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ON THE ORIGIN OF THE KEPLERIAN TELESCOPE

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Abstract: After more than four centuries, we still do not know the genesis of the Galilean or Dutch Telescope precisely. But even less is known about the origin of the astronomical telescope, i.e. the instrument made with two convex lenses, also known as the Keplerian Telescope, which became widely used from the second half of the seventeenth century. In his Dioptricae, Kepler (1611) described the combination either of two or three convex lenses, but he never described a telescope or made such a device. A passage in the Jesuit annual account of the year 1616 at the Tyrolean State Museum shows that this kind of telescope was in the possession of the Archduke Maximilian III, and that it was converted for terrestrial use by the Jesuit astronomer Christoph Scheiner. In his *Novae Coelestium Terrestriumque rerum Observationes*, Francesco Fontana (1646) claimed to have conceived the first positive eyepiece already in 1608. He also produced a testimony by the Jesuit Johan Baptista Zupus who declared to have used his new telescope since 1614. Generally, Fontana's claims were not taken seriously, but he remains the most likely candidate as manufacturer of the first Keplerian Telescope, almost contemporary with the Dutch one.

Keywords: Dutch telescope, Keplerian telescope, Francesco Fontana

1 THE MYSTERIOUS GENESIS OF THE KEPLERIAN TELESCOPE

The astronomical telescope, i.e. the one made with two convex lenses, also called the Keplerian Telescope, became widely used during the second half of the seventeenth century, but its genesis is also quite unclear, possibly even more than that of the Dutch or Galilean telescope (van Helden, 1976; 1977a; 1977b). Already in 1538 Girolamo Fracastoro (ca. 1478–1553) in his *Homocentrica* wrote that "… if someone looks through two eyeglasses of which one is placed above the other, he shall see everything larger and closely." (Fracastoro, 1538, 18v (Section 11, Cap. 8; my English translation). Probably, Fracastoro was able to see enlarged images but without resolving details. The latter telescope requires high-quality lenses, which probably were not available at that time. Fracastoro's experiment was not followed up, and it took almost one century before such the telescope made its second appearance.

Johannes Kepler's *Dioptrice* (1611) was devoted to explaining the functioning of the Galilean Telescope, but in a separate section of the book Kepler considered also all other possible combinations of lenses, including two and three convex lenses. This is why this kind of telescope took his name. However, when discussing the image formation, Kepler did not mention the magnification, which is the main characteristic of an astronomical telescope, and as a matter of fact he did not produce 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." The first printed mention of a telescope formed with two convex lenses appeared in *Rosa Ursina Sive Sol* by the Jesuit Christoph Scheiner in 1631. When Scheiner describes a Galilean Telescope projecting the solar image, he mentions that a different arrangement, made of two convex lenses, is 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." (van Helden 1976: 25). This is probably why Antonio Maria Shyrleus de Rheita (1645) in his *Oculos Enoch et Eliae* credited to Scheiner the invention of the Keplerian Telescope (King, 1955).

2 A NEW DOCUMENT FROM THE TYROLEAN STATE MUSEUM FERDINANDEUM

An interesting document was found by Franz Daxecker (2004) in the Tyrolean State Museum Ferdinandeum in Innsbruck, Austria. It is preserved in the Dipauliana Library, one of the most important collections of historical texts from the Tyrol region. Andrea Alois Di Pauli (1761–1839) was Baron of Treuheim and was one of the founders of the Tiroler Landesmuseum, to which he donated his substantial 'Library Tirolensis'.

