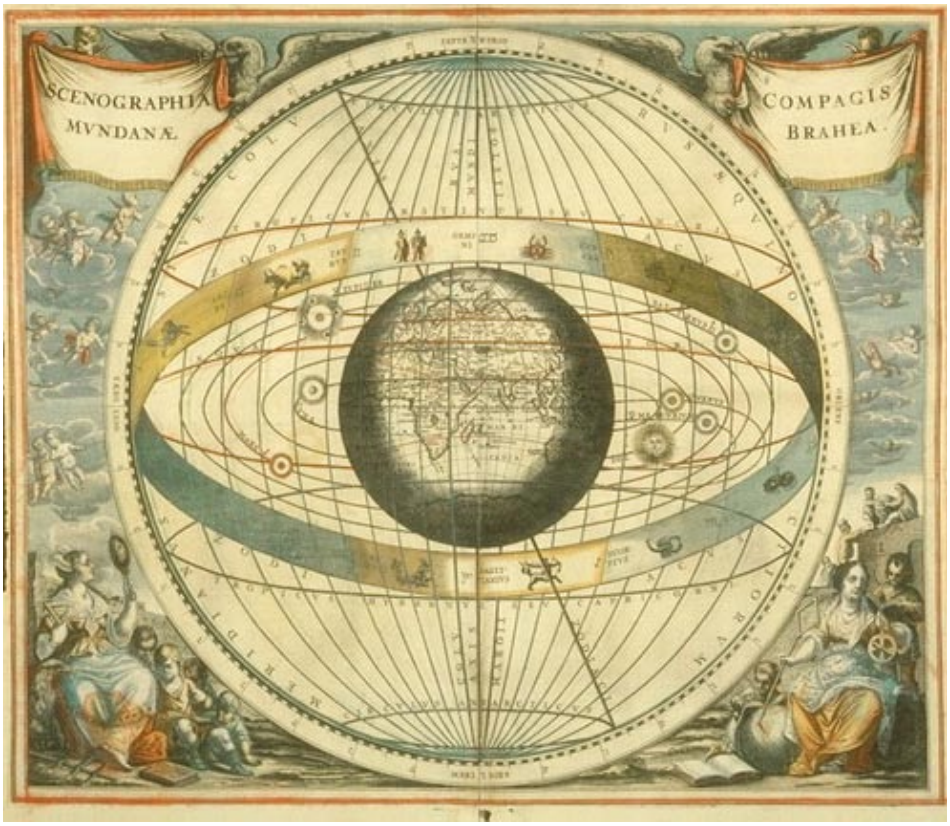

DISCORSO
DELLE COMETE
DI MARIO GVIDVCCI
FATTO DA LVI
NELL'ACCADEMIA FIORENTINA
NEL SVO MEDESIMO CONSOLATO
IN FIRENZE
Nella Stamperia di Pietro Cecconcelli, Alle Stelle Medicee. 1619.
CON LICENZIA DE' SVPERIORI.

Discorso delle comete di Mario Guiducci fatto da lui nell'Accademia fiorentina nel suo medesimo consolato, in Firenze, nella stamperia di Pietro Cecconcelli alle Stelle Medicee, 1619 – Frontispiece



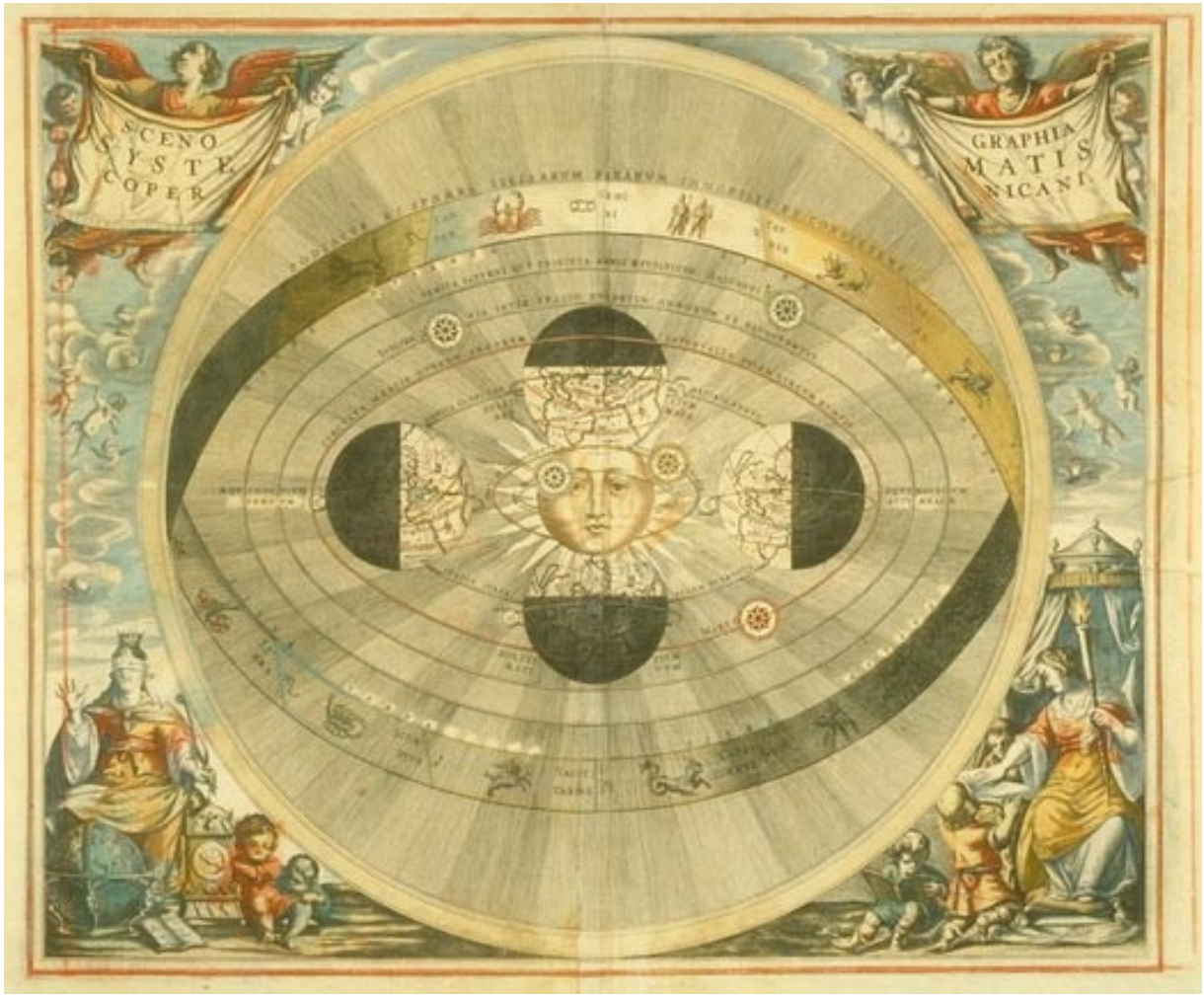
Map of the heavens charting the passage of a comet that appeared in December 1618 (Charles Le Pois, *Physicum cometae speculum, in quo natura, caussae, species atque formae, varii motis, statio, moles, natale tempus, aetas, occasus viresque seu effectus deteguntur et accurate atque dilucide demonstrantur*, Ponte ad Montionem, apud Carolum Mercatorem, 1619)

explanation. Underlying the discussion, though not made explicit, was the clash between two different world systems: that of Tycho against that of the unnameable, but essential, Copernicus. 'We,' states the *Discourse*, 'should content ourselves with the little that can be conjectured amid the shadows, until the true constitution of the parts of the world has been determined, because that promised us by Tycho remains



Tycho Brahe's cosmographic system (Andreas Cellarius, *Harmonia macrocosmica seu atlas universalis et novus totius universi creati cosmographiam generalem et novam exhibens*, Amstelodami, apud Ioannem Ianssonium, 1661)

imperfect.' What then could be the silent reason for that apparent curve in the movement of comets? 'I hear someone, I know not who, who whispers in my ear, fearful and subdued: the motion of the Earth. Away with this false locution, grating to the ears of a devout man!' said Father Grassi maliciously, repaying Galileo with a coin supposed to ring truer, since it was fused with other metals than those of science alone.



Nicholas Copernicus' cosmographic system (Andreas Cellarius, *Harmonia macrocosmica seu atlas universalis et novus totius universi creati cosmographiam generalem et novam exhibens*, Amstelodami, apud Ioannem Ianssonium, 1661)

Scales and Balances 1619-1623

The controversy did not stop here but went much further, in both time and content. Galileo, in his *Discourse on Comets*, had not spared his adversary, Grassi, and even less the real target of his arrows, Tycho Brahe, dead and buried for him both in reality and metaphorically. Not even the Jesuit *Collegio Romano* was safe from attack, owing to a number of errors committed in the school of mathematics concerning the telescopic observation of comets. Hostility and resentment against Galileo obviously mounted in Jesuit circles and in this poisonous atmosphere the idea was formed of making a reply, which was entrusted once again to Father Grassi, who later in 1619 published the *Libra astronomica ac philosophica* [The Astronomical and Philosophical Weighing Scales] under the pseudonym of Lothario Sarsi. While the title seemed to imply calm, thoughtful consideration (an attitude claimed by the author at every step) in weighing the various theories on comets, in reality the work breathed rancour from every pore. Although justly noting certain logical inconsistencies found in the *Discourse,* which was indeed casual with regard to the development of the argument, the *Libra* was still based on the usual scholastic canons, and thus had few means apart from verbal aggression of combating the deep-seated objections cited by Galileo and Guiducci.

Tycho Brahe's tombstone (Church of Our Lady before T_n, Prague)


LIBRA
ASTRONOMICA
AC PHILOSOPHICA
QVA GALILAEI GALILAEI
Opiniones de Cometis
A MARIO GVIDVCIO
In Florentina Academia expositæ, atque in lucem nuper editæ, examinantur
A LOTHARIO SARSIO
SIGENSANO.
PERVSIÆ,
Ex Typographia Marci Naccarini. M. DC. XIX.
SVPERIORVM PERMISSV.

Orazio Grassi, *Libra astronomica ac philosophica…*, Perusiae, ex Typographia Marci Naccarini, 1619 - Frontispiece

Galileo was to reply in turn, not immediately, but a few years later in 1623, under the patronage of the Academy of the Lincei, which dedicated the work to the new Pope Urban VIII, the former Maffeo Barberini, the cardinal who, on the occasion of the unfortunate events of 1616, had been one of the less radical opponents of the Copernican theories. According to a letter from the academician Francesco Stelluti, Father Grassi, on seeing merely the frontispiece of the newly published volume, 'changed colour', because, if the content matched the title, for him there was little to celebrate. Galileo had written *The Assayer, in which are weighed with a fine and accurate balance the contents of 'The Astronomical and Philosophical Weighing Scales* (libra)*' of Lothario Sarsi of Siguenza*. The *assayer* was the goldsmith's precision balance, the *libra* was the greengrocer's scales. With this preliminary word play, Galileo revealed his intentions, which were to combat the coarse arguments of his rival with scientific rigour. The cutting, ironic tone of the text is deceptive: it was not a blow by blow response to Grassi's animosity. Galileo enjoyed suggesting to him other titles for his work, such as *The Astronomical and Philosophical Scorpion*, referring to the poisonous bites he had been given, playing on the double meaning in the names of the constellations (*Libra* was also the Latin name for the zodiacal

Polychromatic stucco bas-relief picturing the emblem of the Academy of the Lincei with the motto *Sagacius ista* (Museo di Storia Naturale di Firenze, Florence - Sezione di Zoologia "La Specola" - Tribuna di Galileo, vestibule, intrados of the left arch).

Galileo Galilei, *Il saggiatore*, in Roma, appresso Giacomo Mascardi, 1623 – Frontispiece

Allegory of Mathematics. Fresco by Giulio Parigi, 1599-1600 (Galleria degli Uffizi, Florence, Stanzino delle Matematiche)

sign of the Scales), but, notwithstanding this impertinent and occasionally heavy manner, he replied point for point to the whole treatise. Going far beyond the question of comets from which it started, *The Assayer* is a true discourse on method. It launched a frontal attack on the Aristotelian mode of proceeding in naturalist investigations adopted by Catholic culture, now made obsolete by events and kept artificially alive for reasons that had nothing to do with any desire to find the true causes of phenomena. Fitting material for scientific research was not, for Galileo, the work of poets, 'such as the *Iliad* and *Orlando Furioso*, books in which the least important thing is whether what is written in them is true or not', but 'this greatest book that lies constantly open before our eyes', that is, the universe. In the past, Galileo had already commented ironically on the library naturalists, who never wished to

Allegory of Natural Philosophy. Detail from the frontispiece of *Il Saggiatore*

Allegory of Mathematics. Detail from the frontispiece of *Il Saggiatore*

'lift their eyes from those papers, almost as if this great book of the world had been written by nature only to be read by Aristotle.' Galileo's knife was double-edged. It struck on one side the principle of authority, the cornerstone of the scholastic method, which was based solely on the opinions of writers and on comparison of texts, while in reality 'human authority' is devoid of any value that overrides 'the effects of nature, which is relentlessly deaf to our vain desires.' It also struck the dominant culture's mode of expression, which Galileo deemed 'vain wandering through a dark labyrinth.' Common language is not the one proper to natural philosophy, because the book of the universe is 'written in mathematical language', and the letters of this language are 'triangles, circles and other geometric figures.' Considering, however, that 'concentration on rigorous geometric demonstrations is too dangerous a venture for those who do not know how to manage them well', the scholars of the Aristotelian tradition, ignorant of mathematics, had always taken refuge in 'limitations', 'distinctions', 'distortion of words' and reckless, tortuous reasoning which had brought anything but progress to the knowledge of nature. Galileo saw the linguistic acrobatics of his opponents as a means of eluding the inevitability of demonstration, the only way that led, concisely and immediately, to a definitive distinction between the true and the false. He elaborated this in his own way with one of his most elegant images: 'In the necessary demonstrations… one must, in brief words and in the first assault, become either Caesar or nothing.' Apart from his mastery of the mathematical language, he was second to none in his skilled use of ordinary language.

Mathematics. Detail with a portrait of Galileo. Fresco with tempera retouches by Agnolo Gori, 1663 (Galleria degli Uffizi, Florence, west corridor, span 74)

Within a few years, the tactics of the Jesuits, in the face of such science, showed themselves for what they were, raising the spectre of prison whenever theory could not come to their aid. In 1626 Father Grassi, in yet another of his replies, isolated a passage from *The Assayer* in which Galileo described as intrinsically proper to bodies only certain characteristics such as motion, figure, number, dimension (that is, everything that can be measured), which, he maintained, depended on the activity of 'a multitude of tiny bodies' of which matter is composed. The other characteristics, such as taste, colour, and odour, have value only for the sense organs that perceive them, being nothing in relation to the bodies and their physical properties, 'pure names', as Galileo said. But, commented Father Grassi, 'It is commonly affirmed that, in the Host, heat flavour and such persist. We must thus infer that Galileo maintains that heat and taste do not exist in the host. The soul is horrified at the very thought!' With this *coup de main* the discussion was shifted from the scientific level, where the confrontation was unequal, to the theological one, where confrontation was inadmissible. And Rome was now haunted by the spectre of prison. The Inquisition began to examine the work of Galileo, who only a few years before had obtained the *imprimatur* without difficulty, to identify all the points where his stealthy atomism might have violated the Catholic doctrine of the Eucharist and the dogma of transubstantiation.

