FRANCESCO FONTANA AND THE BIRTH OF THE ASTRONOMICAL TELESCOPE

Paolo Molaro
INAF, Osservatorio Astronomico di Trieste,
Via G.B. Tiepolo 11, 34143 Trieste, Italy.
E-mail: molaro@oats.inaf.it

Abstract: In the late 1620s the Neapolitan Francesco Fontana was the first to observe the sky using a telescope with two convex lenses, which he had manufactured himself. Fontana succeeded in drawing the most accurate maps of the Moon's surface of his time, which were to become popular through a number of publications that appeared throughout Europe but did not acknowledge the author. At the end of 1645, in a state of declining health and pressed by the need to defend his authorship, Fontana carried out an intense observing campaign, the results of which he hurriedly collected in his *Novae Coelestium Terrestriumque rerum Observationis* (1646), the only publication he left for posterity. Fontana observed the Moon's main craters, such as Tycho (which he referred to as 'Fons Major'), their radial debris patterns and changes in their appearance due to the Moon's motion. He observed the gibbosity of Mars at quadrature and, together with the Jesuit Giovanni Battista Zupus, he described the phases of Mercury. Fontana observed the two—and occasionally three—major bands of Jupiter, and inferred the rotation of the major planets Mars, Jupiter and Saturn, arguing that they could not be attached to an Aristotelian sky. He came close to revealing the ring structure of Saturn. He also suggested the presence of additional moons around Jupiter, Venus and Saturn, which prompted a debate that lasted more than a hundred years. In several places in his book Fontana claimed to have conceived the first positive eyepiece in 1608, and he provides a declaration by Zupus that his telescope was in use from 1614. Finally, we suggest that the telescopes depicted in the two paintings *Allegory of Sight* and *Allegory of Sight and Smell* by J. Brueghel the Elder might have been made by Fontana, and that he might by portrayed in the *Allegory of Sight* by Jusepe Ribera.

Keywords: Francesco Fontana; astronomical telescope; *Novae Coelestium Terrestriumque rerum Observationis*; observations of the Moon, Mercury, Venus, Mars, Jupiter and Saturn; positive eyepiece; paintings: *Allegory of Sight* and *Allegory of Sight and Smell*.

1 INTRODUCTION

The scarce information we have on Francesco Fontana is given by his contemporary Lorenzo Crasso (1623–1691), who in 1666 dedicated a book to the outstanding people of his time and counted Fontana among them. From Crasso's short biographical notes we learned that Fontana was born in Naples sometime between 1580 and 1590 and that at the age of twenty he graduated in Theology and Law, obtaining his Doctorate at the University of Naples Federico II. However, he never practiced in that profession and, following a vocation he had shown interest in ever since his childhood, he taught himself mathematics and devoted himself to grinding lenses. Crasso (1666) reported that Fontana used to say he preferred the truth of science to that of the Forum. Upon the death of Giovan Battista Della Porta (1535–1615), whom Fontana considered as the inventor of the telescope, Fontana made several unsuccessful attempts to obtain Della Porta's instruments.

In Naples Fontana was close to Camillo Gloriosi (1572–1643), who corresponded with Galileo Galilei (1564–1642) and in 1610 succeeded him at Padua University. Fontana also was close to the Lyncean Fabio Colonna (1567–1640), who commissioned him to make microscopic observations in 1625, and the Neapolitan Jesuits (who frequently were opposed to the Lynceans), and in particular Fathers Gerolamo Sersale (1584 – 1654), Giovanni Battista Zupus (1589–1667) and Giovan Giacomo Staserio (1565–1635).

Fontana was a fine craftsman and never needed to do anything else for a living. His telescopes reached the courts all over Europe that were interested in scientific and military developments. The quality of his lenses was such that Fulgenzio Micanzio (1570–1654) wrote in a letter to Galileo:

> By continually working on and constructing telescopes it is said that Fontana's achievements reached such a high standard that in matters of the heavens he is a genius. (Micanzio, 1638).[1]

To advertise his telescopes, Fontana used to send maps of the Moon and news of other discoveries he had made by observing the sky from the roof of his house in Naples:

> … after personally manufacturing two [telescopes] of enormous length and attaching them to a wooden support on the top of his house, Fontana regularly observed the planets, which featured in a book titled *Novae Observationes caelestium terrestriumque rerum* [*New Celestial and Terrestrial Observations*] that was published in 1646. (Crasso, 1666: 298).

The *Novae Coelestium, Terrestriumque rerum Observationes, et Fortasse Hactenus non Vulgate a Francisco Fontana Specillis a se Inventis, et ad Summam Perfectionem Perductis, Editae*

(1646) is the only work that Fontana published, although Crasso mentioned a treatise titled *On Fortifications*, but this has never been found. In 1656 Fontana and all his family died from the plague.

However, during his life, and even after his death, Fontana's work received little attention from scholars, apart from rare exceptions like F. Colangelo (1834: 246–268), and there was even open opposition to his ideas. His numerous detractors generally emphasized the superficiality, if not the incorrectness, of his observations and the lack of any optical theory for the functioning of the telescope. His claim to have constructed a telescope with two convex lenses in 1608 was generally considered as unreliable. Thus, on 25 May 1647 Evangelista Torricelli (1608–1647) wrote to Vincenzo Renieri (1606–1647): "I have the book of stupidities observed, or rather dreamed up, in the heavens by Fontana." In his *Almagestum Novum*, the Jesuit Giovanni Battista Riccioli (1598–1671) acknowledged the quality of the instruments constructed by Fontana (1651) but he rejected most of the 'novelties' that Fontana claimed to have observed (Riccioli, 1651). The recent translation from Latin by Beaumont and Fay (2001) now allows us to make an accurate evaluation of Fontana's writings, and this reveals a rather different—and probably more realistic—image of the scientist and of his work.[2]

Figure 1: An etching of Fontana's self-portrait printed in his *New Celestial Observations*. In the oval frame Fontana identifies himself as the inventor of the telescope (Fontana, 1646: [ii]).[3]

2 THE *NEW CELESTIAL OBSERVATIONS*

The *Novae Coelestium, Terrestriumque rerum Observationes, et Fortasse Hactenus non Vulgate a Francisco Fontana Specillis a se Inventis, et ad Summam Perfectionem Perductis, Editae*, or simply the *New Celestial Observations* as we will henceforth refer to it, was published in Naples by Gaffaro in 1646. The title makes an explicit claim that Fontana was the inventor of the instruments used for the observations, and this claim is iterated rather obsessively in several passages in the book. Dedicated to Cardinal Camillo Pamphili (1622–1666), the book opens with four testimonies supporting Fontana's claim. The first is from the Jesuit Giovanni Battista Zupus, who had been a Professor of Mathematics at the Jesuit College in Naples for twenty-seven years. In his declaration Father Zupus asserts that he first used Fontana's telescope in 1614, together with his superior Jacobo Staserio, and that through his own observations he could confirm all the discoveries announced by Fontana:

> I, Jo. Baptista Zupus of the Society of Jesus in the kindly Neapolitan College, Professor of Mathematical Sciences, assert that many, if not all the phenomena, which Dom. Francesco Fontana is bringing to the public domain in print, not once or twice but on several occasions by me and by others of our Society by means of the very optic tubes constructed by the same Dom. Fontana … I assert that he was he who first employed two convex lenses in optical tubes, beginning in the fourteenth year of this century when he displayed for inspection a tube equipped with such lenses both to Jacobo Staserio, my Master, and to me, to the surprise and delight of us both. (Beaumont and Fay, 2001: 7).

A second declaration, by Father Sersale, states that Fontana invented both the telescope and the microscope. The remaining testimonies are two eulogies, one from an anonymous scholar and the other from Ippolito Vigiliis, a monk in Cassino, Reader in Philosophy at the cloister of St Severino in Naples and a member of the Academia degli Oziosi. Vigillis supports the truthfulness of the numerous discoveries made by Fontana, and he also states that Fontana made his own telescope, although he fails to mention when this occurred.

The *New Celestial Observations* includes an etching of the author, and this is shown in Figure 1. The surrounding oval frame contains an inscription where Fontana identifies himself as the inventor of the telescope, and his age as 61. This could either represent Fontana's age in 1646, which implies that he was born in 1585 and invented the telescope at the age of 23 or, as suggested by Favaro (1903), it could be read in reverse as 19, which implies that Fontana was 19 years old when he invented the telescope and that he was born in 1589. Both hypotheses are consistent with the range of the possible years proposed for Fontana's birth.

In the 'Preface to the reader', after recalling once more that he had invented an optical tube with two convex lenses, Fontana explains the motivations behind his book. He complains that various authors, including Michael Florentius Langrenus (1598–1675) and Athanasius Kircher (1602–1680), had circulated papers based on his planetary observations without crediting them to him. The only exception was Giorgio Polacco (1644) who in his *Catholic Treatise against Copernicus* gave credit to his claims. An extensive list of these forged copies, including some not even mentioned by Fontana, is given in Van de Vijver (1971a; 1971b). Fontana (1646: 9) explicitly says that in order to avoid that

> … others reap the glory for themselves of all my hard work ... I wish to quickly collect everything together.

The *New Celestial Observations* contains observations that Fontana made in 1629, along with later observations made mostly in the last two months of 1645 and at the beginning of 1646. However, Fontana (ibid.) considered the material included as incomplete, and warned that "I could not finish for lack of health and time."