The manuscript concerns the origin and the history of the Jesuits in the Innsbruck region between the years 1561 and 1658. The reference is: Tyrolean State Museum Ferdinandeum: Initium et progressus Collegii Soc. Jesu Oenipontani. Litterae Annuae eiusdem

Collegii 1561-1658, Dipauli 596/ Tomus I, 1616, fol. 41. The document states that Archduke Maximilian III (r. 1612–1618) acquired an optical instrument of admirable utility, but since he wished to see the images in an upright position he gave the instrument to the Jesuits who in turn passed it on to the Ingolstadt physicist and astronomer Christoph Scheiner (1575–1650). In lines 11–21 of the manuscript, he states:

> … opticum quodam instrumentum acquirerat admirandi usus, ita tamen ut imagines inversas redderet; quos cum Ser.mus [Serenissimus Maximilian III] rectas videre cuperet, nec que ratione id perficeret vel per alios reperiret.

Translated into English, this says:

> [Maximilian III] … had acquired an optical instrument for observing, but it gave inverted images; as His Most Serene Highness desired to see things right way up … [Scheiner] would accomplish this or arrange it through others.

This manuscript is dated 1616 and is the oldest known record that makes *direct* reference to a Keplerian Telescope (as opposed to the Galilean Telescope). The first printed mention appears in *Rosa Ursina Sive Sol*, also by Christoph Scheiner (1631: 130) where he writes: "… thirteen years ago, I made erect the images intercepted for the most Serene Maximilian, Archduke of Austria". Since it took four years for the publication of *Rosa Ursina*, thirteen years before the publication date would correspond to the years 1613–1617 (van Helden, 1976). The manuscript found by Franz Daxecker confirms Scheiner's recollection of the episode and fixes the date at the year 1616. But, more importantly, the documents do not say that Scheiner was the inventor of the device, but only that he had added one lens to a pre-existing telescope to rectify the image for the benefit of Maximilian III. Thus, neither in this document, nor in *Disquisitiones Mathematicae* (1614), nor in the manuscript *Tractatus de Tubo Optico* (1616), nor in *Oculus Hoc est Fundamentum Opticum* (1619), nor in the *Rosa Ursin*a (1631), does Scheiner refer to himself as the inventor of the Keplerian Telescope. This omission would be very strange if he were indeed the inventor of a new type of telescope.

Gargano (2019) suggested a different hypothesis on the basis of a letter that Giambattista Della Porta (1535–1615) wrote to Galileo Galilei (1564–1642) on 26 September 1614, where there is a reference to a new kind of telescope:

> I am working with Mr. Fabio Colonna, who is very ingenious and a mechanic, to realize *a new kind of telescope*, which will multiply the effect more than usual; if we see until the eighth sphere with the usual one, we will be able to the highest heaven with this new one; God willing, we will investigate what is above, and we will publish the Empyrean Messenger. (Della Porta, 1614; my italics).

Gargano (2019) argued that this new Neapolitan telescope was used to observe the solar eclipse of 3 October 1614, on the basis of the letter that Fabio Colonna (1567–1640) wrote to Galileo the same day of the eclipse:

> I send you six images of today's eclipse … you will be able to recognize the accurate parts, taking what is possible, and you will invert them ... I know that Your Lordship and other scholars would have done likewise… (Colonna, 1614).

Gargano (2019: 54) adds:

> Upon reading this letter it is evident that Colonna used a telescope and not a Galilean spyglass. Therefore, this was the first astronomical observation made from Naples using a Keplerian-like refractor.

But what Gargano (ibid.) seems to ignore here is that the projected image of a Dutch telescope is an inverted one. Colonna was also aware that Galileo did the projection in a similar way and did not need to add anything else. If he had used a different telescope, this would have been specified. Thus, there is no doubt that the telescope used by Colonna to project the solar eclipse onto a piece of paper was a Galilean one.

Selvelli and Molaro (2009) suggested that the telescope depicted in the 1617 'Allegory of Sight' painting by Jan Brueghel the Elder is Keplerian. This is a very sophisticated silver telescope made with seven and eight draw tubes, so its total length when fully extended would likely exceed two meters, which is typical of Keplerian telescopes. Moreover, it has a boxy-shaped eyepiece, which was made to help the eye remain positioned precisely at the focus of the convex lens (Molaro and Selvelli, 2011). The telescope depicted in the painting belonged to the collection of scientific instruments of Albert VII, Archduke of the Low Countries and a brother of Emperor Rudolf II and of Maximilian III.