View of Saint Peter's and the Palace of the Inquisition from the Porta Cavalleggeri (Giuseppe Vasi, *Delle magnificenze di Roma antica e moderna*, in Roma, nella stamperia del Chracas presso S. Marco al Corso, 1747-1761, vol. I)

Hopes 1624-1631

Portrait of Urban VIII. Oil on canvas by Pietro da Cortona, c.1627 (Pinacoteca Capitolina, Rome).

Those who imagined that prohibitions, insults, provocations, or even threats would persuade Galileo to abandon his world system were greatly in error. The conviction of 'having in his mind things of importance for the learned world' was equal to his innate stubbornness. The expression of thought can be inhibited, but the act of thought, apart from drastic solutions, fortunately cannot. And Galileo had never lost hope of the rehabilitation of Copernican thought; unless its truth could be recognised, his world would remain forever warped. The election of Pope Urban VIII seemed an occasion to be grasped immediately. A few years before, in the grip of poetic inspiration, the pope-to-be had composed verses full of wondering admiration, significantly entitled *Adulatio perniciosa* [Pernicious adulation], in praise of the 'lens' of the 'learned Galileo' and the 'skill' that had allowed him to use it so profitably. Galileo's Roman friends too were enthusiastic, especially those associated with the Academy of the Lincei, some of whom had been called upon to form part of the papal entourage and had told Galileo how much the Pope had appreciated the dedication of *The Assayer*, so much so that he even had it 'read to him at table.' Further encouragement may have came from meetings Galileo probably had in 1616 with the future Pope in person. A dove among the hawks of the Inquisition, the then Cardinal Barberini must have worked to keep the theory of the Earth's mobility from being branded as heresy, and Galileo must have appreciated his more flexible approach.

The years from 1624 to 1631 were dense with activity. Galileo was absorbed in a new work, the most important of his life, which he succeeded in completing in spite of the time taken up by his frenetic diplomatic activity and his widespread network of contacts. Two journeys to Rome became necessary, in 1624 and again in 1630, as well as continuous correspondence, especially with Academicians of the Lincei who took on direction of the enterprise in Rome, having assumed responsibility for printing this work. All this represented a considerable burden for Galileo, now, at sixty, entering what was seen then as old age and constitutionally of fragile health. 'Courting is an activity for young men,' he wrote from Rome in 1624, 'who, with the robustness of their bodies and the enticement of hopes, are strong enough to tolerate such effort.' To think that his daughter Virginia had worried even about the walks Galileo took in the hills around Florence! Visiting her was no easy matter: from the villa at Bellosguardo to the convent at Arcetri the road was long, even on mule-back.

The Villa "Il Gioiello" at Arcetri, Florence

His son, who in the meantime had married Sestilia Bocchineri, of a well-to-do family, had acquired, thanks to the generous dowry, a comfortable house on the Costa S. Giorgio 'with a vegetable garden, water cistern and courtyard', which was closer to his sisters' residence. But Galileo did not live with him, continuing to prefer the isolation of his own hillside. Virginia, unresigned to this situation, busied herself to find an alternative and within a few years persuaded her father to move nearer: 'Now I have just heard of Signor Esaù Martellini's villa at Pian dei Giullari, very close to us.'

Galileo was to rent this in 1631 and the villa, Il Gioiello, near the convent of Arcetri, was to become the scene of the disappointment and unhappiness that poisoned the last years of his life.

In Rome, in 1624 Galileo had met a number of influential people, had received encouragement and assurances and had been given many gifts by the Pope, including a painting, a gold and a silver medal, a pension for his son, a laudatory brief to be handed to the Grand Duke, and 'a good number of *Agnus Dei* prayers.' In 1630 he brought home also the *imprimatur* for his new work, now finished, which was to have been printed in Rome. But he never obtained what he most wanted: public recognition of Copernicanism.

Were the views of Urban VIII really so different from those held officially by the Church up to then? The answer, it must be said, is an emphatic no. According to his personal theologian, Barberini, in line with the late Cardinal Bellarmine, gave further

The body of Cardinal Robert Bellarmine (Church of Sant'Ignazio, Rome)

force to the subordination of science to Scripture by bringing divine omnipotence into the question. To human reason, essentially weak, the concept of a moving Earth explained the appearances of the phenomena. But God, being omnipotent, would have had infinite other ways, incomprehensible to limited human reason, of producing the same phenomena. Could weak human reason demonstrate the incongruence

of any other structure in the universe, established by omnipotent God, that might give rise to exactly the same phenomena? Obviously, it could not. Consequently, regarding as true only one of these possible structures of the universe, the one that seemed the more plausible to weak human reason was purely illusory knowledge and should be abandoned in favour of the holy texts, which may be less convincing to a mathematical mind (also weak), but are always the word of omnipotent God and thus

Allegory of Theology (*Iconologia del cavaliere Cesare Ripa perugino notabilmente accresciuta d'immagini, di annotazioni e di fatti dall'abate Cesare Orlandi…*, in Perugia, nella stamperia di Piergiovanni Costantini, volume IV, 1766)

unquestionable. On these premises, the whole of scientific progress became pure illusion and nothing could be regarded as acquired knowledge. As it was impossible to refute each individual scientific achievement, no course was open but to negate the very possibility of science, acknowledging revelation as the only human path to knowledge. It seemed as if Barberini had never really wanted to have the hypothesis that the Earth moved condemned as heresy, content to call it 'daring', as was reported to Galileo, being basically convinced that there was no need 'to fear that anyone would ever be able to demonstrate that it was necessarily true.'

Needless to say, Galileo's attitude was completely different. For him science had its own field of action, particular to it and autonomous. It was concerned, not with understanding 'what God could do', but rather with 'what He had done', as he commented regarding a French mathematician who held similar opinions to those of Barberini. Certainly, to show his omnipotence, God could have caused birds to fly 'with their bones made of solid gold, their veins full of quicksilver, their flesh heavier than lead, and with their wings exceedingly small and heavy'; and he could have made fish heavy too. But he did not do so. Instead he 'preferred to make the former with bones,

Allegory of Science. Fresco by Giulio Carlini, 1854. (Palazzo del Bò, Padua, vault of the Aula Magna).

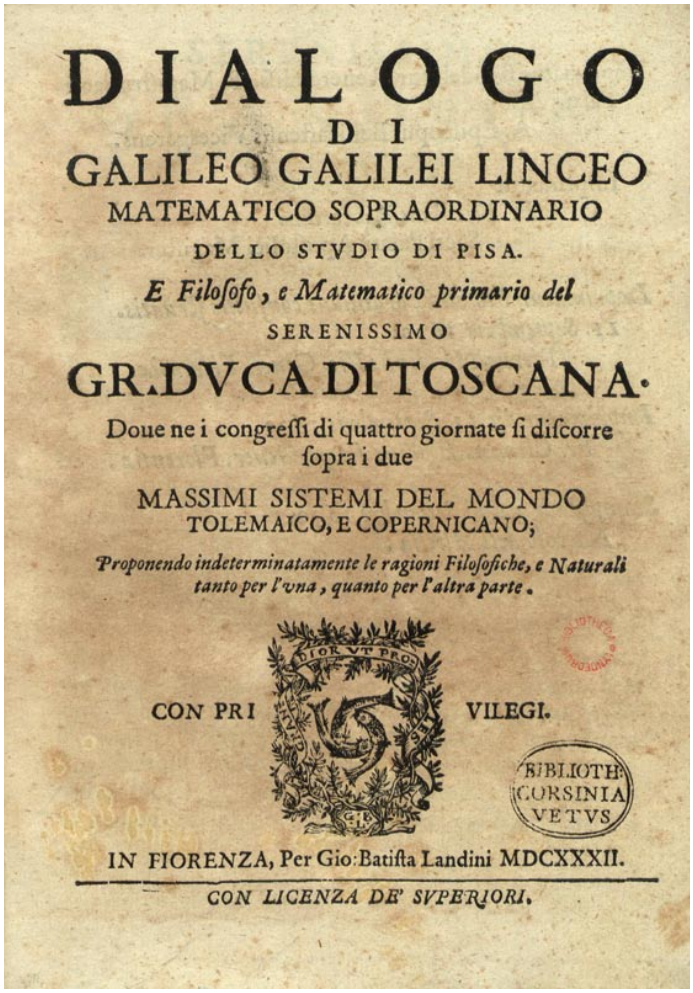
flesh and feathers very light in weight', so that they could fly, and the latter the 'same weight as water' so that they could swim. God, in fact, 'delights in simplicity and facility', that is, he takes pleasure in the clear, precise laws that govern nature. And moreover, was not nature itself divine language, a mathematical language at that?

Theology and science were now travelling on two parallel tracks, never again to meet, and this palpable contrast boded ill for the future. Fate also contributed to the gathering of other clouds on the horizon. In August 1630 Federico Cesi died. Galileo thus lost a strong supporter on the practical side of his work but, above all, his chief advocate in Roman circles, where Cesi had acted as a cushion through his network of mediation, thus considerably lessening the risks inherent in Galileo's difficult temperament. Then came the plague. With epidemic sweeping through Italy, objects could not be transported unless subjected to dangerous disinfection procedures. It was not safe to circulate Galileo's manuscript, just completed, in these precarious conditions. And what could Rome now offer him more than Florence? On the advice of all, Galileo decided to print his book at home. In his eagerness to publish it and in the precipitous course of events that followed, he failed to recognise the signs of a contrary wind.

The beginning of a new age 1632

Several years ago there was published in Rome a salutary edict which, in order to obviate the dangerous tendencies of our present age, imposed a suitable silence upon the Pythagorean opinion that the earth moves. There were those who impudently asserted that this decree had its origin not in judicious inquiry, but in passion none too well informed… Therefore I propose in the present work to show to foreign nations that as much is understood of this matter in Italy, and particularly in Rome, as transalpine diligence can ever have imagined… To this end I have taken the Copernican side in the discourse, proceeding as with a pure mathematical hypothesis and striving by every artifice to represent it as superior to supposing the earth motionless – not, indeed, absolutely, but as against the arguments of some professed Peripatetics. These men indeed deserve not even that name, for they do not walk about; they are content to adore the shadows, philosophising not with due circumspection but merely from having memorised a few ill-understood principles.

With this announcement in the foreword *To the discerning reader* Galileo thought he had ensured the safety of his *Dialogue … where, in the meetings of four days, there is discussion concerning the two Chief Systems of the World, Ptolemaic and Copernican, propounding inconclusively the philosophical and physical reasons as much for one side as for the other*, which was published in Florence in 1632 and dedicated to the new Grand Duke of Tuscany, Ferdinand II de' Medici. Indeed, Galileo's announcement contained the gist of the matter: Copernican theory presented as a mathematical hypothesis; terrestrial motion understood not in the absolute sense but only as methodological criticism of the Peripatetics, who opposed it; the censorship


DIALOGO
DI
GALILEO GALILEI LINCEO
MATEMATICO SOPRAORDINARIO
DELLO STVDIO DI PISA.
E Filosofo, e Matematico primario del
SERENISSIMO
GR. DVCA DI TOSCANA.
Doue ne i congressi di quattro giornate si discorre
sopra i due
MASSIMI SISTEMI DEL MONDO
TOLEMAICO, E COPERNICANO;
Proponendo indeterminatamente le ragioni Filosofiche, e Naturali tanto per l'vna, quanto per l'altra parte.
CON PRI VILEGI.
BIBLIOTH: CORSINIA VETVS
IN FIORENZA, Per Gio: Batista Landini MDCXXXII.
CON LICENZA DE' SVPERIORI.

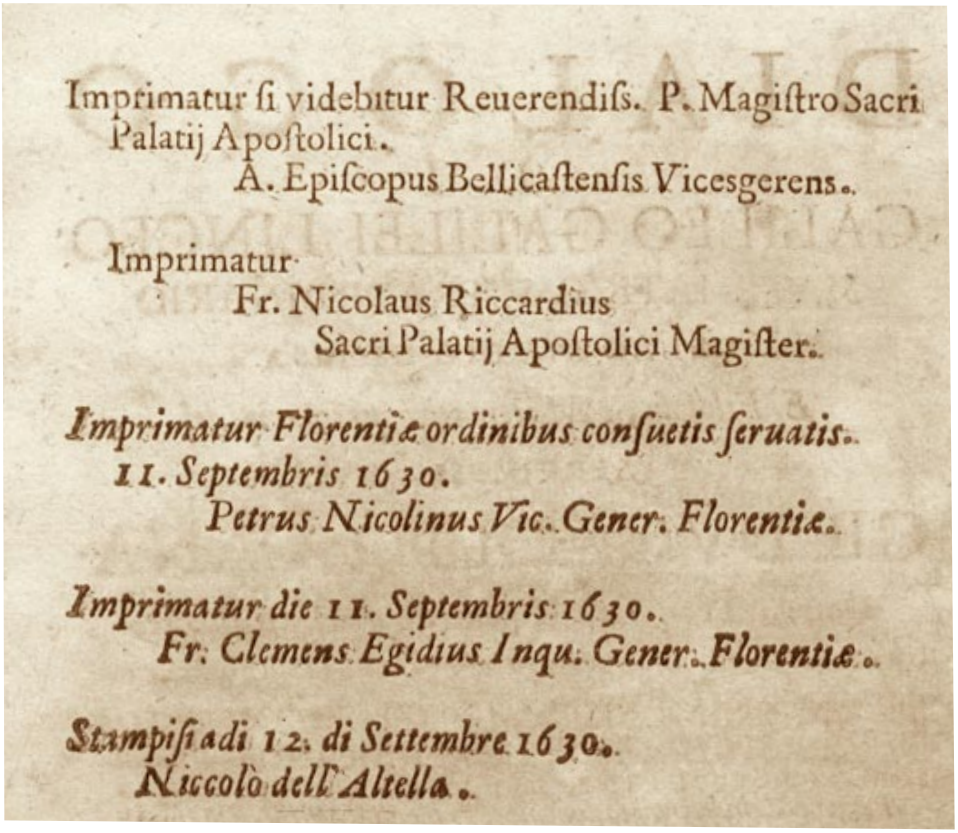
Galileo, *Dialogo sopra i due massimi sistemi del mondo*, in Fiorenza, per Gio. Batista Landini, 1632 - Frontispiece

of 1616 defined as a *salutary* measure against scandal and the scent of heresy; and the whole book presented as a defence of the Roman ecclesiastic milieu, accused of ignorance abroad, where certain prohibitions had never prevented scientific investigation. What more could be asked?