The book contains eight treatises. The first is dedicated to the telescope; the next three to his observations of the Moon; the fifth to the planets Mercury and Venus; the sixth to Mars and Jupiter; and the seventh to Saturn and the Pleiades. The final treatise is on the microscope. The observations are accompanied by 27 full-page etchings of the Moon, a larger folded map of the Full Moon (made by Fontana), and 26—mostly full page—woodcuts of the planets based on Fontana's own observations (as he declares in the Preface). This is the first published 'atlas' of the Moon, where Fontana features images of our satellite at nearly every phase of the lunar cycle, a sort of illustrated astronomical book that would become very popular at a later time (cf. Winkler and Van Helden, 1992).

3 THE FIRST TREATISE: THE TELESCOPE[4]

Fontana believed that the concept of the telescope was first proposed by Della Porta and that it was then put into practice and refined by Galileo.[5] Fontana also included verses of the Lyncean Giovanni Faber (1574–1629), the doctor and herbalist to the Pope, who celebrated Galileo as the first scientist of his times:

> Porta holds the first realm; German [i.e. Keper!], you may have the second;
> your work, Galileo, gives you the third realm of the stars.
> But as far as the heavens are distant from the earth,
> you, Galileo, shine more brightly than the rest.
>
> (Beaumont and Fay, 2001: 11).

This was quite noteworthy as Fontana was close to the Jesuits of Naples, who were notably hostile to Galileo and whose permission was needed for him to publish. Considering Porta as the inventor of the telescope in 1589, makes clear that Fontana's claim to have invented the telescope in 1608 referred exclusively to the telescope made by combining two convex lenses.

Later in his book Fontana comments on the history of the telescope from antiquity up to his era. He rejects the possibility that the ancients already knew of the telescope on the grounds that they never revealed any details of the Moon or the stars. The earliest important telescopic discoveries about the planets and stars were made by Galileo. A detailed list follows:

(1) The Milky Way is made of stars;
(2) The *hazy* stars are composed of multiple stars;
(3) The number of fixed stars is 10 or 20 times greater than that given by Ptolemy;
(4) Jupiter has four satellites;
(5) The Moon is not a perfect sphere;
(6) Saturn consists of three stars; and
(7) Venus has phases.

After Galileo the only significant discovery was made by Langrenus in 1645, with his map of the Moon showing the maria. Langrenus was the first to propose a system of lunar nomenclature, but few of his names have survived to the present day. However, Fontana (1646: 15) adds that Langrenus' map could have been

> … derived possibly from my maps … first done in 1629 … since Langrenus never reveals the designer of his telescope.

Fontana wrote that with his own telescopes he had confirmed all of the above-listed discoveries, i.e. in an apparently 'empty' sky the telescope reveals that there are in fact "… now 3 now 4 …" stars; the Pleiades contained at least 28 stars; nebulae were composed of stars; and the Milky Way contained an infinite number of them.

The difficulty of grinding and polishing lenses in order to give them a perfect spherical shape is then described, including the role played by bubbles and air-holes in the glass. Fontana stresses the importance of possessing a testing tool to check for lens-shape, and he proposed to look at the projected image of a candle as a testing procedure for the quality of the lens (Fontana calls this his first invention). In a chapter titled "Concerning the Astronomical Telescope Invented by the Author", the construction of the author's second invention is described. Fontana clarifies that when he conceived the idea of his telescope he did not know of the book *Dioptrice* by Johann Kepler (1571–1630):

> Although that model seems to be proposed by Johann Kepler in his Dioptrics, Question 86, p. 42 printed in 1611. However, I had in truth no knowledge of this book earlier than the present moment when I am publishing this treatise, and I have received it in return from the aforementioned Johan Baptiste Zupus. It is surprising that it is not recorded that Kepler was the inventor of this device in Germany and myself in Naples; also his method is quite different from the method suggested here … (Beaumont and Fay, 2001: 21).

In the last sentence Fontana seems to doubt the real intentions of Kepler and invites the reader to go directly to the source.

Fontana also describes how to correct inverted images by the use of a third lens with the same radius of curvature (his third invention), apparently ignoring the presence of a similar concept in Kepler's *Dioptrice* and in *Oculus Enoch et Elliae Sive Radius Sidereomysticus* (1645) by Anton Maria Schyrleus de Rheita (1604–1660). An astronomical and terrestrial telescope thought to have been made by Fontana around 1650 is in Luxottica's Museum of Optics in Agordo. It is a terrestrial telescope with an eyepiece containing three lenses, and could be an early implementation of Fontana's third invention.

The last chapter describes how to construct very long telescopes, i.e. with a length of up to 50 palms (i.e. 13.18 metres, since 1 Neapolitan palm corresponds to 0.2637 metres).[6] With such a length the radius of curvature of the lenses was so large that the lenses surface became almost flat and therefore were extremely difficult to work. Fontana describes his solution to the problem by introducing for the first time the concept of the optical meniscus:

> This inconvenience will be avoided, if the glass is figured on one side in a convex shape and on the other side in a concave one. (Fontana, 1646: 23).

Fontana considered this his fourth invention. But he does not mention the problem with chromatic aberration, which severely affects this kind of telescope.

3.1 On Fontana's Telescopes

Some information on Fontana's telescopes can be obtained from the correspondence between the natural philosophers and scholars of his era. The first mention is contained in a letter from Colonna to Federico Cesi (1585–1630), dated 30 November 1629:

> F. Fontana made a telescope of eight palms [2.1 m], with which he shows the Moon and the stars though upside down.

In 1637, when he was trying to sell his telescopes to the Grand Duke of Tuscany Federico II, Fontana contacted Benedetto Castelli (1578–1643), who wrote to Galileo celebrating the virtues of Fontana's telescopes (see Castelli, 1637a, 1637b).

In the following year, Fontana made a 14-palms (i.e. 3.7-m.) telescope. The construction of this very long telescope was documented in a letter written by G.G. Cozzolani to Carlo Antonio Manzini on 11 September 1638, and in two letters that Castelli wrote to Galileo in July 1638. Thus, on 3 July, Castelli (1638a) wrote:

> I am holding a glass of Naples that is for a telescope long fourteen Neapolitan palms … magnifies the object ninety times.

Two weeks later the magnification had become "… 160 times … a monstrosity." (Castelli, 1638c). This telescope was then bought by the Extraordinary Imperial Ambassador in Rome, the Duke of Cremau, Prince Ecchembergh (Del Santo, 2009).

Fontana's grinding and polishing technique still remains unknown as it was only partially disclosed in his book. On 3 January 1638 Fontana wrote to the Grand Duke of Tuscany with the offer to reveal his secret way of working lenses for a reward of 2000 piastres but the Grand Duke declined the offer. This attempt is also recorded in a letter by Castelli (1638d) to A. Santini written in the same year (cf. Arrighi, 1964). In a letter dated 10 July 1638 Castelli (1638b) wrote to Galileo that he thought he had figured out Fontana's secret way of grinding lenses. Apparently Fontana was working only the central part of the lens, as we deduce from Galileo's answer of 20 July 1638 (see Galileo, 1638b).

On 23 October 1639 Fontana directly addressed the Grand Duke of Tuscany proposing a 22-palms (i.e. 5.8-m) telescope (del Santo, 2009). We do not know the Grand Duke's answer, although del Santo suggests that this telescope had actually reached Florence.

3.2 The Genesis of the Astronomical Telescope

Four centuries later the details of the genesis of the Dutch telescope are still unknown, but even more mysterious is the birth of the astronomical telescope, i.e. the one made up with two convex lenses (Van Helden, 1976; 1977a; 1977b; Van Helden et al., 2011). After the publication of *Sidereus Nuncius* by Galileo, in the summer of 1610 Kepler wrote *Dioptrice*, the publication of which followed one year later. Kepler's book was devoted to an explanation of the functioning of the Dutch telescope but also considered all other possible combinations of lenses, including two and three convex lenses. However, these considerations were not inserted in the Dioptrice's section on the telescope and, when discussing image formation, Kepler did not mention the magnification, which is the main characteristic of a telescope. As argued by Malet (2010: 281) "… the idea of turning his theoretical combination of two convex lenses into a working telescope may have never crossed Kepler's mind." A similar doubt was expressed by Fontana, when invited to read carefully Kepler's book. As a matter of fact, Kepler did not make a telescope, and we had to wait as long as 1645 before Schyrleus de Reita manufactured the first 'Keplerian' telescope, apparently on the basis of Kepler's instructions.

In 1655 Johannes Sachariassen (b. 1611) claimed that his father Sacharias Janssen (1585–1648) was the first to construct a 'long tube' telescope, in 1618, when he attended a Middelburg City Council investigation set up in 1655 to clarify the origin of the telescope:

> In the year 1590 the first tube was made and invented in Middelburg in Zeeland by Sacharias Janseen, and at that time the longest were 15 to 16 inches ... The length of 15–16 inches was in use until the year 1618; then I and my father invented the long tubes which are used at night for seeing the stars and the Moon.

However, Van Helden (1976) and Zuidervaart (2011) have noted several inconsistencies in his declaration and probably the definition of 'long tubes' did not refer to a Keplerian telescope but rather to a Dutch one with a longer focal length (Van Helden, 1976).