Interestingly, as documented by the manuscript in the Ferdinandeum, Maximilian III was in possession of a Keplerian Telescope around 1616. The three Habsburg brothers were ruling Catholic Europe, to which also the Kingdom of Spain and of Naples belonged. Lorenzo Crasso (1666) reported that the Neapolitan astronomer Francesco Fontana (ca. 1585–1656) made telescopes for all the

courts and nobles of Europe, and it is quite possible that a preferential circulation of scientific instruments took place within the Catholic countries already in those early years.

3 FRANCESCO FONTANA'S CLAIM

In several passages in his *Novae Coelestium Terrestriumque rerum Observationes* the Neapolitan astronomer Francesco Fontana (1646) claims that already in 1608 he was the primogenitor of the first positive eyepiece. In his book he also produced two testimonies, one by the Jesuit astronomer Johan Baptista Zupus (1589–1667) who declared that from 1614 he and his master, the Jesuit Jacobo Staserio (1565–1635) used Fontana's telescope:

> 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. (Fontana, 1646: 5).

The second testimony was by the Italian Jesuit astronomer and selenographer, Girolamo Sersale (1584–1654), who claimed that Fontana invented both the telescope and the microscope. I see no obvious reason to question Father Zupus' testimony. He was still alive when Fontana's book was published (in 1646). Moreover, publication of the book was approved by Gregory Peccerillus, Vicar General of Naples and by Father Joseph de Rubeis of the Conventuals, theologian of Cardinal Philamarini, who probably had to review the book and verify the veracity of the statements contained therein. Fontana's book documents the existence of the Keplerian Telescope already by 1614, but he never claimed that he was its inventor. Rather, he states that the idea of the telescope was first developed Della Porta in 1589, but it was Galileo who converted the concept into reality:

> The theory of its construction is to be found in no earlier author than in Book 17 of Johann Baptist Porta's Magic of Nature Chapter 10, printed 1589, which says this: 'Concave lenses make distant objects clearly visible, convex lenses near objects … And that either Galileo put Porta's into practice, or he perfected it.' (Fontana, 1646: Tractatus I, Ch. I, 12).

Instead, he claims to have invented the telescope in 1608 referring specifically to one made with two convex lenses. Moreover, Fontana in his book celebrates Galileo as the first scientist of his times. He declares that all important discoveries about planets and stars were made by Galileo, and that he was able to confirm them with his own self-made telescope. This is noteworthy if we consider that Fontana was close to the Jesuits of Naples, who were notoriously hostile to Galileo and from whom he was seeking permission to publish. Fontana also explicitly mentions that when he conceived his telescope he did not know about Kepler's *Dioptrice:*

> 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 at Naples … also his method is quite different from the method suggested here, read it. (Fontana, 1646: Tractatus I, Ch. VII, 20).

What is important to note here is the very end of the last sentence: he is inviting the reader to carefully read Kepler's words. He clearly doubts that Kepler actually build an example of the new type of telescope that he describes in his book (and this is also argued by Malet, 2010).

Fontana was an excellent optician and probably one of the most gifted of his times. He had a deep understanding of the difficulties of working lenses to give them a perfect spherical shape, including the role played by bubbles and air holes in the glass, and he invented a tool to check the shape of the lenses by looking at the projected image of a candle. He was able to construct very long telescopes—of up to 50 Neapolitan palms, or about 13 metres—for which he invented the meniscus lens.

4 FIRST DOCUMENTED USE OF THE KEPLERIAN TELESCOPE FOR CELESTIAL OBSERVATIONS

To advertise his astronomical instruments, Fontana used to send out maps of the Moon and news of other discoveries that he made by observing the sky from the roof of his house in the historic centre of Naples. In the late 1620s Fontana was the first to observe

the sky using a telescope with two convex lenses, which he had manufactured. He succeeded in drawing the most accurate maps of the Moon's surface known at that time, and these demonstrated the technical superiority of his telescope. One of his first drawings of the Moon, made in 1630, is shown in Figure 1.