Portrait of Ferdinando II de' Medici dressed in Turkish costume. Oil on canvas by Justus Sustermans (Palazzo Pitti, Galleria Palatina, Florence)

Obtaining the *imprimatur*, however, was not easy. In Florence things had moved rather fast, but in Rome the Master of the Holy Palace, Niccolò Riccardi, a native of Genoa, had inexplicably delayed matters. Galileo had had dealings with him since the time of *The Assayer*, whose approval he had formalised, and they had met when Galileo visited Rome in 1624. Riccardi was nicknamed Father Monster for his amazing memory, it seems, and even more for his ugliness. He had never been particularly opposed to astronomical discoveries, and had always deemed it necessary to keep science separate from Scripture. But he was not a great intellectual power: 'He is ready to settle for a quiet life by postulating angels who, without difficulty or complications of any kind, direct the known movement of the celestial bodies.' Thus Galileo portrayed him, disconcerted more by Riccardi's mental laxity than by the angels. In

1630 Riccardi had read the manuscript of the *Dialogue* without raising objections, giving his approval for the Roman edition, which however was not published. It was strange that a year later, having asked to inspect only the preface and the epilogue, Riccardi was still delaying his opinion on the Florentine edition. Francesco Niccolini, the Tuscan ambassador to Rome, took a strong line on this and Riccardi finally gave


Imprimatur ſi videbitur Reuerendiſs. P. Magiſtro Sacri Palatij Apoſtolici.
A. Epiſcopus Bellicaſtenſis Vicesgerens.

Imprimatur
Fr. Nicolaus Riccardius
Sacri Palatij Apoſtolici Magiſter.

Imprimatur Florentiæ ordinibus conſuetis ſeruatis.
11. Septembris 1630.
Petrus Nicolinus Vic. Gener. Florentiæ.

Imprimatur die 11. Septembris 1630.
Fr. Clemens Egidius Inqu. Gener. Florentiæ.

Stampiſi adi 12. di Settembre 1630.
Niccolò dell'Altella.

Galileo, *Dialogo sopra i due massimi sistemi del mondo*, in Fiorenza, per Gio. Batista Landini, 1632 - Imprimatur

his authorisation for printing, but demanded a written release relieving him of all responsibility. Clearly, he was under pressure from above, from very high up. In the end, he did not hide the fact that he was acting under the direct instructions of Urban VIII, sending the Florentine Inquisitor a letter with the Pope's demands. In addition to the known provisos, punctiliously included by Galileo in the preface, the Pope desired that, in line with his personal opinions, reference should be made to 'the reasons of Divine omnipotence … which must restrain the intellect.' Moreover, it was strictly forbidden to mention, either in the title or in the main argument, the problem of 'ebb and flow', that is, tidal motion – an extraordinary demand.

With official approval and permission, and with some correction to the preface made by Father Monster, the volume was ready within a few months. The *Dialogue* was the result, not only of Galileo's experience as a scientist, but also of his experience as a man. In his book, Galileo paid homage to two men who had been among his

Galileo, *Dialogo sopra i due massimi sistemi del mondo*, in Fiorenza, per Gio. Batista Landini, 1632 – Antiporta with engraving by Stefano della Bella

closest friends: the Florentine Filippo Salviati, represented as a sort of new Copernican Socrates (as Campanella saw him, although it was perhaps only as a projection of himself), and the Venetian, Giovanfrancesco Sagredo, depicted as an acute interlocutor, intellectually honest and free from bias. The third figure is an imaginary one: a certain Simplicio, a Peripatetic, a concentrate of all the errors of Aristotle's followers, prey to the most obtuse prejudices. Galileo explained in the preface that he had given this character the same name as that of Aristotle's ancient commentator, but the provocative linkage of his name to the simplicity of his thoughts was obvious to all.

The veneer of caution adorned only the preface. For the rest, the *Dialogue* was a brandishing of the sword against the foundations of the Aristotelian world and the 'unbelievable cowardice' of all those 'servile minds' incapable of rebelling against it. Galileo gathered the fruits of decades of work, reviewing all the stages leading to his Copernican convictions. The idea of the incorruptibility of the heavens was shown to be false by the use of the telescope, together with observations of the Moon and of sunspots, whose optical deformation had led him to hypothesise an inclination of the Sun's axis of rotation in respect to the plane in which the Earth orbited. Also, the idea of a single centre of the universe coinciding with that of the Earth was refuted by the knowledge acquired on the motion of falling weights. Further, the idea of the static position of the Earth was contradicted, not only by the implausibility of the rapid rotation of the celestial sphere, but also by telescopic observation of the behaviour of the other planets in the solar system and by measurement of their orbits. Age-old myths on the motion of falling bodies, demonstrations claimed to disprove terrestrial movement, were eliminated through a single proof, that of the relativity of motion: inside a moving structure, such as a ship (but it could also be the Earth), the motion imparted to the containing structure is 'common to all the things contained in it and also to the air.' Accordingly, motion inside the structure was unaffected by it. In other words, the flight of a fly inside a ship (or the falling of a body on the Earth) will take place in the same way whether the ship (or the Earth) is moving or standing still.

Polychromatic stucco bas-relief picturing sunspots (Museo di Storia Naturale di Firenze, Florence - Sezione di Zoologia "La Specola" - Tribuna di Galileo, intrados of the entrance arch to the apse).

Galileo's astronomical observations: detail with a picture of the Moon. Fresco by Ezio Giovannozzi (Dipartimento di astronomia e scienza dello spazio, Florence, Edificio Garbasso)

All were castigated – Aristotle, Ptolemy, Tycho Brahe and, by implication, their still living followers - and this was to have negative consequences for Galileo. His attack was wide-ranging, launched in a language that was terse and penetrating, occasionally caustic, at times even lyrical, never trite, where each word had its own precise meaning, going straight to the centre of a problem without idle abstraction and leaving no space for misunderstanding. The *Dialogue* is thus not only one of the

Allegory of Astronomy holding a tablet with the inscription *Sistema copernicano*. Fresco by Luigi Sabatelli, 1840 (Museo di Storia Naturale di Firenze, Florence - Sezione di Zoologia "La Specola" - Tribuna di Galileo, vault of the Sala Quadrilatera)

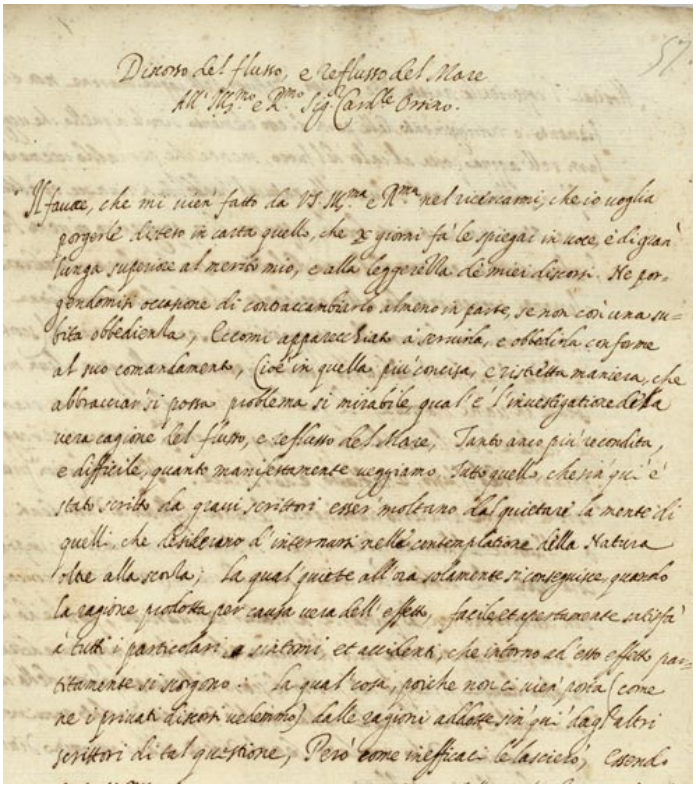
most important texts of modern science but also a literary masterpiece, in which physics is discussed in the language of poetry. There emerges in it, along with a passionate love of truth, a fascination with nature and its phenomena, almost humanised in the descriptions of their appearance and behaviour. That Moon we perceive is full of 'eminences and cavities', similar to our 'highest and steepest mountains', of 'de-

tached and solitary boulders, very steep and precipitous', of plains that contain 'a mountain soaring high' or 'exceedingly dark material.' Its relation to the Earth, to which it always turns the same side, 'almost as if attracted by magnetic power', is ambiguous; and the Earth in recompense, on 'very clear nights', in turn reflects on the Moon the rays of the Sun, a positive effect 'when the Moon has most need of them', only then to respond negatively, by taking light away from it in an eclipse. Those 'flies, butterflies and such little winged animals', those darting 'little fishes', illustrate the principle of the relativity of motion. And there was an almost obsessive observation of daily life, seeking to find links with scientific theories in silk, velvet, mother-of-pearl, diamonds, marble, musical instruments, household items, and petty human limitations among those 'who know all poetry by heart, but are then dismayed to have to compose only four verses' and others who 'know all the precepts of Da Vinci, but are unable to paint a stool.'

Galileo's scientific exposition also advanced the bold concept of man, in virtue of his own nature, thirsting for knowledge, in a continuous, inexhaustible search which, truth by truth, comes ever closer to understanding the laws that govern the universe, even if 'there is no effect in nature, however small it may be, that can be entirely understood by even the most speculative intellect.' Galileo may have concluded the preface to the *Dialogue* by diplomatically reaffirming that he questioned the 'immobility of the Earth' only following a 'mathematical whim', not through ignorance, but through 'the knowledge of Divine omnipotence and awareness of the weakness of the human intellect'; but at the same time he was unable to restrain the enthusiasm that in truth his faith in the capacity of human reason aroused in him. 'My admiration is boundless,' he wrote, 'regarding the way in which reason overcame sound sense in Aristarcus and Copernicus and took charge of their belief.' This is hardly an awareness of human weakness.

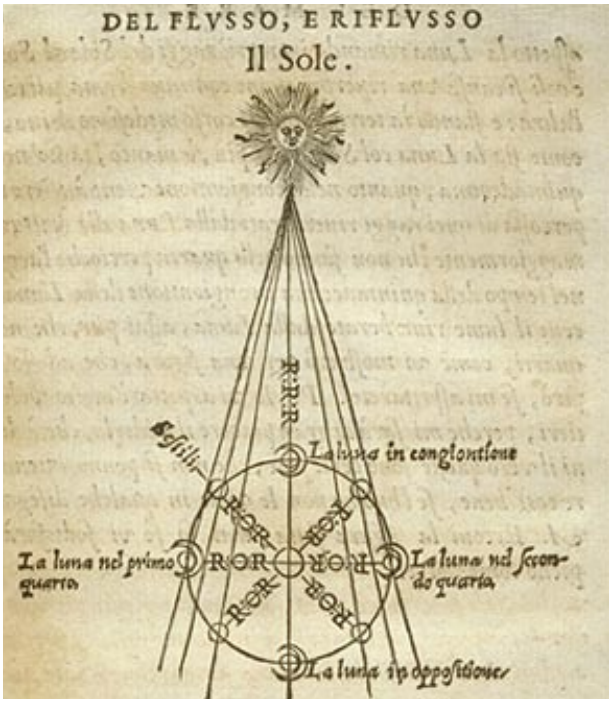
Allegory of Reason (*Iconologia del cavaliere Cesare Ripa perugino notabilmente accresciuta d'immagini, di annotazioni e di fatti dall'abate Cesare Orlandi…*, in Perugia, nella stamperia di Piergiovanni Costantini, volume IV, 1766)

Many readers, too many, understood immediately that human intellect, despite the best intentions, had by no means subdued itself before Divine omnipotence. To the point of getting their fingers burnt. A good part of the fourth day of the *Dialogue* was dedicated to discussing the reasons for the infamous 'ebb and flow' of the sea. Galileo had been interested in this problem for many years, probably since his time in Padua, and since 1616 his *Discorso sul flusso e reflusso del mare* [Discourse on Tides] had been circulating in manuscript form. Unable to determine the true cause of this phenomenon, he had maintained that tidal motion was caused only by the movement of the Earth and had no connection with the attraction of the Moon, as some other scientists, Kepler included, thought, and as is in fact the case. It would have been only a marginal extra element in favour of his hypothesis, and it was moreover debated among the Copernicans themselves. But why was the Pope so afraid of this issue as to bring it to the attention of the Inquisition? Since antiquity, the 'ebb and flow' of the sea had been considered one of the most mysterious and incomprehensible natural events, whose causes man could never understand. In the scholastic tradition, the legend that Aristotle had committed suicide because he had proved unable to dis-


Discorso del flusso, e reflusso del Mare
All'Ill.mo e R.mo Sig.r Card.le Orsino.

Opening page of the *Discorso sul flusso e reflusso del mare*, possibly in the hand of Benedetto Castelli (Biblioteca Nazionale, Florence, Ms. Gal. 68, c. 57r)

Girolamo Borro, *Del flusso e reflusso del mare et dell'inondatione del Nilo,* in Fiorenza, nella stamperia di Giorgio Marescotti, 1583 – Detail of the frontispiece



Explanatory scheme of the incidence of the lunar influx on the generation of ocean tides (Niccolò Sagri, *Ragionamenti sopra le varietà de i flussi et riflussi del mare oceano occidentale…,* in Venetia, appresso Domenico et Gio. Battista Guerra, 1574)

cover the cause had persisted for years. In Catholic circles, it was held up as an example of how Divine omnipotence overstretched the feeble talents of man. Confronting the problem by means of science meant not only violating an age-old taboo, but also, in this specific case, going against the beliefs of the Pope. But this was far from all. Tidal ebb and flow, if Galileo had succeeded in his aim, would have sounded the death knell of mathematical hypothesis, since it would have constituted physical proof that the Earth moved. The study of the tides was not, indeed, considered the domain of mathematical sciences such as cosmology, but was regarded as a concern of natural philosophy. So far, Galileo, with his telescopic observations, had succeeded only in proving the falsity of Ptolemy, but not the truth of Copernicus, demostrable only through geometry, and the danger that he might so succeed, thanks to tidal motion, could not have escaped the shrewd eye of the Pope. Galileo, however, had obeyed orders and had not centred his *Dialogue* on the phenomenon of the tides, nor mentioned the latter in the title. But he had not refrained from explaining in detail his whole theory, indicating tidal motion as one of the most important 'statements of the Copernican system.' He had been careful not to omit mention of the Pope's ideas, and referred to the Pope himself without name, praising the 'most sound doctrine' of Divine omnipotence learned 'from a most erudite and most eminent person … before whom we must necessarily keep silent.' But, the figure singing these praises, between one stupid utterance and another, was the simpleminded Simplicio. It was an unconsidered choice, and one that was to cost him dear.

The reading of the Dialogue stunned men of science, not only Galileo's closest followers and not only in Italy. A scene of fervent excitement, amazement and rapture dawned. It was immediately clear that this was a revolution. 'This is new light on ancient truths, of new worlds, new stars, new systems, new nations… it is the beginning of a new age,' cried Campanella with his usual impulsive *élan*. 'May He who guides all make haste. We for our own small part will follow. Amen.'

But not all were friends; and the 'new age', at least in Italy, was still in the future. Just dawning, it was soon to come to an abrupt halt.