The first printed mention of a telescope formed by two convex lenses appeared in *Rosa Ursina sive Sol* (1631) by Christoph Scheiner (1573–1650). When describing how to use a Dutch telescope to project the solar image, he mentioned that a different arrangement for the projection which made use of two convex lenses was also possible:

> If you fit two like [convex] lenses in a tube in the same way, and apply your eye to it in the proper way, you will see any terrestrial object whatever in an inverted position but with an incredible magnitude, clarity, and width. Scheiner, 1631: 130).

Then on page 130 Scheiner (1631) wrote: "… thirteen years ago, I made erect the images intercepted for the most Serene Maximilian, Archduke of Austria." Thirteen years before the publication date was the year 1617; but since *Rosa Ursina* took a four-year period to be printed, it could have been within 1613–1617 (cf. Van Helden, 1976). However, a document of 1616, kept in the Tyrolean State Museum Ferdinandeum, states that

> … the Archduke [Maximilian] acquired an optical instrument of admirable utility but that was giving inverted images; since he wished to see the pictures erect, and this could not be obtained he turned to the Jesuits, who gave him the Professor of Mathematics in Ingolstadt [Christoph Scheiner] as an expert. (Anonymous, 1616).

This was the first document to refer to an astronomical telescope, and it confirms Scheiner's reconstruction and fixes the date at 1616. However, neither this document, nor the *Rosa Ursina* mention Scheiner as the inventor. He was simply reported to have added a lens to a preexisting telescope and rectified the image, for the benefit of Maximilian III. Moreover, neither in *Disquisitiones Mathematicae* (1614), nor in the manuscript *Tractatus de Tubo Optico* (1616), or even in *Oculus hoc est fundamentum opticum* (1619), does Scheiner ever refer to himself as the inventor of the Keplerian telescope. Such an omission would be rather bizarre if he really was the inventor of a new kind of telescope.

Actually, so very little was known of Kepler's telescope that, when Schyrleus de Rheita mentioned it in his *Oculos Enoch et Eliae* (1645)—disregarding altogether the contribution of Fontana—he was generally credited with this inventtion (see King, 1955). However, a very different story was presented by Francesco Fontana in 1646 when he claimed throughout his book to be the first to construct a telescope made with two convex lenses. There are no apparent reasons to question Father Zupus' declaration to have used Fontana's telescope in 1614, since he was still alive when the book was published. Allowing for some time to improve the quality of the lenses, even the year 1608 does not seem implausible as the birth-date of Fontana's telescope, though it is based only on his own word. The improvement in the optical quality of the lenses was probably the decisive factor if we consider that already in 1538 the Italian scholar Girolamo Fracastoro (1478– 1553) wrote:

> If someone looks through two eye-glasses of which one is placed above the other, he shall see everything larger and closely. (Fracastoro, 1538: p18v, section II, cap 8).

4 OBSERVATIONS OF THE MOON

Fontana dedicated three treatises of his *Novae Celestium Observationes* to the Moon. The first is a summary of all of his lunar discoveries; the second presents thirteen observations of the waxing Moon; and the third reports eleven observations of the waning Moon made in January 1646 together with four previous lunar observations made in 1629, in 1630 (two) and in 1640. Fontana considered the results of these earliest observations as less accurate since "… they took place at a time when the optic tube had not reached its present standard of perfection …" and he therefore presents them at the end of the fourth treatise. They were probably obtained with his telescope of 8 palms, while for his last observations he probably used his 12-palms telescope. However, his earliest observations are more interesting since they were the first observations ever performed with an astronomical telescope. Let us now examine these early observations.

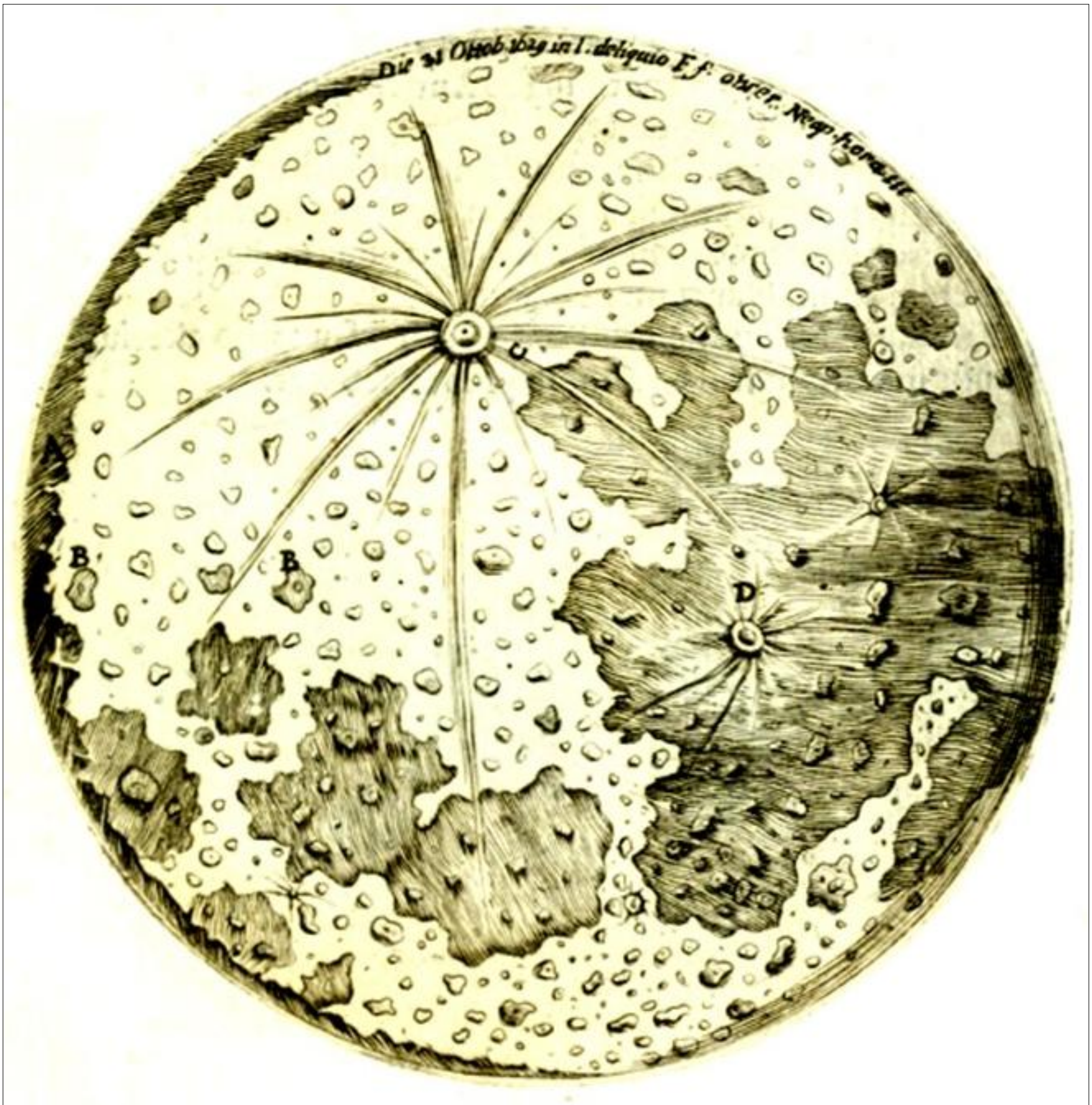

Figure 2: A drawing of the Moon based on observations made on 31 October 1629, three hours after sunset. The actual size of the etching is 10.3 cm. The Moon is shown upside-down with the South at the top and East on the right, as seen in an astronomical telescope. Some features are marked with letters. Letter A highlights that the Moon is not perfectly spherical but is irregular along the limb like an axe blade.[7] Letter B indicates a new, though relatively small, spot. Letter C indicates what we know today as the crater Tycho. This crater was observed (in this position) for the very first time by Fontana, who also saw several rays formed by the material splashed out during the impact, and a central peak, which is a characteristic of large craters. Fontana named Tycho 'Fons Major', i.e. biggest fountain, echoing his own name Fontana (which in Italian means fountain). Letter D marks the crater today known as Copernicus, which was also seen for the first time by Fontana (courtesy: Perkins Library of the Duke University).

4.1 The Lunar Observations of 1629 and 1630

Figure 2 shows Fontana's observation of the Moon made on 31 October 1629 three hours after sunset, probably from the roof of his house in Naples. The quality of this map can be judged by comparing it with those available at about this time, prepared in 1619, 1620 and 1627 by Charles Malapert (1581–1630), Giuseppe Biancani (1566–1624) and Christoforo Borri (1583–1632) respectively (see Figure 3), and with the modern high-resolution image shown in this figure (after Whitaker, 1999). Fontana was definitely the first to draw the true shape of both the Moon's maria and the major craters.