A detailed description of Fontana's discoveries is presented by Molaro (2017) who, by means of historical simulations, showed that they were more accurate than generally assumed. Fontana observed the Moon's main craters, including Tycho (which he named Fons Major—Big Fountain), and noted the changes in their appearance according to the phases of the Moon. He observed the gibbosity of Mars at quadrature, and together with the Jesuit Giovanni Battista Zupus, the phases of Mercury. He observed the two—and occasionally three—major bands of Jupiter, and 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 for more than a century (Kragh, 2008).

5 FRANCECO FONTANA AND RIBERA'S PAINTING, THE *ALLEGORY OF SIGHT*

In a previous paper in this journal I argued that the sitter for the painting 'The Allegory of Sight' by the Spanish artist Jusepe de Ribera could be Francesco Fontana (Molaro, 2017).

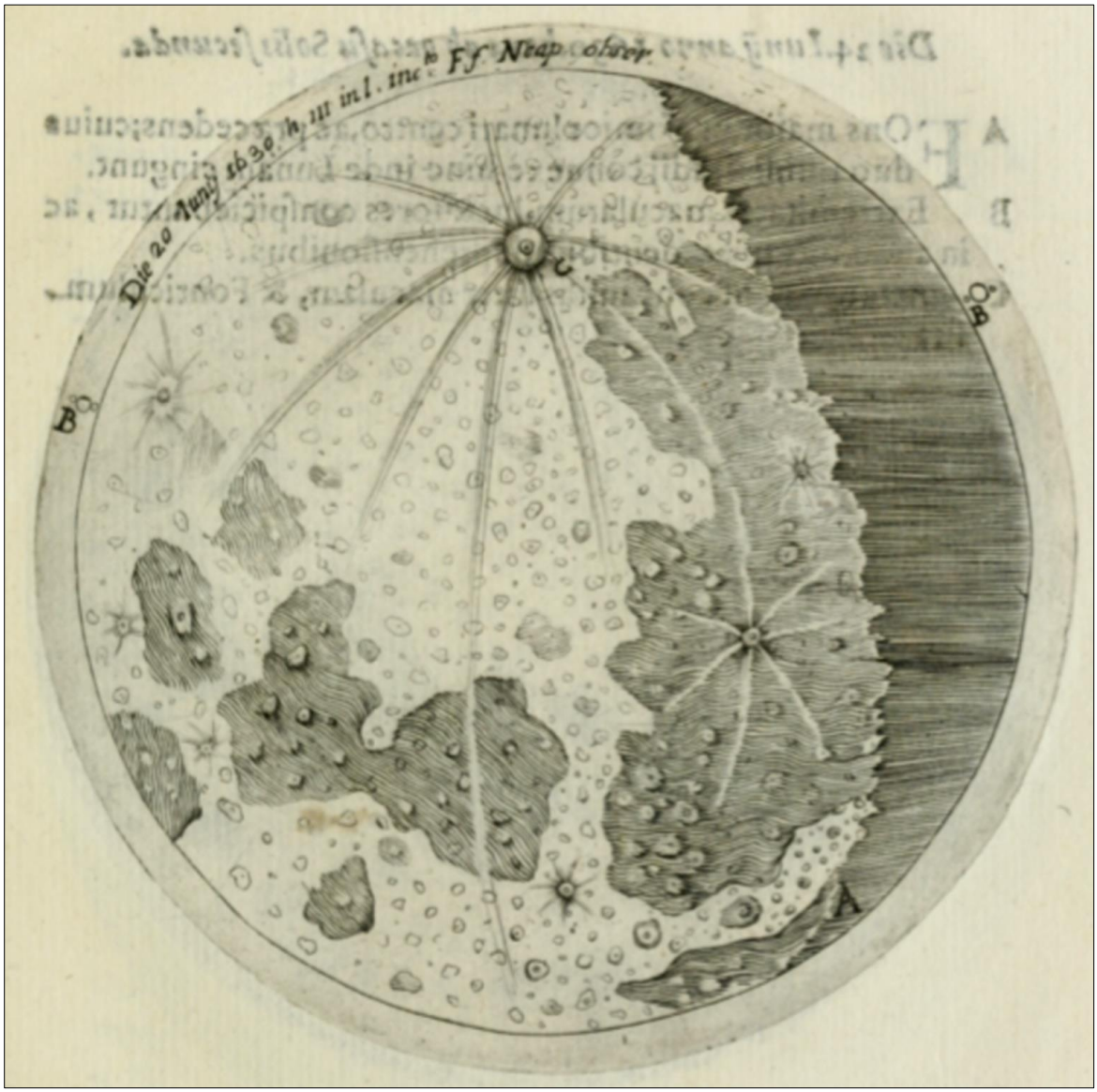

Figure 1: The Moon on 20 June 1630 showing a rare occultation of Saturn by the Moon. The Moon is upside-down, as seen with an astronomical telescope. Note that the crater Tycho is recorded for the first time, together with the rays formed by splashed material. Fontana named it Fons Major, i.e. 'biggest fountain', echoing his own name—Fontana, in Italian, means fountain (after Fontana, 1646: Tractatus IV, 83).

This suggestion is now questioned by Del Santo (2022), who raises some issues that we will try and address here.

The Spanish painter Jusepe de Ribera arrived in Rome in 1611 and moved to Naples in May 1616. Between 1613 and 1616 he completed a series of five paintings depicting the five senses (Mancini, 1956). We have therefore considered that the *Allegory of Sight* was painted or finished in Naples in 1616, in part because the view through the window in the painting looks like a marine landscape. Del Santo argues that it could be the river Tiber due to the presence of a tree, but we note that the size of the tree suggests it is close to the window and not in the distance. Anyway, Ribeira was often in Naples in those years as can be inferred from the fact that in November 1616 he married the daughter of the painter G.B. Azzolino who lived there.