Irate theologians 1632–1633

In Rome a few copies of the newly printed *Dialogue* dropped into an atmosphere densely polluted by the fumes of the Counter Reformation and intricate political issues connected with the Thirty Years' War. On the international front Urban VIII was subjected to strong pressure from Spain, which felt that its Swedish campaign was inadequately financed from the papal coffers, while on the domestic front the shabby practice of nepotism was becoming ever more visible and attracting ever more opprobium. Feeling himself besieged from without and within, the Pope, now in a state of total insecurity, began a well-aimed purge of his own ranks. One of the first heads to fall was that of Giovanni Ciampoli, a member of the Academy of the Lincei and a close friend of Galileo, who lost his position as Secretary of Briefs to Princes.

Portrait of Giovanni Ciampoli (Giovanni Ciampoli, *Lettere*, Firenze, nella Stamperia di Amador Massi, 1650)

Even more toxic was the animosity of the anti-Copernicans, the Jesuits in particular, who, mindful of the derision and stinging defeats inflicted on them by Galileo in the past, 'worked covertly with great energy' to get the work banned. This was reported by Filippo Magalotti to Guiducci, directly quoting what had been told him by Niccolò Riccardi: 'The Jesuits will persecute him remorselessly.' One of the most energetic was probably Scheiner, whose 'canine rage' against Galileo had taken a thousand forms in his *Rosa Ursina* [The Orsini Rose], a recently published text on astronomy. Already, during his last visit to Rome, Galileo had been the object of malicious gossip and calumny – miraculously ignored at the highest level – perhaps linked to his risky contacts with the Vallombrosan monk, Orazio Morandi, sentenced soon afterwards to life imprisonment for having predicted the death of the Pope; the gossip against Galileo showed a tendency to attribute to him also horoscopes and predictions of death as insolent as Morandi's. After the publication of the *Dialogue*, no inventiveness was needed to discredit Galileo

in the eyes of the Pope; it was enough merely to fan the flames. Even on a quick examination, the *Dialogue* had aroused his animosity. 'Let the book be held back; without our corrections it must not be circulated,' wrote Father Monster to the Florentine Inquisitor, inquiring also whether the representation of three fishes in a circle with the motto *grandior ut proles* (greater, like my descendants) appearing on the frontispiece was an original witticism of Galileo's. It was not easy to convince Father Monster that this motto appeared on all the books published by Giovambattista Landini. Obviously the printer's mark had incensed Barberini, who read into it an allusion to the easy promotion of brothers and nephews in key positions in the Roman Curia. The Pope was as suspicious as he was infuriated. He had certainly not appreciated the fact that his infallible argument for Divine omnipotence, giving the intellect its quietus, had not, as requested, been the final irrefutable conclusion to the *Dialogue*, like a gravestone over human aspiration to research, but had been 'put into the mouth of Simplicio, a person … very little esteemed, but, rather, derided and mocked.' In the presence of the ambassador, Francesco Niccolini, he had been able to overlook the personal offence, so inappropriate towards the Pope, but had been unable to control his vexation. Galileo 'had dared to enter where he should not'; in league with Ciampoli he had avoided the obligations imposed on him in exchange for approval, proclaiming a 'doctrine… perverse in the highest degree,' occupying himself indeed with the 'most perverse material that one could ever have in one's hands.' Shortly afterwards Ciampoli was transferred to a mountain village in the Marches. How much his banishment was due to his presumed favouring of Spain and how much to his close ties with Galileo is hard to say. Barberini's obsession with betrayal and plotting and the lack of respect for his opinion had transformed his former *adulation* into a disappointment much more *pernicious* to the person adulated than to the adulator.

Giovambattista Landini's emblem on the frontispiece of the Dialogo with three fishes and the motto *grandior ut proles*

Portrait of Tommaso Campanella. Oil on canvas by an unknown painter, 17th century (Musée Départemental de l'Oise, Beauvais)

An order was issued to find and sequester the few copies of the *Dialogue* in circulation. Tommaso Campanella warned Galileo that a 'congregation of irate theologians', members of various religious orders, was about to meet for the purpose of scrupulously examining the text. 'I fear the violence of people who do not know,' he fretted and, showing a very poor sense of reality, asked the Grand Duke of Tuscany to use his influence to have him enter the commission, along with Benedetto Castelli, as advocates for the defence. Father Castelli, after some attempts at mediation had failed miserably, prudently disappeared, and Campanella, already on the Index for his *Apologia pro Galileo* [Defence of Galileo] written after the accusations of 1616, went so far as to propose himself for the task of securing the fate of the *Dialogue* and the safety of its author. Father Monster dismissed this idea out of hand, saying, 'He wrote an almost similar work that has been prohibited, and can in no way act for the defence while he is guilty.' In the end, Campanella was alone when he responded in regard to his unwise support of Galileo's cause, 'If we fail to win, I will be called a beast.' The commission indeed met, unsurprisingly without him, composed only of 'people who did not know': the Pope's personal theologian, a Hungarian Jesuit and Father Monster himself, who displayed friendship and benevolence but, obliged to exonerate himself for the imprudent approval granted to the *Dialogue*, found himself both judge and judged at the centre of a deep conflict of interests.

After closely examining the *Dialogue* the commission minutely listed its faults in a written document. The *imprimatur* from Rome had been affixed to the Florentine edition without any precise authorisation and without the person who had granted it being informed (this exonerated Riccardi). The conciliatory tone of the preface contrasted with the bold assurance of the rest of the work, where the 'medicine of the end' (that is, the conclusive argument imposed by Urban VIII) had been put 'in the mouth of a fool', and so well buried 'that it could only be found with difficulty', and would certainly not be 'approved … dispassionately by the interlocutor.' Frequently heliocentrism was not

presented as a mathematical hypothesis but asserted as absolute truth with powerful arguments, while the proofs to the contrary were dismissed as impossible. The structure of the universe was presented not as a presumption, in accordance, naturally, with an earth-centred system, but was still to be defined. The anti-Copernican authors, regarded as fundamental points of reference by the Church, were derogated. Human intellect was deemed comparable to Divine intellect 'in understanding geometry.' It was stated as true that many Ptolemaics had converted to the viewpoint of Copernicus, and not vice versa. The 'ebb and flow' of the sea, a phenomenon that 'exists', was attributed to the motion of the Earth and the immobility of the Sun, causes that 'do not exist.'

Portrait of Galileo Galilei. Oil on canvas by Justus Sustermans, 1636 (Galleria degli Uffizi, Florence)

All this, continued the document, could have been corrected, had 'any usefulness in the book' been seen, but there was much more so gravely erroneous as to be uncorrectable. With the publication of the *Dialogue* Galileo had disobeyed the decrees of the Inquisition issued after the trial of 1616, according to which the heliocentric theory could not be *held, taught or defended in any way whatsoever, in either words or writing*. It is surprising that the only document known prior to the work of the commission, namely,

the letter of explanation sent by Cardinal Bellarmine to Galileo, did not specify the issue with the same degree of precision, but framed, rather, a generic prohibition to *hold* or *defend* the concept of the Earth's mobility. Where did the prohibition *to teach it in any way whatsoever, in either words or writing* come from?

The seriousness of the situation, it was decided, made it necessary to call in the Inquisition, and the Pope expressed his regrets for this with a deceptive show of compassion. But, on the other hand, Galileo had 'entered a dense thicket of problems, which he could have avoided', dealing with 'disturbing and dangerous matters', which had, moreover, been 'condemned' sixteen years earlier. There was nothing to be done. The Inquisition met soon afterwards. The reading of the commission's document was enough

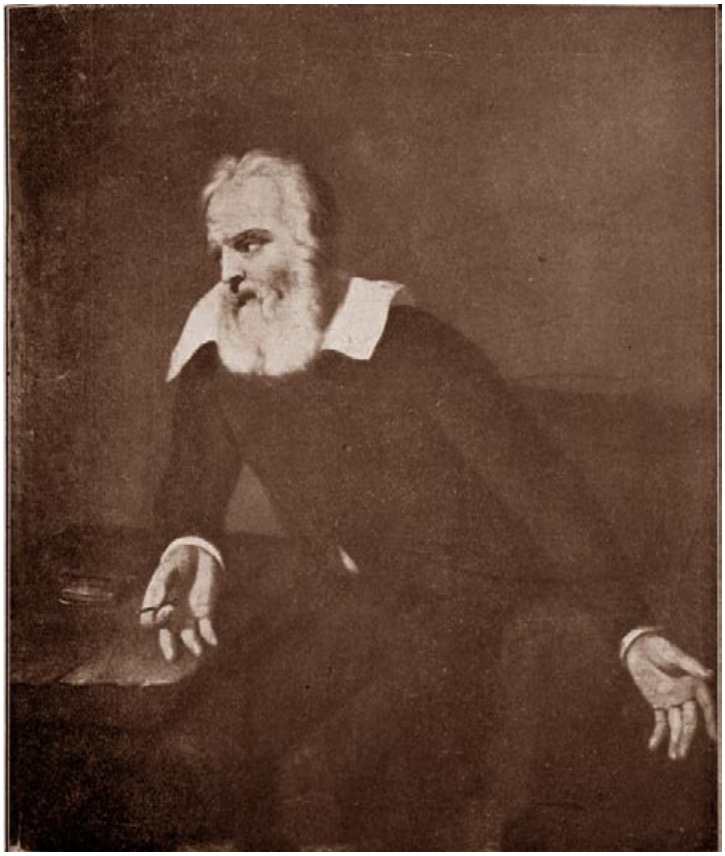
Statue of Urban VIII by Bernini, c.1635-1640 (Palazzo dei Conservatori, Rome, Aula maggiore or Sala degli Orazi e Curiazi)

to cause the Inquisition to begin preparing a trial. Galileo was given one month's time to appear in Rome and answer in person for his crimes. Old, in poor health and now terrified also, Galileo sought in every way, through letters of supplication and the intercession of his friends, to avoid the journey. The ambassador, Francesco Niccolini, presented an official request for dispensation, and, at the Pope's sharp refusal explained to him in private that, considering Galileo's precarious health, advanced age, difficulties in travelling and suffering over the severe accusations, he would be risking his life. 'Let him come slowly, borne in a litter, and at his ease,' was the compassionate reply, in the hope that God may pardon him for 'the error of having brought himself into such a difficult situation.' The Pope himself, while still a cardinal, had 'freed Galileo from a similar situation.'

When all hope of avoiding a trial had vanished, Galileo had a physical and psychological breakdown. 'He has gone to bed and is in danger of going more to the other world rather than to Rome,' wrote the Grand Duke's Secretary, Andrea Cioli, from Florence to Niccolini in Rome. Several deferments were requested, supported by medical certificates that painted a gloomy picture (albeit somewhat exaggerated) of the health of Galileo, whose pulse rate was 'intermittent by three or four beats' due to a 'vital faculty hindered and extremely debilitated' in his 'declining age', but probably also due to 'suffering from frequent dizziness, from hypochondriacal melancholy, a weak stomach, wakefulness, pains all over the body', as well as 'a severe fleshy hernia, with weakening of the peritoneum.' The reports, no matter how scientific, were not believed by the Inquisition, whose threat of sending officials and physicians to Florence to 'conduct him to the Inquisition's prison', 'bound in chains', determined Galileo, fearing prison more than interrogation, to leave for Rome. But unfortunately, the one did not exclude the other.

The trial 1633

After a disastrous journey, complicated by a long, unpleasant period of quarantine at the border, Galileo arrived in Rome, where he stayed as a guest at the Villa Medici, the residence of the ambassador, Niccolini. The first impression was encouraging. In the villa he was in fact a prisoner, he told Cioli, but one who received a 'treatment very gentle and benign, entirely different from the threatened cords, chains and prison' that he had so greatly feared. He had also been visited by an official of the Inquisition, who had engaged him in pleasant conversation, listening to his words and encouraging him with his 'great humanity.' But it was harder to deceive a shrewd ambassador than a fearful old man, and Niccolini's impression had been quite other: 'It can be taken for certain that the man was sent … to hear what he has to say and how he speaks about and defends his ideas, in order to find out what should be done and how to proceed with him.' In other words, the man was a spy. And the initial confidence of Galileo, who trusted in a swift, painless solution to his case, was undermined by the Pope's behaviour, increasingly cold, detached and set in his opinions, even in response to the pleas of Tuscan diplomats and of the Grand Duke in person to soften his attitude. Galileo, guilty of having wanted to 'impose need' on 'omnipotent God' by laying on Him the burden of the creation of a moving Earth (in this, returning to an earlier error and 'badly advised' by Ciampoli), was already receiving favoured treatment by being allowed to reside at the Villa Medici while awaiting his trial. During the trial, it was understood, there would be no alternative to detention within the walls of the Inquisition, and the time would not be brief, neither more nor less than that required by the procedure. Niccolini did not tell Galileo of this in order to spare him 'great suffering', but soon had to inform him of his summons to give evidence and his imminent transfer.



Galileo in prison. Painting by Murillo, 17th century. Present location of the work unknown

Insisting on his 'poor health', recounting how 'for two nights in a row' he had 'cried out and complained constantly of his arthritic pains', had served only to obtain a promise that he would be assigned decent rooms, 'perhaps even unlocked.' The despair that was battering Galileo's morale deeply perturbed the affectionate Niccolini, who became seriously concerned that Galileo might die, but he could do nothing more than express his sincere grief: 'Truly he deserves every good, and all of this house, which greatly loves him, feels indescribable pain.'

Galileo before the Inquisition. Oil on canvas by Niccolò Barabino, 1888. Reduced replica of the fresco in the Palazzo Celesia, Genoa (Private collection, Genoa).

Galileo appeared before the Inquisition, not once but three times in the course of a month, during which he lived in confinement but, as had been promised the Tuscan ambassador, who considered it a good omen, in the apartments of the Fiscal Procurator rather than the 'cells usually assigned to criminals.' His international standing and the good offices of the Grand Duke of Tuscany had served to achieve some good at least. The trial, however, followed a quite unusual course. Since the first interrogation, in fact, the content of the *Dialogue* had played an entirely marginal role. Galileo had been very clever; precluded by decree from formally asserting the truth of heliocentrism, he had nevertheless constantly presented it as the only plausible position. He had always treated the opposing position as an alternative, in practice advancing *the philosophical and physical reasons, as much for one side as for the other*. When interrogated the first time, he could even maintain (although only by arguing that

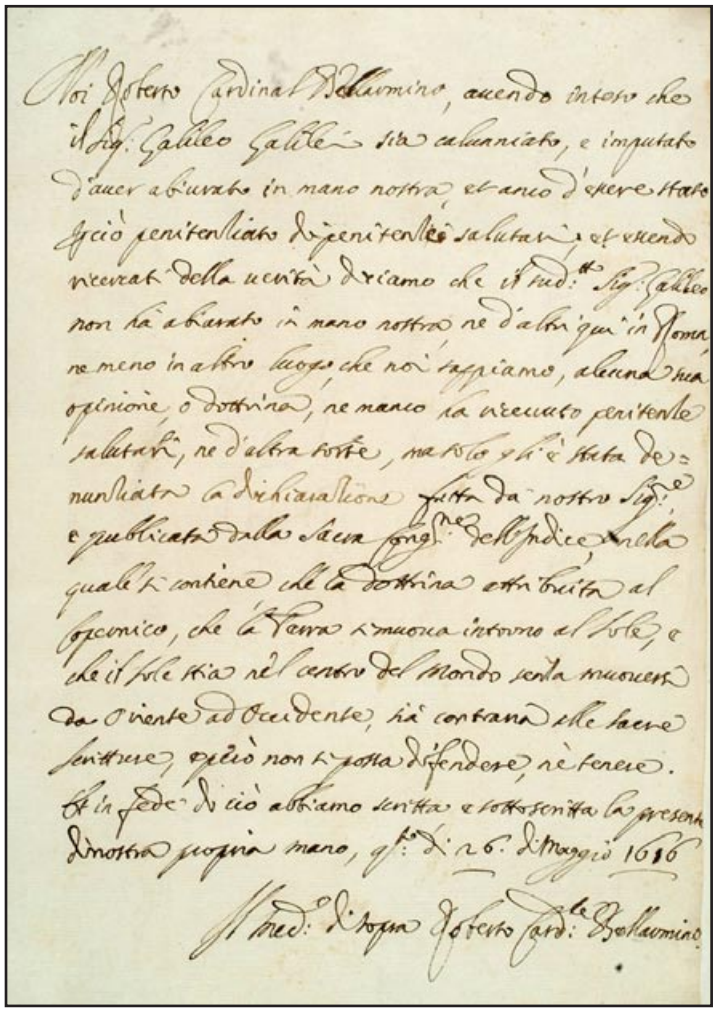
black is white, and little convinced himself) that he had demonstrated 'the contrary of the said opinion of Copernicus', showing how the latter's 'reasons' were 'invalid and not conclusive.'