Fontana's etchings of the Moon were circulated around Europe long before they were published in his *Novae Celestium Observationes*. For instance, one of his lunar maps was sent to scholars in Genoa by Castelli, as documented in the letter Renieri wrote to Galileo on 5 March 1638:

> A picture of the Moon has arrived in Genoa, sent here by Benedetto Castelli, with news of

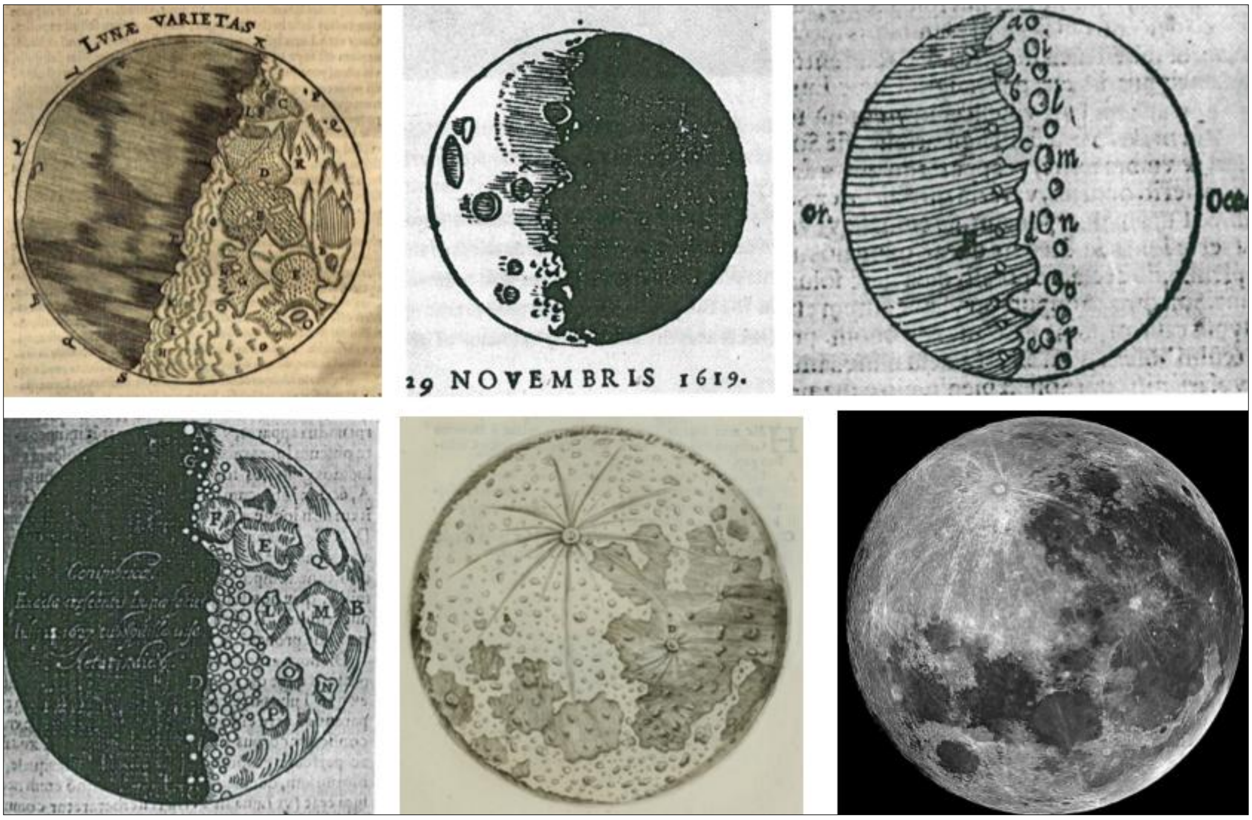

Figure 3: Drawings of the Moon made before Fontana did his first drawing. Top, left to right: Christophe Scheiner (1614), Charles Malapert (1619) and Giuseppe Biancani (1620). Bottom, left: Christoforo Borri (1627). Bottom, centre is Fontana's first drawing (1629), shown upside down, and bottom right is a modern view of the Moon (also shown upside down).

> a new telescope invented by a certain Fontana from Naples showing things more exquisitely than any other.

Then from a letter Gloriosi wrote to Santini on 13 March 1638 (Arrighi, 1964: 444) we learn:

> In Naples there is a person ingenious but has not studied science. His name is Francis Fontana ... I send to you the map of the Moon ... observed also designed by Fontana. These maps have gone to Rome to S. Cardinal Barberino, the Grand Duke of Florence and perhaps to other people that I do not know. (My English translation).

Fontana's lunar maps were reproduced by several authors. According to van de Vijver (1971b), Matthias Hirzgarter (1574–1653) used them in his *Detectio Dioptrica Corporum Planetarum Velorum* (1643); Andrea Argoli (1570–1657) in his *Pandosium Sphaericum*, (1644); Kircher in *De Arte Magna de Lucis et Umbrae* (1646) and Polacco in his *Anticopernicus Catholicus* (1646). And as we have already noted, Fontana suggested that his maps might have been the source of the map that Langrenus (the Royal Cartographer of King Philip IV of Spain) published in 1645, where he provided the first nomenclature of the lunar features, some of which are still in use today. As Fontana explained in his opening address to the reader, his wish to claim priority for the invention of the astronomical telescope was one of his motivations for writing the book.

The observation of 20 June 1630 shown in Figure 4 is of special interest since it records a rare occultation of Saturn by the Moon. Fontana wrote that the occultation took place on 20 June

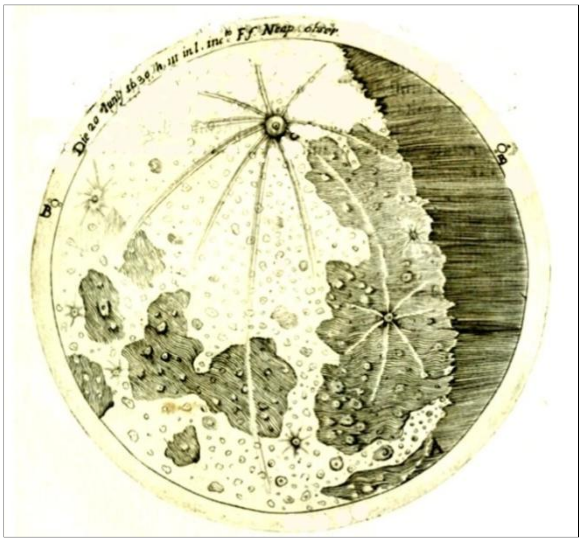

Figure 4: An English translation of the inscription around the Moon reads: "20 June 1630, IIIrd hour of the waxing Moon observed by Francesco Fontana in Naples." Beside the letter B there is the Galilean symbol for Saturn, which marks the position of Saturn both at the start and the end of the occultation. The letter A highlights the presence of a special darker area than the dark surroundings, and the letter C marks the 'Chief Fountain' (the crater Tycho) and one of the rays that joins up with a ray originated from the other 'great fountain' (Copernicus) in the great dark area (Oceanus Procellarum). The diameter of this Moon map is 10 cm.

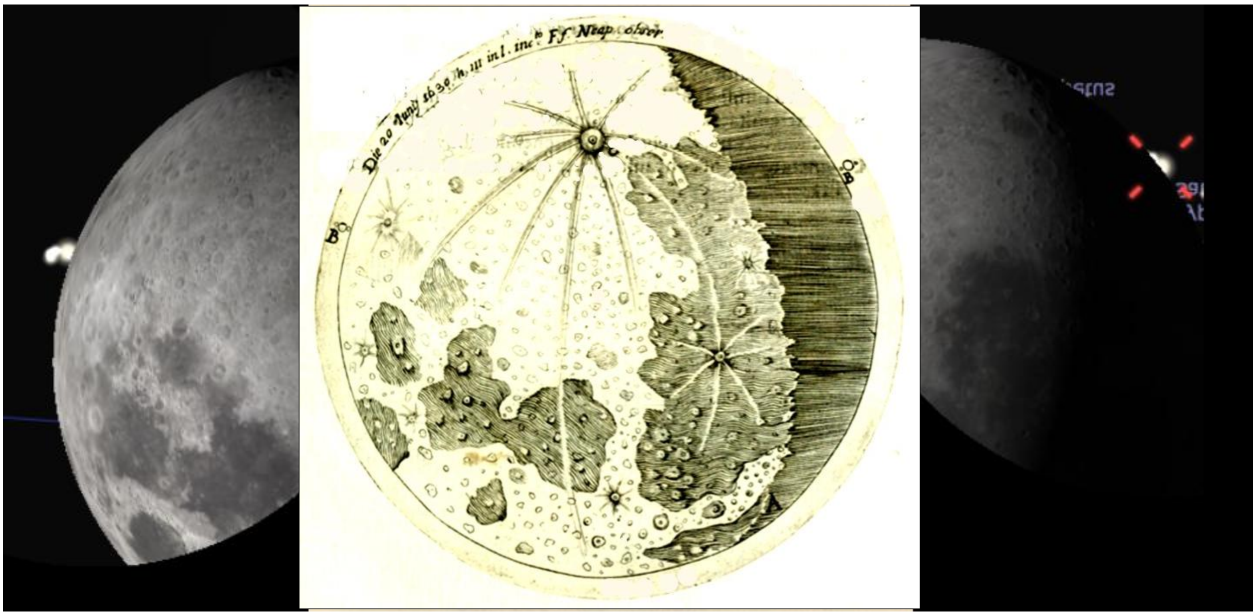

Figure 5: The same as the previous figure, but with the end of the occultation on the left and the start on the right. The occultation is reconstructed with Skygazer 4.5. This shows that the positions marked by Fontana were drawn precisely.