The painting depicted by Ribera shows a man holding a sophisticated telescope. It is evident that the composition was not born from the pose of someone who knew the functioning of the telescope. The telescope is composed by a main tube and one draw-tube where the eyepiece is located. The eyepiece is in the furthest part in the sitter's left raised hand, while the objective which is in the main tube is held in his right hand and further down. Thus, the painting is not a naturalistic portrait but very likely it is a reconstruction that the painter made from his own memory. This may explain several detailed differences that we also noted in the first place. It is therefore possible that Ribeira somehow saw Fontana at the Royal Court around 1616 or learned about the invention of the telescope and was the inspiration for this painting.

The telescope in the painting is precious and decorated in gold, and possibly belonged to the Viceroy himself. Ribera was a painter of the court of the Viceroy Pedro Téllez-Giron y Velasco, III Duke of Osuna, whom he had met in Rome when he was an Ambassador of Spain. They both arrived in Naples in the same year. The Ferdinandeum document we have discussed here shows that an astronomical telescope was in the possession of Maximilian III in 1616. Another was at the disposal of Albert VII in 1616–1617, if the interpretations of the *Allegory of the Sight* proposed by Selvelli and Molaro (2009) is correct. Thus, considering the military value of the instrument, we can infer that the diffusion of his instrument took place through the reigning Catholic courts. Fontana remains the only candidate for the construction of the astronomical instrument, thus it is quite possible that his telescope arrived in Innsbruck and in Northern Europe through the Viceroy of Naples. As we have seen, it is possible that some communications could have been occurred between the courts of Naples, Innsbruck and Brussels, which were all ruled under the dominions of the House of Hasburg. We must consider that Albert VII's wife was Isabella Clara Eugenia, daughter of Philip II and sister of Philip III, the King of Spain at the time, and certainly one of the most powerful women at the beginning of the seventeenth-century Europe. This is confirmed by Crasso, the only biographer of Fontana, who reports that Fontana's telescopes had been sold in European courts. It also may not be a simple coincidence that two painters, Jusepe Ribera and Jan Brueghel the Elder, both produced a series of paintings dedicated to the five senses, the former in 1616 and the latter in 1617, and that in both a telescope was chosen as a symbol for the Allegory of Sight.