A commission met for further analysis, almost identical to the previous one, except that Father Monster was replaced by a Theatine father. But to what purpose? The court already had before it a thorough, minutely detailed statement. Any attempt to discover in the text of the *Dialogue* formal grounds for the accusation of heresy would have been without purpose, since it was not possible to go beyond the *strong suspicion* of a *convicted adherence* to the theories of Copernicus. To condemn Galileo a different

Galileo before the Inquisition. Oil on canvas by Joseph Nicolas Robert-Fleury, 1847 (Musée du Louvre, Paris).

hand of cards would have to be found. A way forward was seen in his violation of an injunction alleged to have been imposed on him in 1616, in the presence of the then Commissary of the Inquisition, Michelangelo Seghezzi, in which he was forbidden *to hold, defend or teach in any way whatsoever, in either words or writing* the heliocentric theory. Publication of a book that examined it in detail would have contravened the second part of the injunction, and such contravention was necessary for a condemnation. Among the documents before the court was the notarial deed that gave legal force to the injunction, but Galileo did not recall ever having been summoned before a notary and, as stated in the draft record of the interrogation, he pulled out 'a sheet

of paper written in twelve lines on one side only, which began: "We, Robert, Cardinal Bellarmine, having, etc…'" He recalled only this. Bellarmine's declaration did indeed prohibit *defending* or *holding*, that is, believing in or declaring to be true, the Copernican theory, as contrary to Holy Scripture, but it made no mention of *teaching it in any way whatsoever, in either words or writing*. So, unexpectedly, there were two different documents, which did not agree in content. And the one in the hands of the Inquisi-



Vincenzo Viviani's handwritten copy, dated 26 May 1616, of the declaration Cardinal Bellarmine sent to Galileo (Biblioteca Nazionale, Florence, Ms. Gal 13, c.3r). The copy that Galileo himself made and displayed at his trial is today in the Vatican Secret Archives

tion was a very strange notarial deed, drawn up by an unknown notary whose name appeared nowhere, lacking a seal or any kind of signature, either that of the notary or the witnesses or, obviously, of Galileo. It was never publicly shown and seems to have been merely a draft or, on the worst diagnosis, a specially prepared forgery. There was no trace of any more formal document. Had that injunction really existed?

The trial stagnated. Given the 'various difficulties in pursuing the case and bringing it to a conclusion,' wrote Vincenzo Maculani, Commissary of the Inquisition, to one of the Pope's cardinal nephews, it would be necessary for Galileo to confess. If he continued to deny 'that which manifestly appeared in the book written by him', it would become necessary to apply 'greater rigour in justice', a neutral, aseptic term that meant nothing other than torture. But this was not a method that could be used with such a famous figure, who was moreover in poor health. Maculani requested and obtained 'the power to confer with Galileo outside the court.' He visited him in his confinement and after some hours of discussion persuaded him to confess, promising in exchange that he would soon regain his freedom. Sure of having made him 'recognise his wrongdoing', by convincing him 'of having been in error and in his book of having exceeded', Maculani was equally sure that the court, being able thereby to retain 'its repute', would 'use clemency.'

An elderly prisoner, probably Galileo. Watercolor drawing by François Marius Granet, 19th century (Musée des Beaux-Arts, Rennes)

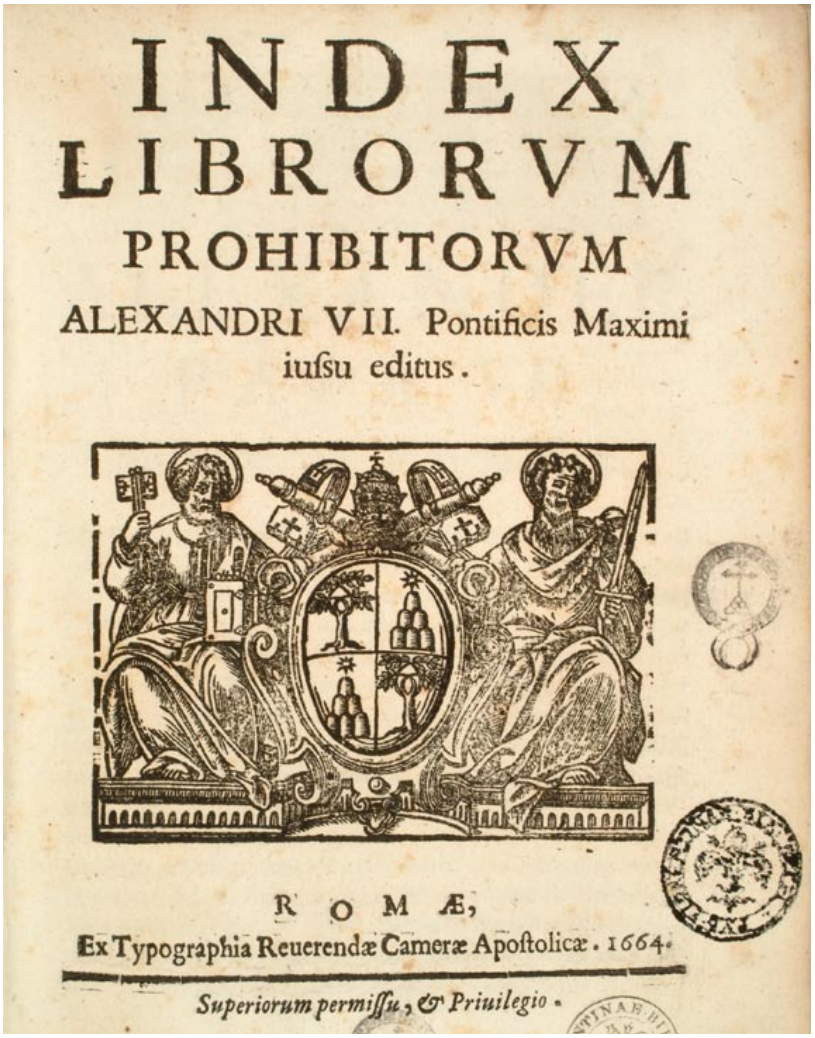
But things did not go as Maculani expected. Galileo, in the event, brought before the court again, did declare himself guilty – but only of an error in style. In any case,

in a system based mainly on formal cavils and ritualistic sophistry, he was certainly entitled to use the same arms to defend himself. Acknowledging the fact that it was three years since he had last looked at his *Dialogue*, he had sought to verify whether, against his ' purest intention', there might have 'come forth from his pen' inadvertently anything to cause misunderstanding. The book, upon renewed evaluation, appeared to him 'from its long disuse almost like a new text and by another author', and so – he 'freely confessed' – it had become clear to him that the reader, unaware of his objectives, might have formed a mistaken idea that 'the arguments supporting the false side', that is, the Copernican (sunspots and tides in particular), 'were expressed so effectively that they were powerfully convincing rather than easily dismissed.' The error, he continued, was caused by ambition, by that 'natural pleasure that each man takes in his own subtle arguments', and by seeking to appear 'more shrewd than is common in men in finding, even for false propositions, ingenious and seemingly probable arguments.' In brief, everything had been due to an excess of virtuosity and Galileo declared himself ready to make amends by invalidating those overly convincing arguments as effectively as possible. The inability to tolerate confinement any longer and the prospect of torture suddenly thrust on him had achieved this result. On that same day, Galileo was allowed to return to the Villa Medici, still segregated, but among friends.

Maculani, according to the ambassador, Niccolini, wished to bring everything to an end quickly and peacefully: 'He expresses… a willing intention … to ensure that this case is quashed and silence imposed on it.' But here again he had calculated wrongly. In a third deposition Galileo reiterated his line of defence. But the resumé of the trial, which covered the whole story since 1616, already gave a clear idea of the direction it was desired to take. Deliberate falsities, deceitful interpretation of documents and attribution of dubious opinions, such as that 'God really laughs, cries, etc.', and that 'the miracles worked by saints are not true miracles', were marshalled to worsen Galileo's position.

Indeed, after two months of total silence the Inquisition met in the Quirinal Palace, in the presence of the Pope, reiterating the need to have Galileo confess 'over and above his purest intention', since his stylistic repentance had been unconvincing, having recourse to torture if necessary. It had already been decided to condemn the *Dialogue*, to reduce the heliocentric theory to perpetual silence by declaring it heretical, to force Galileo to make a public retraction and to inflict on him an exemplary prison sentence. Niccolini knew of this; but on this occasion too, moved to pity, he kept his silence. He spoke with the Pope in an attempt to calm matters, but came up

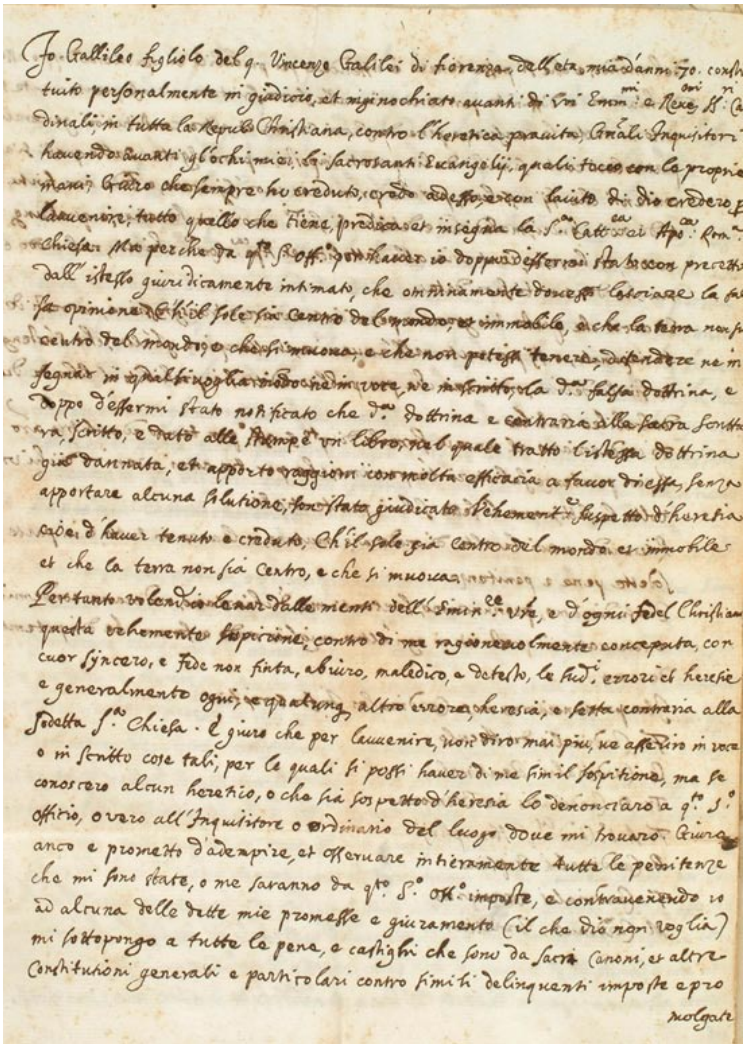
against the familiar falsely paternalistic coldness. Galileo was interrogated again and refused to move an inch from his former position: 'I am here in obedience. I have not held this opinion since Bellarmine's declaration, as I have said.' On the following day the sentence was read. The book was instantly banned: in presenting as 'undecided and expressly probable' a theory contrary to Holy Scripture, and thus heretical, Galileo had laid himself open to the strong suspicion of believing it true, thus incurring all the penalties 'imposed and enacted against such criminals.' His 'severe and pernicious error' could not remain unpunished. He was thus sentenced to retract his presumed convictions, to be detained in the prison of the Inquisition for a term to be decided and, as a matter of course, to recite 'once a week the seven penitential Psalms' for the next three years. Three of the ten cardinals who constituted the court of the Inquisition did not sign the decree. Maculani did, readier to make promises than to disobey higher decisions. And Galileo was now obliged to defame science.


INDEX
LIBRORVM
PROHIBITORVM
ALEXANDRI VII. Pontificis Maximi
iuſsu editus.
ROMÆ,
Ex Typographia Reuerendæ Cameræ Apoſtolicæ. 1664.
Superiorum permiſſu, & Priuilegio.

Frontispiece of the *Index,* 1664 edition, containing the ban on Galileo's *Dialogo* and the readmission of Copernicus after correction (*Index librorum prohibitorum Alexandri VII pontificis maximi iussu editus*, Romae, ex typographia Reverendae Camerae Apostolicae, 1664)

The abjuration 1633

I Galileo Galilei, son of the late Vincenzio Galilei of Florence, aged 70 years, tried personally by this court, and kneeling before You, most Eminent and Reverend Lord Cardinals, Inquisitors-General throughout the Christian Republic against heretical depravity, having before my eyes the Most Holy Gospels, and laying on them my own hands; I swear that I have always believed, I believe now, and with God's help I will in future believe all that is held, preached and taught by the Holy Catholic and Apostolic Church. But since - after having been admonished by this Holy Office entirely to abandon the false opinion that the Sun is the centre of the world and immoveable, and that the Earth is not the centre of the same and that it moves, and that I must not hold, defend, nor teach in any manner whatever, either orally or in writing, the said false doctrine, and after it had been notified to me that the said doctrine was contrary to Holy Writ - I wrote and caused to be printed a book in which I treat of the said already condemned doctrine, and bring forward arguments of much efficacy in its favour, without arriving at any solution: I have been prononced to be under suspicion of heresy, that is, of having held and believed that the Sun is the centre of the world and immoveable, and that the Earth is not the centre and moves.



The abjuration. Probably the copy intended for Galileo (Biblioteca Nazionale, Florence, Ms. Gal. 13, c. 8v).