1630, starting about three hours after sunset and lasting less than two hours, but in fact the occultation took place on 19 June, one and a half hours after sunset and lasted less than one hour.

These differences have often been considered as evidence of Fontana's overall inaccuracy. However, these inaccuracies can be explained if we consider the way Fontana recorded his observations. As suggested by Beaumont and Fay (2001), Fontana took sunset as the start of the day, instead of midnight. Thus, the third hour after sunset of 20 June corresponded to the evening of 19 June. In the Skygazer simulation of the event the occultation from Naples started at 22:10:19 (UT) and ended at 22:58:59, for a total duration of about 49 minutes, thus much shorter than the two hours reported by Fontana. Nonetheless, I suggest that Fontana could possibly have used Roman timekeeping. In this system there are 12 hours between sunset and sunrise and the length of the hour over the year and between night and day is variable. The occultation took place almost at Summer solstice, when the night hours are shortest. Adopting a modern astronomical definition of sunset, the end and the start of twilight at the time in Naples were respectively at 20:44 UT and at 1:23 UT, which yields an hour length of 4:39m/12h = 23.25 minutes. It is possible that Fontana used a less strict definition for sunset, such as the civil or the nautical sunset, with the Sun at 6° or 12° respectively, thus getting an average hour slightly longer than 25 minutes and thereby accounting for the length of time reported by Fontana. Moreover, this hypothesis also is consistent with the start of the occultation, which he said occurred three hours after sunset. With sunset at 20:44 UT and a 28-minute-long hour, the occultation would have started around 22:08 UT, in agreement with the Skygazer simulation of 22:10 (UT). Figure 5 reproduces the start and the end of the occultation in our simulation, as well as Fontana's drawing, showing that the positions were accurately drawn in the etching.

The third of Fontana's etchings of the Moon referred to an observation on 24 June 1630, just a few days later than the previous one. Here Fontana noted that the 'Chief Fountain' (Tycho) was nearer to the centre of the Moon, which implied that the Moon was rocking back and forth. In the fourth observation, on 9 June 1640, Fontana noted that Tycho was closer to the centre of the Moon than he had ever seen before. Moreover, the middle of the great marking (Oceanus Procellarum) was at the limb of the Moon, definitively proving the existence of the third motion, i.e. the E-W motion. It is really remarkable that Fontana made these suggestions in the summer of 1630.

Before presenting his observations, Fontana summarized his lunar discoveries in Treatise II. The first chapter opens with a theory about the source of the Moon's light, which he believed came from the Sun, although according to him some feeble light also originated from the Moon itself (which could be seen in the non-illuminated part of the disk). The origin of this secondary light was a quite controversial issue, with Galileo defending the interpretation of its terrestrial origin and the Jesuits taking the opposite view (Molaro, 2013).

In Chapter II the Moon's shape is discussed and reported to be irregular:

> A large number of observations seem to indicate that the Moon is not a perfectly spherical body, but on its surface various irregularities are to be found. (Fontana, 1646: 26. Cf. Note A in Figure 2).

Chapter III describes the lunar markings, which Fontana thought were actual irregularities on the Moon's surface.

Chapter IV is dedicated to lunar movements. As already noted, the observation of the crater Tycho revealed a North-South direction movement which was to be added to the already known shift in an East-West direction. Galileo first described the Moon's libration in depth in a letter dated 7 November 1637 (Galileo, 1637), and he returned to the subject in a letter written to Alfonso Antonini (1584–1657) of Udine on 20 February 1638 (Galileo, 1638a). This letter, which Galileo asked to keep reserved, was only published in 1656, in the Bologna edition of Galileo's works (i.e. after the publication of Fontana's book). It is therefore unlikely that Fontana had read Galileo's letter. Fontana connected the Moon's motions with its rotation, which he assumed to last 27 days, the same as the solar rotation estimated by Scheiner in "The Revolution of the Sun" (Book IV, Part II, Chapter 10) in the *Rosa Ursinae*. It is interesting to note that Fontana argued that the Moon's rotation and North-South motion implied that it could not be a fixed body on the celestial sphere which, according to Aristotle, was moving East-West. The same argument was used later for the other planets, which he found to rotate on their own axes.

Treatise III and Treatise IV contain 13 etchings of the waxing Moon and 11 of the waning Moon, which were meant to show how the lunar features changed with phase. Fontana also remarked that he had been capable of reproducing only one thousandth part of the details that he had seen through his telescopes. Such a detailed lunar atlas has no precedents, and it is the first astronomically illustrated book (cf. Winkler and Van Helden, 1992). Of particular interest is observation N. 10 where, together with the lunar observation of November 1645, Fontana summarized his main planetary discoveries in the four corners of the etching. The label in the round framework recalls that the observations were performed with a "Telescope invented in 1608" (my English translation), where the Italian word 'Thelescopio' is used here for the first and last time.

5 THE FIFTH TREATISE: OBSERVATIONS OF MERCURY AND VENUS

5.1 Observations of Mercury

Two observations of Mercury are presented in Treatise V in which the planet is described as

> … curved like a bow with the concave edge pointing towards the sky and the convex edge turned towards the horizon. (Fontana, 1646: 90).

Thus Mercury revealed its phases conclusively, showing that it was orbiting the Sun. Fontana revealed that these observations were not made by him but rather by Father Zupus with one of his telescopes. In Figure 6 we show woodcuts of the two Mercury observations, together with the Skygazer simulations of the planet seen from Naples on the dates provided. These simulations give a percentage of illumination of about 40% on 23 May 1639 and of about 36% in January 1646, which are quite consistent with the drawings.

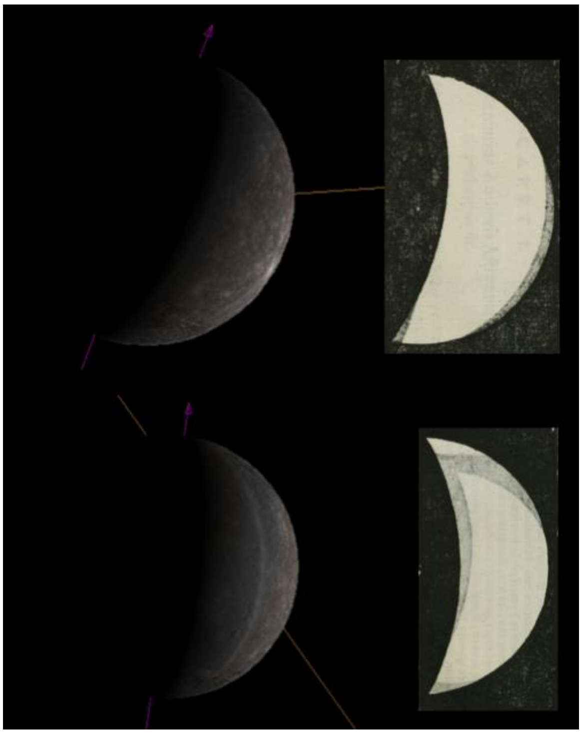

Figure 6: The top images show Mercury as seen from Naples on 23 May 1639. The concave edge pointing towards the sky and the convex edge turned towards the horizon. The bottom images show Mercury on January 1646. The cusps of Mercury's concave side pointed to the sky at a different angle to that seen in the first observation.

In his *Almagestum Novum* Riccioli (1651) ascribed the former observation to Father Zupus and the latter to Fontana. Riccioli also observed Mercury's phases in 1643–1644 and in 1647. He considered the detection of Mercury's phases a very difficult observation because of the small dimensions of the planet. These observations show both the quality of Fontana's telescope and his rectitude in attributing the discovery of Mercury's phases to Father Zupus.

5.2 Observations of Venus

Observations of Venus are shown in six drawings. The first was made on 22 January 1643 and the last on March 1646, which was probably the last observation that Fontana recorded before the publication of his book. His drawings show Venus' phases at their best, and are reproduced in Figure 7. The simulations with Stargazer are also shown beside the drawings, providing illuminated values of 17% and 35%, which are in good agreement with Fontana's drawings. Fontana also noted that the concave side showed an irregular edge with the light appearing a little dimmer near the edge, a phenomenon known as 'terminator shading'. In particular, using these two observations Fontana thought that Venus had an oval shape and that therefore the change in its appearance implied that it was rotating around its axis.

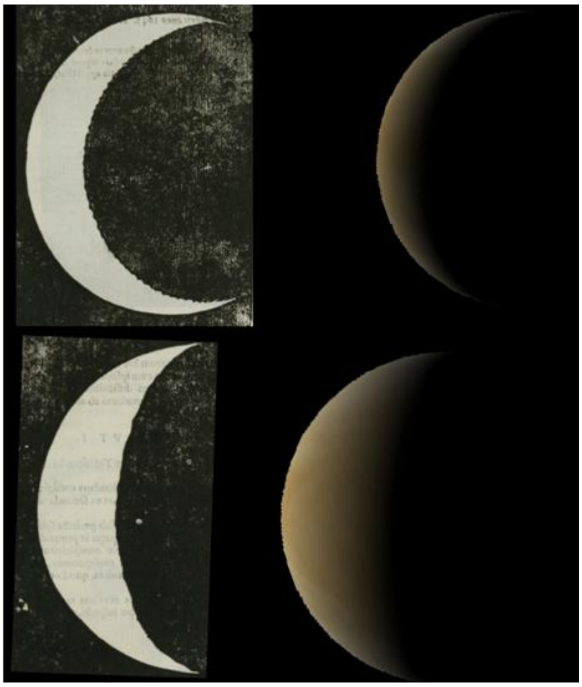

Figure 7: The top images show Venus on 22 January 1643. The illumination was only 17%, matching very well Fontana's observations. The bottom images show Venus on March 1646. The illumination is 35%, the same as in the drawing. Fontana noted also that the brightness was unequally distributed with the light appearing dimmer near the concave edge, an effect known today as 'terminator shading'.