Elsewhere (Molaro, 2017) I have suggested that Fontana may have been the sitter for Ribera's *Allegory of Sight* painting, after comparing this man with a portrait of Fontana that was published in his 1646 book *Novae Coelestium ...* Although there is some controversy regarding the interpretation of the inscription that surrounds Fontana's portrait (e.g. see Favaro (1903), I have the impression that the sitter for the engraving hardly represents a 61-year-old man. Rather, I think that whoever made the engraving, purposely 'rejuvenated' the image so as to reflect Fontana's appearance in 1608, the date when he claims to have invented the astronomical telescope. Since Fontana was born in 1585, he would have been about 23 at the time, and 31 when Ribera painted his *Allegory of Sight*.

Del Santo (2022) does not accept that Fontana was the sitter for Ribera's *Allegory of Sight* painting, but I still find a general resemblance in the expression of the two faces (see Figure 2). Although I cannot prove it, I still maintain the intriguing possibility that although Ribeira retained his own personal artistic approach, he wanted to pay a lasting tribute to the inventor of this new type of telescope—which he became aware of through the court of the Viceroy—so decided to portray him in the *Allegory of Sight* painting.

6 CONCLUDING REMARKS

Turning from these artistic comparisons, Del Santo (2022) argues that Fontana was not known in Naples—let alone throughout Italy

Figure 2: On the left is the engraving that appears in Fontana's 1646 book, while on the right is the head of the sitter in Ribera's 1616 painting, the *Allegory of Sight* (after Molaro, 2017: Figure 13).

and beyond—so would not have come to Ribera's attention. To justify this claim, Del Santo provides a letter from Colonna (1613) to Galilei, dated 1613, where the former states that "… in Naples there is no one who knows how to make perfect telescopes." However, Colonna was a member of the Accademia dei Lincei, while Fontana was close to the Neapolitan Jesuits, and in particular the astronomer Johan Baptista Zupus, Professor of Mathematics at the Jesuit College in Naples (with whom he shared some astronomical discoveries), and to Fathers Girolamo Sersale and Giovanni Giacomo Staserio. Fontana's house was located in the Lower Decumano, now known as Spaccanapoli, near the church of San Gennaro all'Olmo and not far from the Jesuit College (Gargano, 2019).

At that time there was no love lost between the Academy and the Jesuits, and indeed the two factions were notoriously hostile towards each other. It is no surprise, then, that in 1613 Colonna totally ignored the existence of Fontana, who had first shown his telescope to Zupus in 1614. Then, in 1624, when Colonna spoke of Fontana as a friend without explicitly mentioning his name, it was not because Fontana was unknown, but to mark the difference between a simple craftsman and a member of the Academy.

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His main field of research is the low metallicity Universe, either of extremely metal-poor stars or of primeval galaxies. Recently, he solved the riddle of the astronomical origin of lithium. Paolo is a member of the Particle Data Group for primordial nucleosynthesis. He was Project Scientist of the ESPRESSO spectrograph at the ESO-VLT, which was designed to search for Earth-like planets and possible variation in fundamental physical constants. He succeeded in detecting the Rossiter-McLaughlin Effect during the transit of Venus of 2012, and in 2014 he observed the Earth transiting the Sun as seen from Jupiter, thereby discovering the Inverse RM Effect.

Paolo is also interested in the history of astronomy. He has written about *Eureka* by the American author Edgar Allan Poe, Galileo's watercolour paintings of the Moon, and the earliest-known depictions of telescopes in paintings. He has also found a possible new portrait of the young Galileo.