Therefore, wishing to remove from the minds of your Eminences and of all faithful Christians this vehement suspicion justly conceived against me, I abjure with a sincere heart and unfeigned faith, I curse and detest the said errors and heresies, and generally all and every error and sect contrary to the Holy Catholic Church. And I swear that for the future I will never again say nor assert in speaking or writing such things as may bring upon me similar suspicion; and if I know any heretic, or person suspected of heresy, I will denounce him to this Holy Office, or to the Inquisitor or Ordinary of the place where I may be.

I also swear and promise to adopt and observe entirely all the penances which have been

or may be imposed on me by this Holy Office. And if I contravene any of these said promises, protests or oaths (which God forbid!), I submit myself to all the pains and penalties imposed and promulgated by the Sacred Canons and other Decrees, general and particular, against such offenders. So help me God and these His Holy Gospels, which I touch with my own hands.

With these words, of far-reaching significance, Galileo, wearing a white gown, a symbol of penitence, and genuflecting in sign of humiliation before the cardinals of the Inquisition who 'burned his book in his face', was forced, on June 22, 1633 to disavow not a faith, but a truth, laboriously won through the work of a lifetime. In

Galileo's abjuration before the Inquisition. Painting by Giovanni Squarcina, 19th century. Present location of the work unknown.

his stubborn, solitary battle for the independence of scientific research, he had been totally defeated. Leaving aside vindictiveness and personal rancour – the negative attitude of the Pope and the conspiring of the Jesuits - all of which weighed on the course of events, Galileo's condemnation for suspected heresy and the abjuration of his scientific convictions created a precedent. From that time on, the Church claimed for itself the right to legislate in matters unconnected with matters of faith, sanctioning the supremacy of the holy texts and their theological interpretation over any other source of knowledge. The search for truths alternative to those of faith was evidently more to be feared than any form of religious heterodoxy. For, far from opposing one dogma to another, it embodied an attitude always critical of acquired knowledge and denied any value to tradition, the age-old bulwark for the control of conscience. To keep silent, to ask no questions, to accept - it was now obligatory by law to comply

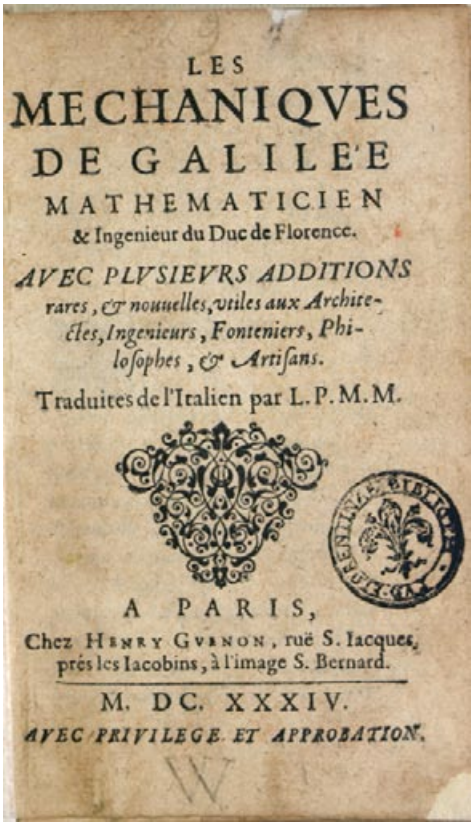
with this concept of man's function. Galileo had experienced this in person, forced to acknowledge the sad fact that the *Dialogue* was considered 'abhorrent and more pernicious to the Holy Church than the writings of Luther and Calvin.'

Portrait of Descartes. Oil on canvas by Franz Hals, 1649 (Musée du Louvre, Paris)

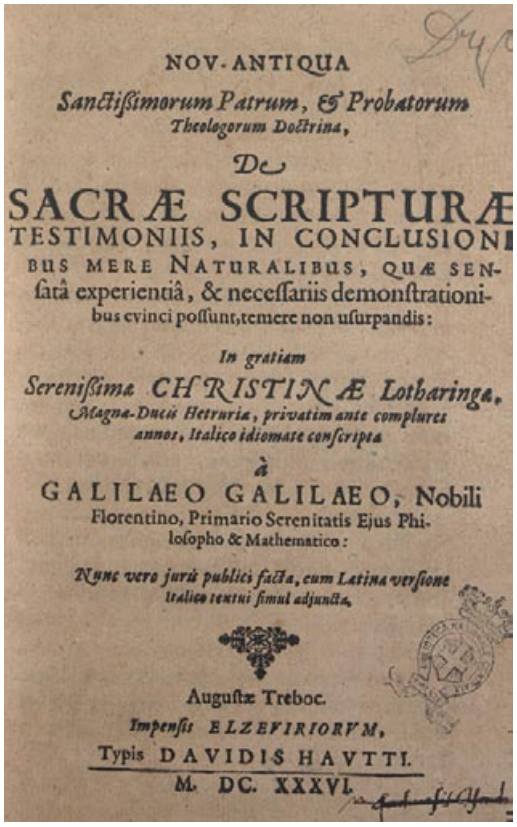
Whether the trial was formally correct or not in the end has no importance, since it was based on the fallacious premise that the beliefs of some can become a norm for mankind as a whole. And to demonstrate the falsity of this premise, there was, fortunately, Europe. Fortunately for Galileo, who thanks to his international fame was spared even worse punishment, and fortunately for mankind, which has been able to broaden its horizons thanks to the freedom of thought enjoyed in places where the power of the Church of Rome was slight or non-existent. In countries where science could be truly science, with no accommodating pretence or coercion to believe, opinion sided overwhelmingly with Galileo and against his condemnation. The blame was laid especially on the Jesuits, deemed chiefly responsible for his persecution. And it came from influential figures: Descartes, Grotius, Gabriel Naudé, Nicholas Fabri de Peiresc, Hobbes, Mersenne, and Gassendi, to mention only a few.

In Italy, however, owing to the weakening of Galileo and the Italian proclivity for backing the winner, albeit a provisional one, there was a flourishing of anti-Copernican writings of all colours. Catholics, orthodox Aristotelians suspected of free-thinking, minor academics (and even those of Pisa) cried out with one rancorous voice against a man who no longer had a chance to fight back. To the abjuration and its injunctions the Inquisition soon added a prohibition on all Inquisitors to issue opinions favourable to the printing of any text by Galileo, whether new works or re-editions. Naturally,

this prohibition was respected only in Italy, while abroad translations proliferated, even of texts that had hitherto remained unpublished, such as the *Mechanics* or the *Letter to Christine of Lorraine*. 'I am thus obliged,' lamented Galileo, his morale at its lowest point, 'not only to remain silent in the face of scientific opposition but, which is even worse for me, to succumb to the mockery, the mordancy and the abuse of my opponents, who are not few in number.' Unable to reply in public as was his custom,


LES
MECHANIQVES
DE GALILE'E
MATHEMATICIEN
& Ingenieur du Duc de Florence.
AVEC PLVSIEVRS ADDITIONS
rares, & nouuelles, vtiles aux Architectes, Ingenieurs, Fonteniers, Philosophes, & Artisans.
Traduites de l'Italien par L. P. M. M.
A PARIS,
Chez HENRY GVENON, ruë S. Iacques, prés les Iacobins, à l'image S. Bernard.
M. DC. XXXIV.
AVEC PRIVILEGE ET APPROBATION.

Galileo, *Les méchaniques de Galilée…, avec plusieurs additions rares et nouvelles, utiles aux architectes, ingénieurs, fonteniers, philosophes et artisans*, traduites de l'italien par le père Marin Mersenne, à Paris, chez Henri Guenon…, 1634 - Frontispiece


NOV-ANTIQUA
Sanctißimorum Patrum, & Probatorum Theologorum Doctrina,
De
SACRÆ SCRIPTURÆ
TESTIMONIIS, IN CONCLUSIONI
BUS MERE NATURALIBUS, QUÆ SENsatâ experientiâ, & neceſſariis demonſtrationibus evinci poſſunt, temere non uſurpandis:
In gratiam
Sereniſſimæ CHRISTINÆ Lotharingæ,
Magnæ-Ducis Hetruriæ, privatim ante complures annos, Italico idiomate conſcriptæ
à
GALILAEO GALILAEO, Nobili
Florentino, Primario Serenitatis Ejus Philoſopho & Mathematico:
Nunc vero juris publici facta, cum Latina verſione Italico textui ſimul adjuncta,
Auguſtæ Treboc.
Impenſis ELZEVIRIORVM,
Typis DAVIDIS HAVTTI.
M. DC. XXXVI.

Galileo, *Nov-antiqua sanctissimorum patrum et probatorum theologorum doctrina de Sacrae Scripturae testimoniis in conclusionibus mere naturalibus…, in gratiam Serenissimae Christinae Lotharingae Magnae Ducis Hetruriae privatim ante complures annos Italico idiomate conscripta…*, Augustae Trebocorum, impensis Elzeviriorum, typis Davidis Hautti, 1636 - Frontispiece

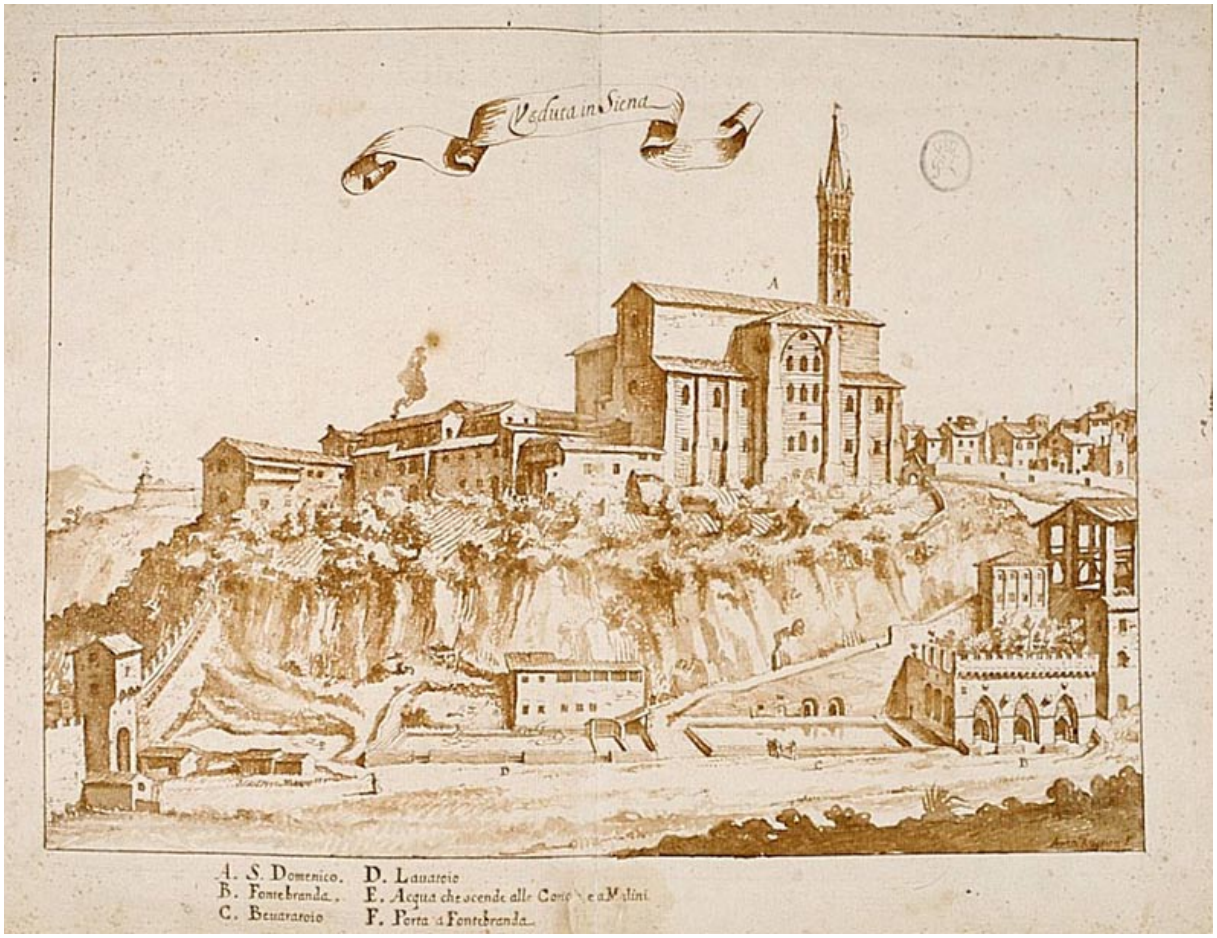
Galileo could not refrain from replying in the seclusion of his study. He annotated with a pen like a sharpened knife the volumes of those who attacked him, shielding themselves behind the same old arguments now completely refuted, and who continued to oppose their false 'way of philosophising … pure and simple physics' to his own way, based in science, 'dressed with a squeeze of mathematics', albeit now violently destroyed. Another safety valve was provided by his friends and pupils, with whom he discussed the replies of his adversaries, scattered with senseless exaggerations, and he made stinging comments in his correspondence. Vincenzo Renieri thus kept him updated on the extravagant opinions of Scipione Chiaramonti, a professor of philoso-

Mathematics: detail with a portrait of Vincenzo Renieri. Fresco with tempera retouches by Agnolo Gori, 1663 (Galleria degli Uffizi, Florence, west corridor, span 74)

phy at the University of Pisa, who had justified his attacks on whoever rejected his inviolable Ptolemy with the unanswerable argument that the Earth could not rotate in perpetual motion because, like all other living beings, it would have become tired and been obliged to stop to rest at some point. And Renieri dedicated to Chiaramonti a sonnet in mock praise, hypothesising that his idea of heaven, 'all, all of glass', made up of perfectly round, smooth circles, could have been inspired only by daily contemplation of a urinal. He even called upon the Sun to confer on Chiaramonti on Helicon, as a well-deserved prize, 'a crown consisting of tripe.' But was mocking sarcasm, a typically Tuscan defence, enough to raise the spirits of a man so deeply mortified as Galileo?

The last light 1634-1642

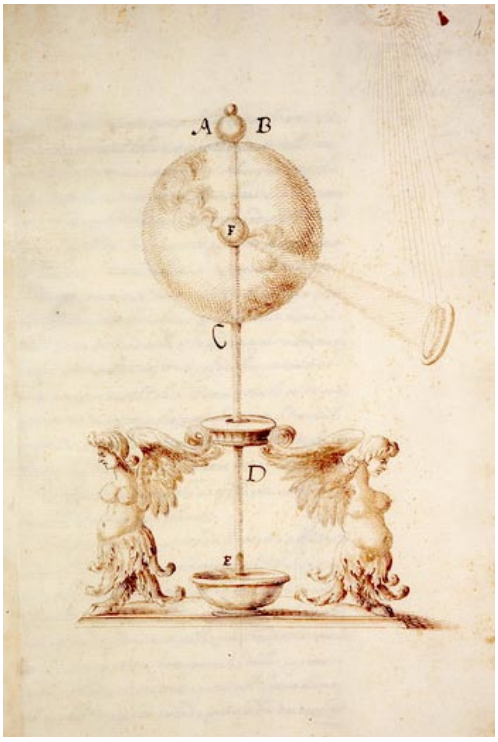
Galileo did not serve his sentence in the prison of the Inquisition, but was confined at the Villa Medici through a kind concession of the Pope, who indeed soon authorised him to return to Florence, to his own home 'in place of prison.' He had been in Rome for almost a year, and the longing for his own city was growing ever more unbearable, despite the support of his friends and frequent letters from Virginia, both of which had allowed him to remain in contact with what was dear to him. On his way back to Florence, he was a guest in Siena of Archbishop Ascanio Pic-



View of Siena, 17th century (*Città e castelli del senese*, Biblioteca Nazionale, Florence, Ms. Pal. C.B.4.80, str. 1422 - [G.F. 166], tav. 2)

colomini, pending the definitive authorisation of his return. In the meantime, the sentence of condemnation and the abjuration had been given public reading everywhere, in the presence of the 'largest number of mathematicians and philosophers they could muster', as reported by Guiducci, who had been obliged to attend one of these 'celebrations', as his superiors 'had received orders from Rome.' For fear of perquisition and sequester, Galileo's pupil, Niccolò Aggiunti, and Geri Bocchineri, brother of his daughter-in-law and a devoted friend, had swiftly hidden all of Galileo's writings that might have been found compromising. The atmosphere was still tense.