The remaining four observations, obtained between 11 November 1645 and 22 January 1646, besides confirming the phases also reported the presence of two Cytherean satellites:

> This is a new discovery not yet published in my opinion. But it is true that they do not always appear, but only when Venus is shimmering … These little dots were ... not always seen in the same situation on Venus, but they moved back and forth like fish in the sea. (Fontana, 1646: 91).

This claim launched a controversy that would last for more than one hundred years, and a detailed account of this research is provided by Kragh (2008). According to Kragh (ibid.), Riccioli said he had never observed the moons and Christiaan Huygens (1629–1695) in 1659—three years after making his observations—concluded that there were no moons. On the other hand, Giovanni Domenico Cassini (1625–1712) claims to have seen a moon in 1672 and in 1686, but never again (Kragh, 2008). James Short (1710–1768) saw a luminous object close to Venus on 3 November 1740 (ibid.) and A. Mayer on 20 May 1759 (ibid.). This issue was resolved only when the 1761 transit of Venus did not reveal any moon (see Woolf, 1959). It is a point of curiosity, therefore, that in the same year (i.e. 1761) the moons of Venus reputedly were seen 19 times! An explanation in terms of optical reflections in the telescope was published in the *De Satellite Veneris* (1765) by the Jesuit Maximilian Hell (1720–1792), and in 1881 William Frederick Denning (1848–1931) provided a similar explanation (cf. Kragh, 2008).

It is very likely that Fontana's telescope was affected by some light reflection, particularly when observing a bright object such as Venus, which also was reported responsible for the presence of rays.

In fact, in commenting on the third observation of 15 November 1645 Fontana noted that

> Two starlike points of that same subdued reddish colour were seen, one at each of Venus' cusps, almost adjoining them. Although this appearance of Venus, if it is a sphere and receives its light from the Sun, might be an optical illusion, yet this is how it really looks. (Fontana, 1646: 96).

Finally, in commenting on his fifth observation Fontana said that a little globe or spot was facing the concave edge of the *real* Venus. The word 'real' is literally 'more true', and Beaumont and Fay (2001) commented that Fontana suspected that the little globe could be an optical illusion. In retrospect, it seems that this wrong prediction influenced the negative judgement reserved for Fontana by astronomers over the years.

6 THE SIXTH TREATISE: OBSERVATIONS OF MARS AND JUPITER

6.1 Observations of Mars

Fontana observed a gibbous Mars with a 'black cone', like a hollow in the middle of the planet. This was probably Syrtis Major, a marking recorded a few years later by Huygens (1659) and Robert Hooke (1635–1703; Hooke, 1666). Figure 8 shows Fontana's undated observations of Mars made in 1636, and his observation of 24 August 1638. While in the former drawing there is no evidence of phase, the latter shows a gibbous Mars. This feature of Mars was also seen by Castelli (1638c) with Fontana's telescope, as recorded in his letter to Galileo of 17 July 1638.

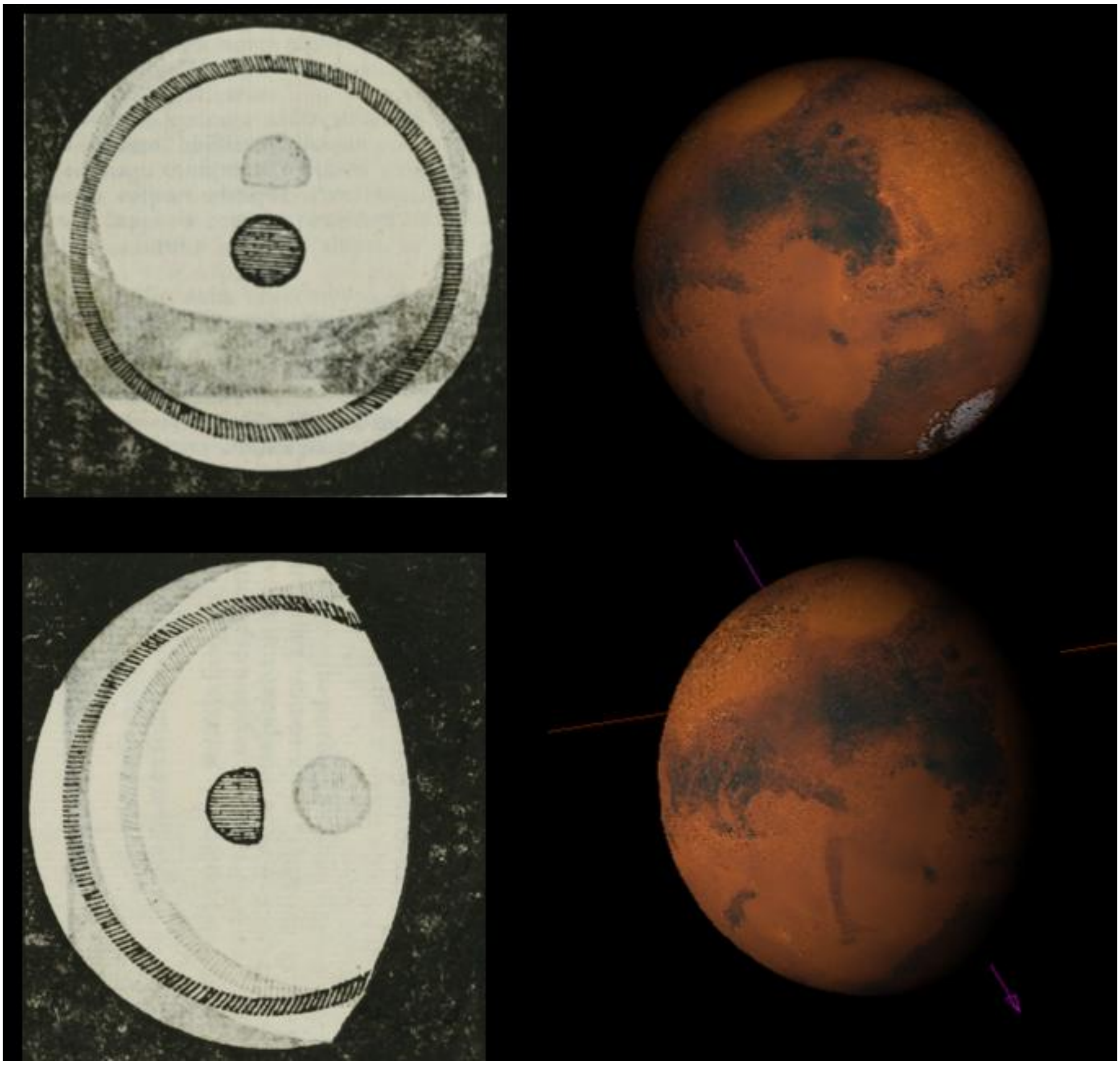

Figure 8: An undated observation of Mars of 1636 (top), and the observation of 24 August 1638 (bottom). In the former Mars is perfectly round, and in the latter it is gibbous. On the right are the Stargazer simulations. In 1638 the illuminated fraction of Mars was 83.3%, as the drawing suggests. The dark spot at the center changed quickly and it could not be reproduced without an hour. Note that Fontana also reported the presence of a ring, which did not exist.

At that date the illuminated fraction of Mars was 83.3%, as the drawing suggests. The dark marking at the center of the disk changed quickly, and since the time of the observation was not provided we have not attempted to reproduce its position. Note that Fontana reported also the presence of a ring which does not exist. From the quick motion of the dark marking Fontana deduced that Mars rotated. The book is not very clear on this point, as in both drawings the dark marking is approximately in the same position. However, a letter dated 11 September 1638 from Cozzolani to Manzini revealed some of the discussions inspired by Fontana's observations long before their publication:

> … in the center of Mars there is a prominence as a black velvet ending in cone shape and around there are two circles or two bands ... and everything is mobile, since you do not look in the same place ...

On 17 July 1638 Castelli (1638c) wrote to Galileo that he had seen a gibbous Mars through one of Fontana's telescopes. Three days later Galileo (1638b) answered, saying how beautiful this observation was, and in a letter to an unknown correspondent dated 15 January 1639 he wrote:

> As to the planet Mars it was observed that being at the square with the Sun, it is not seen perfectly round, but rather flared, similar to the Moon of 12 or 13 days, which from the side opposite to that touched by the solar rays it remains unilluminated, and consequently not seen, what I have said should have happened when Mars was seen superior to the Sun.

6.2 Observations of Jupiter

Fontana presented eight observations of Jupiter dating between 1630 and 1646. The planet was found to be perfectly spherical, but on the globe he noticed, already in 1630, some bands which persisted in subsequent observations. The observation of these bands was independently confirmed by Father Zupus with a different telescope. Fontana also observed the bands with different telescopes to be sure of their existence.

Sometimes Fathers Niccolo Zucchi (1586–1670) and Daniello Bartoli (1608–1685) are credited with having also seen Jupiter's bands in 1630 (Riccioli, 1665; cf. Graney, 2010), but there is no proven documentation for this and we think that the sources are the observations by Fontana and Father Zupus. Indeed, they were the only ones with access to telescopes capable of observing the Jovian bands. According to a letter written by Torricelli on 10 February 1646, Castelli saw Jupiter's bands from Rome in 1632 (see del Santo, 2009).

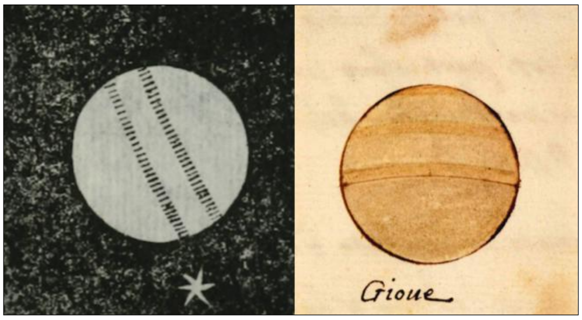

Figure 9: On the left is a woodcut showing Fontana's observations of Jupiter in 1630. The star is one of Jupiter's moons and together with the bands marks the plane normal to the axis of rotation of the planet. On the right is a watercolour of Jupiter showing three bands that was attached to Fontana's letter of 1639 that he sent to the Grand Duke Ferdinand II dé Medici (Courtesy: Archivio di Stato di Firenze, fondo MM, busta 514,fas.1,c 64v).

The bands were "… not more than three not fewer than two …" (Fontana, 1646: 101) and sometime they were seen as convex curves, sometime concave, and also as straight lines. The bands were thought to be circular clefts with some hollow spots on them. From the changes in shape of the bands Fontana deduced that the planet was rotating, and this implied that the planet had an independent existence and was not attached to the revolving heavens. Moreover, these new features implied a flaw in the perfection of the Aristotelian skies. When in 1639 Fontana approached the Grand Duke proposing a telescope of 22 palms (i.e. 5.8 m) as a demonstration of the superiority of his telescopes he attached a watercolour painting showing his discovery of the bands on Jupiter, and this is shown in Figure 9.

In the field of view of Jupiter Fontana noted the persistence of five stars that he suggested could be moons:

> It can be shown that they are not fixed stars for the reason that fixed stars always keep the same positions relative to each other, as all Astronomers agree. But these are seen to behave differently. Also some fixed stars would be visible in the vicinity of Mars too, which is nearer to Jupiter in the order of the planets, and many more around Saturn, the nearest planet to the realm of fixed stars, but the opposite is the case. (Fontana, 1646: 108).

For an observer the argument provided by Fontana is rather naive, since it would seem that he did not realize that he was looking at different regions of the sky:

7 THE SEVENTH TREATISE: OBSERVATIONS OF SATURN AND THE PLEIADES

7.1 Observations of Saturn

Fontana presented a set of seven observations of Saturn which he said appeared in his telescope like the full Moon to the naked eye. The dates are not always reported but there appear to be three groups. The first observation was made on 20 June 1630 when the planet had been eclipsed by the Moon, as we have already discussed. The drawing depicts Galileo's rendering of the planet as three perfectly spherical stars with the middle one about two times larger than the outer ones.

The second drawing does not list the year, but it looks similar to the third, which was made in 1634. Fontana noted that the shape of the planet changed considerably. The central body was oval and the two stars seemed to be "… embracing the planet itself on either side." (Fontana, 1646: 115). Also in the next observations of 1636 these were seen in the form of the "… crescent moon and touching its globe …" (Fontana, 1646: 116), which this time was perfectly spherical. It is quite possible that the different appearance of the planet was linked to improvements to his telescope as it evolved from 8 palms long to 14 palms (i.e. from 2.1 to 3.8 m).

The fifth observation does not include a date but as noted by Beaumont and Fay (2001) it must have been close to the last two observing sessions on 3 and 12 December 1645. The two satellite stars appeared more distant from the central body and

> … they have on either side something in the nature of handles forming a triangular shape which seems attached to the middle of a perfect spherical body. (Fontana, 1646: 117).

The observation on 3 December is very similar, but with the triangular shape of the handles becoming more oval and curved, and in those of 12 December the satellite stars are becoming smaller and more distant. The last observation of 12 December is shown in Figure 10 together with our simulation for the same day. From the simulation it is possible to appreciate how the overall proportions and the tilt of the disc were accurately drawn by Fontana. The description of the planet during the last three observations shows how close he came to revealing the real nature of the planet.

Fontana's thoughts regarding the changing shape of Saturn can be deduced from a letter by Gloriosi dated 21 September 1638 about Fontana's observations where he says that the cause is likely the change in the position of Saturn with respect to the Sun. From the same letter we also know that the regions within the 'handles' were seen by Fontana to be empty sky. The true form of Saturn finally was revealed by Huygens (in 1659), and he admitted to having been inspired by Fontana's observations (Huygens, 1888: 535, 558).

Also for Saturn, as for the other planets and the Moon, Fontana concluded that the planet was moving freely in the sky, and therefore it was not attached to an Aristotelian celestial sphere.

Around Saturn on several occasions Fontana seems to have seen further moons away from the planet. As suggested by Beaumont and Fay (2001) it is possible that Fontana saw Titan and Iapetus, since they were relatively bright. Huygens (1888) discovered Titan on 25 March 1655, and on 12 December 1645 it was visual magnitude 8.23 and about 3 arcminutes from Saturn so it should have been within reach of Fontana's telescope.

7.2 Observations of the Pleiades

Fontana also presented his observations of the Pleiades. With one observation alone his telescope revealed 29 new stars. We recall that Galileo was able to see some 40 stars in the same field. However, no discussion or comparison is made here, apart from Fontana's remark that he believed the stars to be 'countless'.

8 THE EIGHTH TREATISE: THE MICROSCOPE

In the opening pages of his book Fontana inserted a testimonial from the Father Sersale who stated that he had used Fontana's microscope since 1625:

> I Jerome Sirsalis, Jesuit in the College of Naples, wish to bear witness to all that around the year 1625 in the house of this most illustrious gentleman, Francesco Fontana, the glory of his Neapolitan homeland, I saw a microscope, and after a short space of time, a telescope constructed by him with great skill from two convex lenses, so that such outstanding inventions, perceived by his divine genius, deserve to be reported. (Beaumont and Fay, 2001: 6).

In this section of the book Fontana (1646: 143) describes an instrument "… by which the smallest and virtually invisible things are so magnified that they can clearly and distinctly be examined …", made in 1618 (his fifth invention). Colonna informed Cesi of the new invention by his friend Fontana on 17 July 1626 (cf. Freedberg, 2002). Fontana (1646: 145) did not pretend to be the first inventor of the microscope since it "…could have been invented earlier elsewhere by someone else."

Fontana then presents a detailed description of ten observations as an example of what he observed with the microscope. He describes a cheese mite, a flea, an ant, a fly, several unknown animals, a spider, the sand, a human hair, material at the base of the window, and other things. As an example, his description of the cheese mite is provided below:

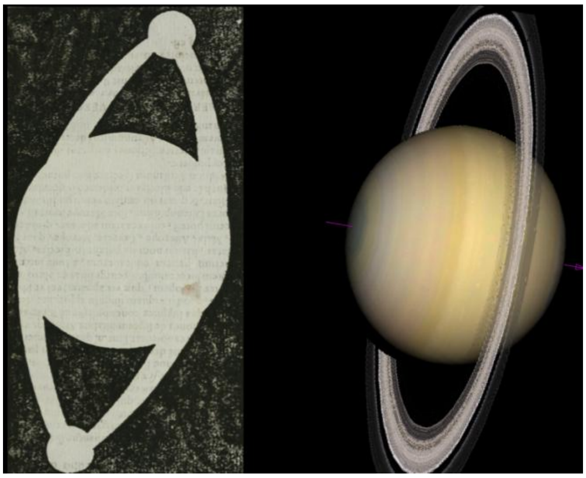

Figure 10: On the left is Fontana's observation of 12 December 1645, and on the right is a simulation of the planet as seen from Naples on the same date. The axis of the simulation has been slightly adjusted by 10 degrees to match the drawing. The disk/body ratio and the tilt of the rings is rather well reproduced in Fontana's drawing (after Fontana, 1646).

> The dust produced by cheese. This dust when placed under the microscope does not present the appearance of dust but of a remarkable living creature. It has eyebrows, lightly drawn as though painted with a brush, in like manner huge globes of eyes manifestly somewhat black, giving out a cheerful light. It is armed with little nails and claws, and seems to-be equipped with eyes. The entire appearance of its body too, in colour outstandingly exquisite, ennobles the tiny form of the animal, never before seen. To see it also – which cannot be done without marvelling – amounts to this: it crawls, feeds and definitely chews as well as moves itself; it seems equal in size to a human nail, its back is all rough and covered with scales, embellished with various star-like feat-

> ures, protected by thick and shaggy bristles, with such wondrous artfulness that you might have said that Nature, the creator of such a work, was born along with it, grew up with it, and even breathing with it, draws breath herself. (Beaumont and Fay, 2001: 126).