Galileo did not cease to work. No longer allowed to look at the sky, he looked at the earth instead, and nothing had changed in his way of looking at things. At Siena, still in detention, he threw himself into a discussion on the causes of vortices, admitting the existence of the void, 'if not natural, at least violent', a view opposed to another cardinal principle of Aristotelian physics, the *horror vacui*, nature's abhorrence of the void, which the Church guarded strictly. An anonymous denunciation against him and Archbishop Piccolomini for unsuitable conduct at Siena reached the Inquisition, but fortunately had no consequences. Galileo had in the meantime departed.



Drawing of the experiment on the behaviour of smoke in a vacuum, one of the experiments on the vacuum undertaken by the Academy of the Cimento (Biblioteca Nazionale, Florence, Ms. Gal. 289, c. 4r)

Back in Florence, he was confined, alone, to his villa at Pian de' Giullari. He resigned himself to an imprisonment ending only in 'the one common to all, narrow and enduring.' In accordance with the Pope's orders, he was not allowed to receive anyone, and certainly not to attend 'academies, meetings of people, gatherings or other similar demonstrations of disrespect.' He could not even go down to the city to see a doctor; every request was refused him, even roughly. The return home thus brought him little relief, and worse came a few months later when, at the age of only thirty-three, Virginia died of a sudden disease. Galileo blamed her death on his trial and on the conflict between a daughter's love and the bonds of her religious vows that must have exhausted her both physically and mentally. He was prostrate with grief, at the mercy of severe psychosomatic symptoms: 'The hernia has returned worse than before; my pulse is made irregular by palpitations of the heart; an immense sadness and


Portrait of Virginia Galilei. Oil on canvas by unknown artist, 17th century (The Wellcome Library, London)

melancholy; extreme lack of appetite; hateful to myself, and in short, I feel myself continually called by my beloved daughter.' But from Rome came no pity, no relaxation of the web in which he was caught.

And this was not all. Galileo was about to be struck by one of the worst misfortunes that destiny could have reserved for him: blindness. Within a few years' time, he lost the sight of both eyes. Incapable of renouncing his studies, he was obliged to create a network of willing pupils and friends to write for him, read for him, guide him, and see for him.

Galileo in the act of dictating to a young Piarist priest. Oil on canvas by Cesare Vincenzo Cantagalli, 1870 (Property of the Istituto d'Arte 'Duccio di Buoninsegna', Siena, curator Fabio Mazzieri, on loan to the Museo Amos Cassioli, Asciano)

You may imagine, Sir – he confided to Elia Diodati, a faithful correspondent in Paris – in what affliction I find myself, that this heaven, this earth, this universe, which I by my marvellous discoveries and clear demonstrations enlarged a hundred thousand times beyond that seen by the wise men of bygone ages, henceforeward for me is shrunk into such a small space as is filled by my own body.

The 'endless prison' of Arcetri, isolated and linked to the most painful memories, was increasingly hard for him to bear. His desolate condition of total blindness and growing need of care urged him to ask Rome again for permission to live in his house in the city. The Florentine Inquisition sent a doctor to examine him, who found him 'in such poor condition' as to have 'more the form of a cadaver than that of a liv-

Galileo at Arcetri (Bozzetto). Oil on wood panel by Nicolò Barabino, 1879 (Private collection, Savona).

ing person.' As the risk was now limited, such authorisation could be given. Galileo was granted permission to reside in his house in Florence but was still forbidden to converse with anyone, and certainly not on the motion of the Earth. He could go to Mass on Sunday, but without making contact with anyone. And these were not empty prohibitions. Strict control was exerted over all who entered or left his house, and no one deemed even vaguely threatening to the restrictions was allowed to enter.

Galileo refusing the necklace offered him by the States General of Holland. Oil on canvas by Demostene Macciò, 1861. Present location of the work unknown. In 1638 Galileo preferred not to accept the gift, fearing that, coming from a Protestant country, it might cause him trouble.

But Galileo was Galileo. And even in the total disaster that had struck him in his health, his affections, his personal dignity, and that would have crushed all incentive in any other man, he was unable, even had he wished, to abandon his ideas. Already blind, he wrote to the Servite, Fulgenzio Micanzio, one of his closest friends who supported him in his last years:

In my darkness I am always fantasising, now of this, now of that effect of nature, nor can I, as I would wish, impose peace on my unquiet brain; this agitation does me great harm, keeping me in a state of almost perpetual wakefulness.

The blind Galileo. Detail of a painting portraying him with Vincenzo Viviani. Oil on canvas by Tito Lessi, 1892 (Istituto e Museo di Storia della Scienza, Florence).

Passages in manuscript of a text written by Galileo had been circulating in Europe for some years, passed from hand to hand in secret. Acceding

to the urgent requests to publish it that he received from many places in Italy and beyond, and undoubtedly thinking also of some kind of liberation from the oppression he was under, Galileo began to conduct complicated negotiations through friends and acquaintances in places where greater freedom could be expected: Venice, Toulouse, Lyon and Germany. Many knew of this, but none spoke of it. And it was not going to be easy; what printer would willingly take the financial risk of publishing a new work by an author over whose head hung severe prohibitions? Landini earlier had found himself in trouble over the *Dialogue*. However, the Elzevier, printers in Leyden, agreed to undertake publication. Among the most famous publishers of the time in Europe, they were happy to ignore any prohibition by the Inquisition, thanks to the freedom of thought and expression permitted in their country, and probably also to their well-established position. In 1638 they printed the *Discorsi e dimostrazioni matematiche intorno a due nuove scienze attenenti alla mecanica et i movimenti locali* [Discourses and Mathematical Demonstrations concerning Two New Sciences pertaining to Mechanics and Local Motions], dedicated to Count François de Noailles. Afraid of worsening his position, already balanced on a knife-edge, Galileo pretended that the publication was an initiative of the Elzevier, undertaken without his knowledge, news of which had come to him as a sudden surprise, since he had decided, 'confused and dismayed by the misfortunes others of his works had suffered', not to publish any more. The instinct for self-preservation had accustomed him to such strategies. The *Discourses* was a sequel to the *Dialogue* in the discussion of ideas and had the same cast of characters, including the embarrassing Simplicio, who had however become less silly and thus less a target for mockery. But the former internal consistency was lacking. Here, old and new material relating to his study of physics coexisted without amalgamation, at times lacking unitary connection. The lines of exposition were continually interrupted by digressions. The appendix even included his boyhood studies on the centres of gravity of solids. Incapable of working


DISCORSI
E
DIMOSTRAZIONI
MATEMATICHE,
intorno à due nuoue ſcienze
Attenenti alla
MECANICA & i MOVIMENTI LOCALI
del Signor
GALILEO GALILEI LINCEO
Filoſofo e Matematico primario del Sereniſſimo
Grand Duca di Toſcana.
Con vna Appendice del centro di grauità d'alcuni Solidi.
IN LEIDA,
Appreſſo gli Elſevirii. M. D. C. XXXVIII.

Galileo, *Discorsi e dimostrazioni matematiche intorno a due nuove scienze attenenti alla mecanica et i movimenti locali*, in Leida, appresso gli Elsevirii, 1638 – Frontispiece

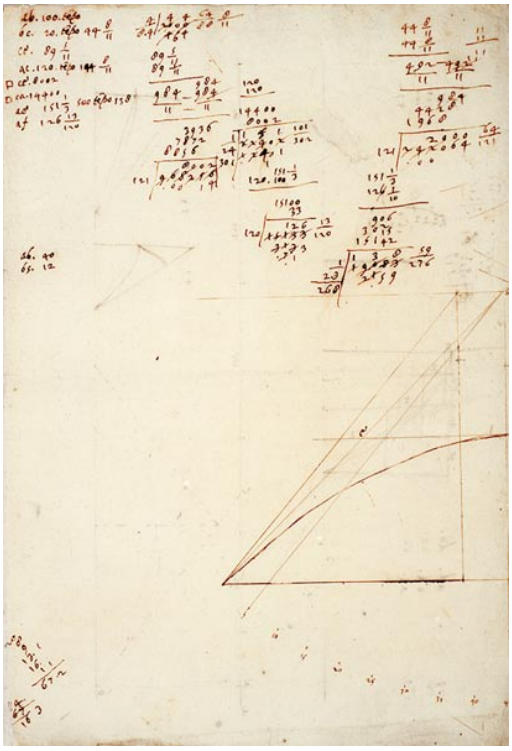
as before owing to poor health and final blindness, Galileo had not been able to take all his investigations to the same depth, and had made use of a wealth of experience acquired throughout his life at different stages of knowledge and intellectual maturity. This was nonetheless still a level unattainable for most of his colleagues, and Galileo remained the great philosopher of method. One of the two new sciences, the one *pertaining to mechanics*, studied the 'resistance of solid bodies to being broken.' What is it that keeps the parts of a solid body joined together, in such a way as to remain united when it is possible to divide them? Galileo replied by hypothesising a structure of matter made up of infinite and continuous atoms, with infinite voids interposed among them, which allow them to be broken into finite parts. And to explain this concept he used geometric examples, where the atoms were points, because the behaviour of matter complied with these same laws. For the Aristotelians, who thought the problem could be solved with the *horror vacui* theory, Galileo still had lessons about the workings of the world and, in opposition to the concept of a non-autonomous nature, adduced the principle that 'nothing is against nature except the impossible.' Everything that exists is in nature by the very fact of its existence, including man, who is not something other than nature but a part of it, nor, certainly, is it for him to theorise about what is pleasing to nature and what is repellent.

Allegory of Mechanics. Detail of the marble floor of the Sala Quadrilatera, a work by G.B. Silvestri after a drawing by Luigi Sabatelli, 19th century (Museo di Storia Naturale di Firenze, Florence - Sezione di Zoologia "La Specola" - Tribuna di Galileo).

Inclined plane (Istituto e Museo di Storia della Scienza, Florence)

The second of the new sciences, *local motions*, also contained surprises. Galileo understood that motion and rest are states of bodies that remain unaltered until changed by some external contingency. He understood (thanks also to the inclined plane) that bodies,

whatever their nature, fall through a void at the same velocity, and that the different times of falling observable in daily experience depend on the greater or lesser resistance opposed to their different weights. He understood that 'the natural motion of falling bodies accelerates constantly' and the increase in velocity occurs in relation to the time that elapses and not to the space covered, as he had believed in the past. He understood numerous minor questions regarding the properties of the infinite, burning glass, the speed of light, condensation and rarefaction, and the fall of projectiles. But above all he understood that neither logic alone, (while serving to verify the consequences of demonstrations but certainly not to discover them in the great quantity of things) nor experience alone (too variable), was sufficient to establish a science of physical phenomena. What was needed was an effort of abstraction from the 'accidents' and the 'impediments' of matter to grasp the mathematical laws that govern nature and then to see their practical application, 'with those limitations that experience … will teach.'

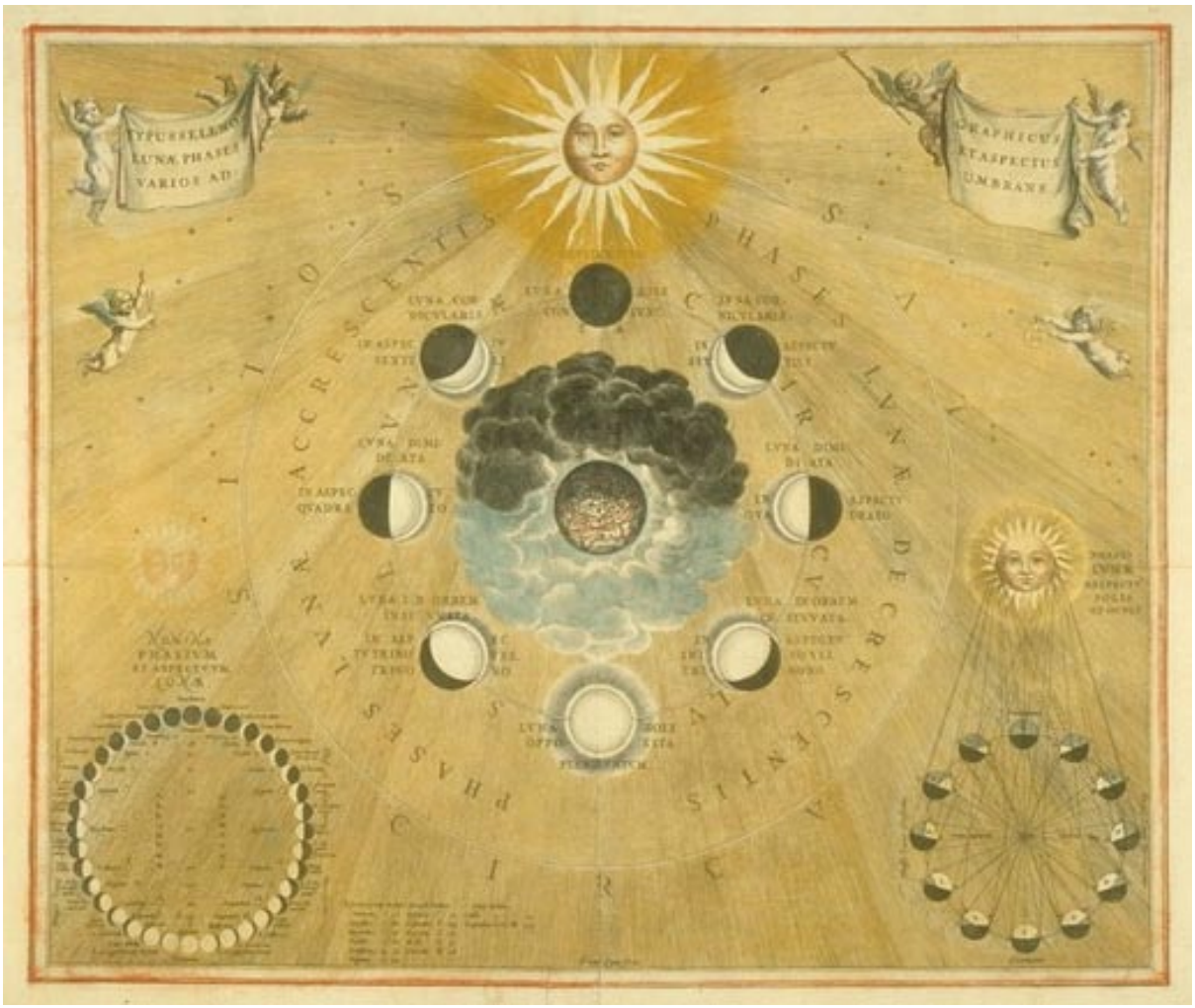


Drawings and calculations concerning the so-called "theorem of equivalence", aimed at correlating the motion of descent along an inclined plane and the parabolic trajectory of the projectile (Biblioteca Nazionale, Florence, Ms. Gal. 72, c. 117v)

The great classifiers of complete world systems, such as Descartes, did not like the *Discourses*, with all those 'effects of nature' assembled from here and there. Those who were satisfied with a more modest approach to the study of physics, such as Bonaventura Cavalieri, found in the *Discourses* an 'immense sea' of 'uncommon and challenging information, any aspect of which is enough to overwhelm anyone, however clever he may be.' Among Galileo's persecutors, there was no disquiet; despite the presence of geometry, atoms and the void. Galileo, by now the shadow of himself, was no longer alarming.

Galileo did not allow his power of reasoning to become inactive. Even when occupied with matter and motion, how could he forget the Moon? He had spent his last moments of sight observing the phenomenon of libration in an attempt to understand why, in its entire period of rotation, we see a portion larger than the exact half of its surface. To the Moon he dedicated his last text, the *Letter to Prince Leopold*, written in

1640. Why is it that, when we see only a segment of the Moon, the part in shadow appears lit by a faint greyish light? Irritated by the Aristotelian, Fortunio Liceti, who, continuing to believe the Moon capable of retaining light, could not accept a Moon made up of clods and dust, and attributed the phenomenon to the sun's rays striking the surrounding 'ether', Galileo saw in the phenomenon simply the reflection of the Earth's surface lit up by the Sun. And Liceti was subjected to the biting criticism of old, which however did not keep him from publishing the *Letter* as appendix to his own reply. Galileo was already totally blind, but of this terrestrial Moon, revealed in the finest detail, he retained an indelible memory.



The phases of the Moon (Andreas Cellarius, *Harmonia macrocosmica seu atlas universalis et novus totius universi creati cosmographiam generalem et novam exhibens*, Amstelodami, apud Ioannem Ianssonium, 1661)

The death of Galileo. Oil on canvas by Giovanni Lodi, 1856 (Accademia Atestina, Modena)

But not even his memories were to last for long; severely weakened by fever and racking pains that had tormented him for weeks, Galileo died on the night of January 8th, 1642, watched over only by those pupils who at their own risk had refused to

The apotheosis of Galileo. Fresco by Gaspero Martellini, 1839 (Palazzo Toscanelli - State Archives, Pisa)

abandon him. He was never to know of the universal acclamation of his work, which would have meant so much to him, and which came only posthumously, making him one of the legendary figures of free thought. The philosopher and scientist left us a new concept of the world, which is now ours, a concept, whether we realise it or not - having experienced nothing else - of modernity. Of Galileo the man there survives the affectionate portrayal by Vincenzo Viviani, who must be pardoned if his objectivity as a historian has been somewhat veiled by a filial love and boundless admiration for the genius of his master.

Signor Galileo was jovial and cheerful in appearance, especially in his later years; of stocky build, just height, by nature of a sanguine and phlegmatic complexion, very strong, but debilitated owing to his great labours and troubles, of both mind and spirit, so that he was often reduced to a state of languor…

Galileo visited by Vincenzo Viviani. Oil on canvas by Tito Lessi, 1892 (Istituto e Museo di Storia della Scienza, Florence)

Although he delighted in the quiet and solitude of his villa, he always loved the conversation of virtuous people and friends, by whom he was visited daily and honoured with delicacies and gifts. With them he was often pleased to dine and, although sober and moderate, he was joyful on these occasions, delighting especially in the taste and variety of wines from every country, with which he was always well provided …

He disliked meanness much more than prodigality. He spared no expense in experimenting and observing in order to obtain information of new and admirable importance. He spent liberally in raising the spirits of the depressed, in receiving and honouring foreigners, in administering the necessary commodities to people without means who excelled in some art or profession, supporting them in his own home until a suitable place could be found for them …

Signor Galileo was not ambitious of the honours of the masses, but of the glory by which he could be distinguished from them. Modesty was ever his companion; conceit and arrogance were unknown to him. In his adversity he was steadfast, and courageously suffered the persecutions of his adversaries. He was easily moved to anger, but even more easily became calm. In conversation he was always most amiable, expressing a wealth of important ideas and judgements in discussing serious matters, and being quick-witted and amusing in pleasant discourse…

He was gifted by nature with remarkable memory; and greatly enjoying poetry, he knew by heart, among the Latin authors, much of Virgil, Ovid, Horace and Seneca, and among the Tuscans almost all of Petrarch, all the rhymes of Berni, and almost the whole poem of Lodovico Ariosto, who was always his favourite author, celebrated above the other poets, and whom he compared in many places to Tasso… He spoke of Ariosto with various expressions of esteem and admiration; and when asked his opinion on the two poems of Ariosto and of Tasso, he at first refused to compare them, declaring that comparisons were odious, but then, obliged to reply, said that Tasso seemed to him more beautiful, but that he liked Ariosto more, adding that the former spoke mere words, and the latter spoke of real things.

After Galileo

On the morning after his death, following a ceremony held almost in secret for fear the Inquisition might refuse him burial in consecrated ground, Galileo's body was placed in a little room below the bell tower of the Basilica of Santa Croce. A temporary burial place, it was said. Grand Duke Ferdinand II had ambitious plans for a magnificent tomb, as twin to the one designed by Vasari for Michelangelo. The great scientist was to face the artist, in an act of homage that would reflect glory on the dynasty that had protected them. Moreover, it had long been believed that Galileo was born on February 18, 1564, the day of Michelangelo's death, a symbolic handing over of the baton of greatness. Needless to say, none of these plans was ever realised. The Pope himself stepped in to check the Grand Duke of Tuscany's commemorative enthusiasm. Through the ambassador, Francesco Niccolini, he actually issued a further belated judgement: Galileo had been summoned before the Inquisition 'for a very false and very erroneous opinion,' which he had even disseminated and taught, causing 'universal outrage to Christianity with a doctrine that had been condemned.' No sovereign who dedicated a monument to his everlasting memory would appear 'an example to the world.' Grand Duke Ferdinand, who later founded and protected the Academy of the Cimento, was to fly the flag for the Galileian heritage. But now, faced with the veto of God's representative on earth, he yielded, and the modest grave became the definitive one. After several attempts had failed, it was

Original tomb of Galileo (Basilica di Santa Croce, Florence, Cappella del noviziato)

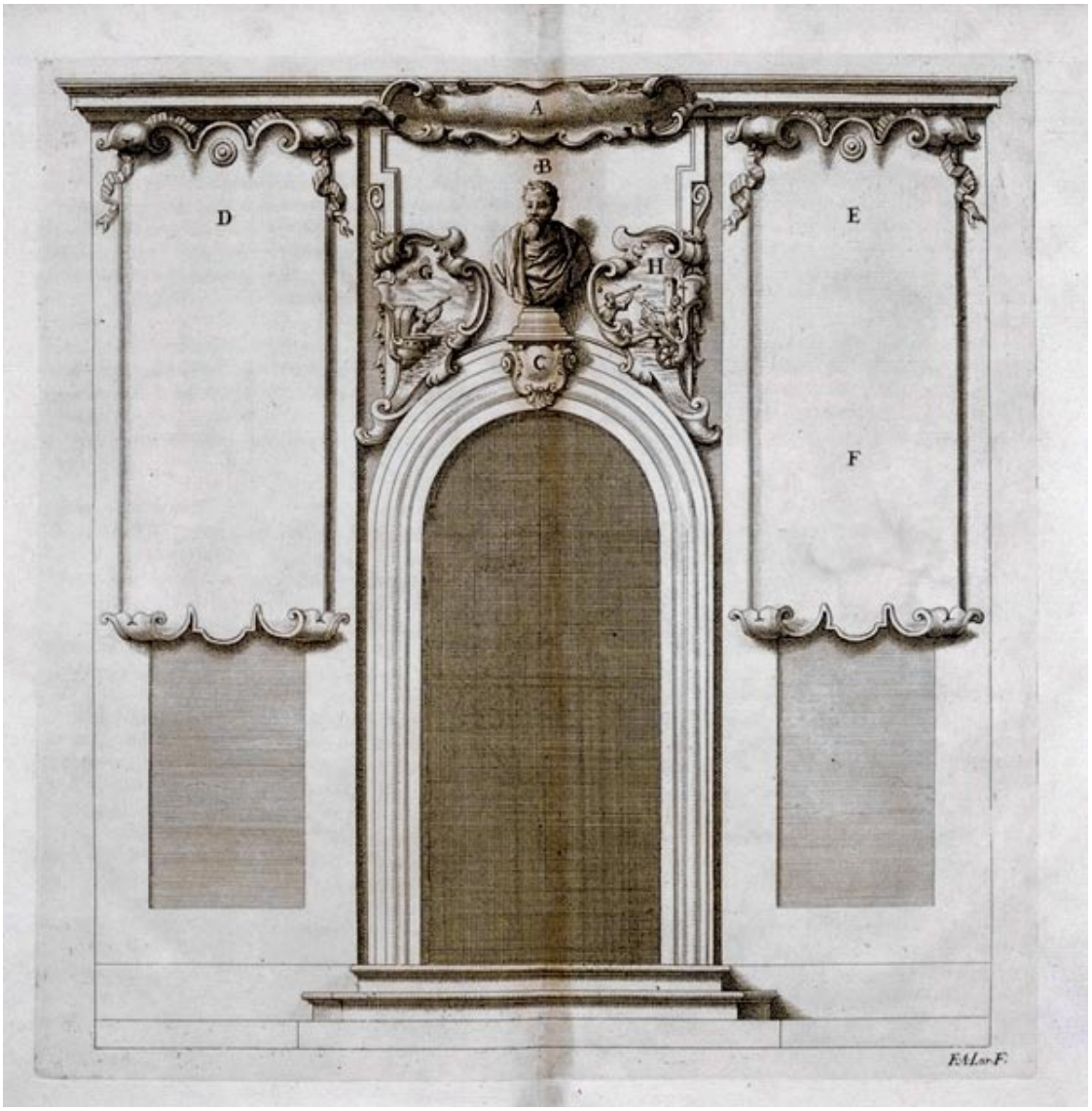
Monumental tomb of Galileo, 1737 (Basilica di Santa Croce, Florence)

only in 1737 that Galileo had his monumental tomb, differing no doubt from how it would have been nearly a century before, but equally solemn, with a portrait bust, a marble urn, and two statues, one of Astronomy gazing in fascination at the sky and the other of Geometry inconsolable at the death and, perhaps, at the injustice.

Portrait of Vincenzo Viviani. Pastel on paper by Domenico Tempesti, c. 1690 (Galleria degli Uffizi, Florence)

Present at the bedside of the dying Galileo and at the removal of the body, in addition to his son, Vincenzo, and his direct intellectual heir, Evangelista Torricelli, was the twenty-year-old Vincenzo Viviani. Galileo's last pupil, as he was to refer to himself for the rest of his life, Viviani was to spend his future years in the vain, and at times clumsy, attempt to reinstate his master's ideas. Thanks to a pension granted by the King of France, Louis XIV, he had a house built in Via dell'Amore, called the Palazzo dei cartelloni (Palace of the Scrolls), a kind of large mausoleum adorned with a portrait bust and commemorative scrolls on the façade, inscribed with the life story of Galileo written in Latin by Viviani himself. All this Viviani had done despite his many anxieties. He had been supposed to write a real biography, initially conceived as a massive and imperishable work, in exchange for the pension that had funded the house. But he never wrote it, in part out of fear of retaliation, in part through his inability to reconcile geometry with the dogmas of faith, and in part influenced by more or less explicit warnings to be prudent (which, at times, came from within), evidently more convincing than the pressure exerted on him from the palaces of Paris by such prominent figures as Jean-Baptiste Colbert, at the time Minister of the King's Palace. Of

Viviani as a direct witness, if not always faithful chronicler or clear interpreter, there now remains only the slender *Racconto istorico della vita di Galileo Galilei* [Historical Account of the Life of Galileo Galilei], written in the form of a letter addressed to Prince Leopoldo de'Medici, and with this we must be content. It was printed, not during Viviani's lifetime, but only in 1717, well camouflaged even then among the dozens of biographies of the *Fasti consolari dell'Accademia Fiorentina* [A Biographical History of the Florentine Academy] edited by the canon, Salvino Salvini.



Entrance to the Palazzo dei Cartelloni, or Palazzo Viviani, surmounted by a bust of Galileo (Vincenzo Viviani, *De locis solidis secunda divinatio geometrica*, Florentiae, typis Regiae Celsitudinis apud Petrum Antonium Brigonci, 1701)

In time, much time, the waters calmed. Over a century after the death of Galileo, Giuseppe Pelli Bencivenni, a Florentine notable, who a few years later would also be put on the Index for some witty remarks he had made at the expense of friars, noted in his diary on January 5th 1768:

What would Galileo say if he came back to life and saw his hypothesis that the Earth moved around the Sun taught and explained even in almanacs? And yet it is so in the 'Mangia di Siena', an almanac printed there with the necessary approval, well explained to both the common people and to the educated, both last year and this. Thus does the world change, and it will change even more, so that in a century or two our grandchildren will perhaps laugh at us, at our errors and our prejudices.

Science Clipping the Wings of Error. Presumably a portrait of Galileo. Oil on canvas by Van Dyck, 17th century. Present location of the work unknown

Time exalts Science and stamps out Ignorance: a celebration of Galileo and his scientific discoveries. Detail of a fresco by Anton Domenico Gabbiani, 1692-1693 (Palazzo Pitti, Florence, Palazzina della Meridiana, dome of the Sala della Meridiana).

In effect, things had indeed changed. For a long time, the danger of Galileo had been fading, and the Church had been engaged in an attempt to curb the spread of Newton's theories on universal gravitation, already considered proven in the rest of Europe. Clearly, the Church continued to see scientific progress, although within different systems and parameters, as a threat to the conservation of its own power. It had, moreover, hastened to prohibit not Newton's *Principia*, incomprehensible to most and, all things considered, harmless, but the popularized *Newtonianismo per le dame* [Newtonianism for Ladies] by Francesco Algerotti, comprehensible to all and therefore a source of greater danger. Many of the best minds had gradually turned, as many more were to continue to do, to fields of intellectual activity less risky to their personal safety or simply less harmful to the quality of their lives. This circumstance bore heavily on the direction that Italian culture was to take in the centuries to come. As regards error and prejudice, every age, it seems, produces its own, a process that cannot be easy to remedy, considering that Galileo had to wait until 1992 before he was recognised as a victim of persecution.

John Paul II on a visit to the Aula Magna Storica of Pisa University. Statue of Galileo by Paolo Emilio Demi

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