Federico Cesi and Francesco Stelluti (1577–1652) in their *Apiaria* of 1625 provide the first description of the anatomy of bees based on microscopic observations. *Apiaria* was a gift to Pope Urban VIII and bore an attached engraving by Matthaeus Greuter (1564–1638) entitled the 'Melissographia', reproducing three bees as seen under the microscope. The arrangement of the bees referred to the trio of bees on the crest of the Barberini Family.

The word 'microscope' was coined by Giovanni Faber in 1625, and the first printed microscopic illustrations were published five years later in the translation of the Latin poet Aulus Persius Flaccus by Stelluti, *Persio Tradotto in Verso Sciolto e Dichiarato* (1630). On page 52 there is a reproduction of three bees that closely resemble those in Greuter's 'Melissographia'. We note that on page 47 Stelluti writes that the bees were "… observed and drawn by Francesco Fontana …", thus confirming that Fontana had a major role in the first microscopic observations of bees. In his letters of 1626 to Cesi, Colonna refers to Fontana as a friend of the bee (see Gabrieli, 1989).

The invention of the microscope also is unclear (Rezzi, 1852; Zuidervaart, 2011). Galileo made explicit mention of his microscope in the *Saggiatore*, which was written in the period 1619–1622 and published in 1624, but he could have invented the microscope a few years earlier. On 23 September 1624 Galileo sent an instrument that he referred to as an 'occhialino' to Cesi with instructions on how to use it to see things close up (Zuidervaart, 2011). In the same year, Abraham Kuffler (1598–1657) and his brother Aegidius provided Cesi with a microscope made by Cornelis Drebbel (1572–1633) (ibid.). Like the telescope, the microscope also can have two optical configurations and it is quite possible that Fontana was the first to conceive of a compound microscope made only with convex lenses.

9 FONTANA AND HIS TELESCOPES IN CONTEMPORARY PAINTINGS

The *Allegory of Sight* and *Allegory of Sight and Smell* by Jan Brueghel the Elder (1568–1625) were painted in 1617 and around 1618 respectively, and show very sophisticated silver telescopes made with seven and eight draw tubes. It has been suggested that these are Keplerian telescopes (Molaro and Selvelli, 2011; Selvelli and Molaro, 2009). This is deduced from the length of the telescopes which likely exceeded two meters, and from the boxy shape of the eyepiece which was made to help the eye to be positioned precisely at the focus of the convex lens. As we have seen, in those years Fontana was the only one able to work two convex lenses in an accurate way to manufacture a Keplerian telescope. The telescopes in J. Brueghel The Elder's paintings belonged to the collection of scientific instruments of Albert VII (1559–1621), Archduke of the Southern (or Austrian) Low Countries. Albert VII was the brother of Emperor Rudolf II (1552–1612) in Prague, the protector of Kepler and Tycho, and the brother of Maximilian III (1558–1618) who, as we have seen, had a Keplerian telescope around 1616. All three Hapsburg brothers were ruling Catholic Europe, to which Naples and the Kingdom of Spain belonged. The Viceroys in Naples also were fond of astronomy and of the military applications of the telescope, and they were in possession of Fontana telescopes, as documented in the letter of Colonna to Cesi of 30 November 1629. According to Crasso (1666: 298; my translation),

> Fontana made telescopes for all the courts and nobles around Europe which when obtained one of his telescopes conserved it together with the most precious things.

Thus, it is quite possible that a preferential circulation of scientific instruments took place within the Catholic countries, and that Fontana's instruments reached the far courts in northern Europe even before other places in Italy.

Brueghel's series of paintings was preceded only a few years earlier by another series of 'senses' painted by the Spaniard Jusepe de Ribera (1591–1652), who in his *The Sight* chose a telescope for the first time. We note here that the sitter in *The Sight* by Ribera bears a close resemblance to the self-portrait made by Fontana for his book. *The Sight*, depicted by the young Ribera under the influence of Velasquez, is shown here in Figure 11, where a man is holding a sophisticated telescope. Ribera's painting is not dated, but according to Mancini (1956) it was executed during the end of the Roman period of the painter, therefore some time between 1613 and 1616. The canvas was commissioned by an unknown Spaniard, who has now been identified by Longhi (1966).

Earlier, the *Allegory of Sight* was attributed to Velasquez. Ribera was definitely in Rome in 1611, and possibly arrived in 1608, and in May 1616 he moved to Naples where in November he married the 16-year old daughter of the painter Giovanni Bernardino Azzolino (1598–1645). Such a quick acclimatization to Naples suggests that Ribera was familiar with the town and he could have visited it before. It must be recalled that Pedro Téllez-Girón y Velasco, the Third Duke of Osuna (1574–1624), was the Spanish Ambas-

Figure 11: Jusepe Ribera's 114 × 89 cm oil on canvas, the *Allegory of Sight* painted around 1615 (courtesy: Franz Mayer Museum, Mexico City).

sador in Rome when Ribera was in Rome, became the Viceroy in Naples in 1616 (the same year that Ribiera moved to Naples), and was a patron of Ribera from the early days, probably appointing him as a court painter. In my view, the idea that the *Allegory of Sight* could have been painted or finished in Naples is also suggested by the marine landscape depicted in the window, which is similar to what could be seen from a window of a house in Naples.

The series of the five senses shows a caravaggesque naturalism with the figures represent-

Figure 12: On the left is the self-portrait published by Fontana in 1646, but showing his likeness in 1608. On the right is the head of the sitter in *The Allegory of Sight* painted by Ribera around 1615.

ed with high contrast in the tradition of tenebrism painting. The two faces on the self-portrait by Fontana and the anonymous sitter in Ribera's painting are shown next to one another in Figure 12.[8] The shape of the head and the characteristics of the face and of the gaze are strikingly similar. One main difference between the two portraits lies in the hair. However, Fontana in 1646 presented himself as he looked in 1608 (i.e. almost 40 years younger), and the simplest way to look younger is by adding hair. Anyway, the possible Fontana in the painting by Ribera should be a few years older. Also, the ears are different, but it must be considered that Fontana's self-portrait cannot be compared to those of one of the most talented painters of his times. Thus, although it is generally believed that Ribera took his models from everyday life, it cannot be excluded that for the specific subject of the *Allegory of Sight* Ribera took inspiration from the figure of Fontana, who by this time was already a renowned telescope-maker. The difference between the expression of profound reflection in the *Allegory of Sight* with the drinker in the *Sense of Taste* has already been noted (Pérez Sanchez, 1992). A telescope decorated with gold is not something that can be associated with a man from the street since at that time it was very precious and was a symbol of power. We admittedly prefer the possibility that the man in Ribera's portrait could be the inventor of the *astronomical* telescope.

10 NOTES

1. Unless it is otherwise stated, I am responsible for all of the English translations in this paper.
2. Beaumont and Fay's translation has been distributed privately, and for this study I used the copy in the Paris Observatory Library.
3. This figure, and all others from Fontana (1646) are taken from a copy of this book that is in the Perkins Library at Duke University, Durham, North Carolina, USA.
4. In the following Sections I use English translations of the original titles listed by Fontana.
5. The first mention of the theory of the telescope is in Book 17 in Della Porta's (1589) *Magic of Nature*, which in Chapter 10 says: "Concave lenses make distant objects clearly visible, convex lenses near objects [smaller?] …" (Beaumont and Fay, 2001: 11).
6. The size of the 'palm' varied throughout Italy. Although in Naples 1 palm was reportedly equal to 203.1 mm according to Riccioli and 218.0 mm according to others, in this paper I have adopted the value of 263.7 mm, suggested by del Santo (2009).
7. Fontana (1646: 41) wrote "The border of the illuminated part was not perfectly circular, but was an irregular shape, like an axe." Fontana was the first to note the irregular shape of the Moon. We recall that in the *Sidereus* Galileo mentioned the presence of mountains and estimated their heights. He was surprised not to see an irregular lunar limb. He also postulated the presence of a lunar at-

mosphere.

8. Two other portraits of Fontana are reproduced by Crasso (1666) and Terracina (1822), but probably both were derived from Fontana's self-portrait.

11 ACKNOWLEDGEMENTS

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The following abbreviation is used:

ENO = *Edizione Nazionale Opere di Galileo Galilei*, *Volume XVII*.

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Professor Paolo Molaro was born in Artegna (UD), Italy in 1955. He completed a Ph.D. at the International School for Advanced Studies in Trieste with Denis Sciama and since 1987 has been a researcher at the Astronomical Observatory of Trieste which he directed during 2000–2003. His main field of research is the low metallicity Universe, either of extremely metal-poor stars or of primeval galaxies. Paolo is a

member of the Particle Data Group for primordial nucleosynthesis. He is also Project Scientist of the high resolution spectrograph ESPRESSO that has just seen the 'first light' at the ESO-VLT in a search for other Earth-like planets and possible variation in funda-mental physical constants. In 2012 he succeeded in detecting the Rossiter-McLaughlin Effect during the transit of Venus, and in 2014 he observed the Earth transiting the Sun as seen from Jupiter. As far as the history of astronomy is concerned, Paolo found the first painted telescope in a painting by J. Brueghel the Elder. He even found a possible new portrait of the young Galileo.