SIDEREUS NUNCIUS

or

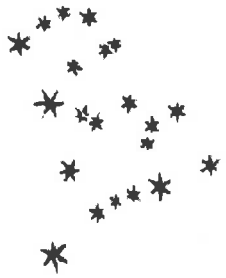
THE SIDEREAL MESSENGER

GALILEO GALILEI

Second Edition

Translated and with Commentary by

ALBERT VAN HELDEN



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GALILEO GALILEI (1564–1642) was an Italian physicist, mathematician, philosopher, and astronomer.
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SIDEREAL MESSENGER

unfolding great and very wonderful sights
and displaying to the gaze of everyone,
but especially philosophers and astronomers,
the things that were observed by

GALILEO GALILEI,

Florentine patrician[1]
and public mathematician of the University of Padua,
with the help of a spyglass[2] lately devised[3] by him,
about the face of the Moon, countless fixed stars,
the Milky Way, nebulous stars,
but especially about
four planets
flying around the star of Jupiter at unequal intervals
and periods with wonderful swiftness;
which, unknown by anyone until this day,
the first author detected recently
and decided to name

MEDICEAN STARS[4]

Venice, at the press of Tommaso Baglioni. MDCX
With permission of the authorities and privilege

1. Galileo came from a Florentine family that can be traced back to the thirteenth century. His ancestors included several members of the governing council of the Florentine Republic and a celebrated physician. His family tree can be found in *Opere*, 19:17. See also Stillman Drake, *Galileo at Work*, 448.

2. The Latin word used here is *perspicillum*. Galileo used the Italian word *occhiale* to describe the instrument. I have translated these terms as *spyglass* throughout. The word *telescope* was unveiled only in 1611. See p. 115, below.

3. Galileo used the Latin word *reperti*, from the verb *reperio*. This word can mean both *invented* and *devised*. Although Galileo was often accused of claiming he actually invented (in our sense) the telescope, this is clearly a calumny, as demonstrated by the passage on p. 39, below. See Edward Rosen, "Did Galileo Claim He Invented the Telescope?" *Proceedings of the American Philosophical Society* 98 (1954): 304–12.

4. Galileo referred to Jupiter's satellites as both "planets" and "stars." In the old terminology, based on Aristotelian cosmology, both terms were correct. See also note 32, p. 16.

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, nemini in hanc vſque diem cognitos, nouiſſimè Author deprehendit primùs; atque

MEDICEA SIDERA

NVNCVPANDOS DECREVIT.

VENETIIS, Apud Thomam Baglionum. M DC X.
Superiorum Permiſſu, & Priuilegio.

MOST SERENE
COSIMO II DE' MEDICI
FOURTH GRAND DUKE OF TUSCANY[5]

A most excellent and kind service has been performed by those who defend from envy the great deeds of excellent men and have taken it upon themselves to preserve from oblivion and ruin names deserving of immortality. Because of this, images sculpted in marble or cast in bronze are passed down for the memory of posterity; because of this, statues, pedestrian as well as equestrian, are erected; because of this, too, the cost of columns and pyramids, as the poet says,[6] rises to the stars; and because of this, finally, cities are built distinguished by the names of those who grateful posterity thought should be commended to eternity. For such is the condition of the human mind that unless continuously struck by images of things rushing into it from the outside, all memories easily escape from it.

Others, however, looking to more permanent and long-lasting

5. Cosimo II de' Medici (1590–1621) was the grandson of Cosimo I, the first of the family to bear the title of Grand Duke. He ascended the throne in 1609 upon the death of his father, Ferdinand I.

6. The reference is to the *Elegies* of the Roman poet Sextus Propertius, who lived in the last half of the first century B.C. Book 3, no. 2, is on the power of song and reads in part: "For not the heaven-raised Pyramids' expense, / Nor Jove's house which, at Ellis, mimics heaven, / Nor Mausulus, his tomb's magnificence, / By Death's supreme indemnity forgiven. / To filching fire or rain their crowns submit, / By Time's stroke, and their weight, they crash, defied. / Not so shall pass the fame by poet's wit / Achieved; for that endures in deathless pride." See E. H. W. Meyerstein, *The Elegies of Propertius* (London: Oxford University Press, 1935), 95–96.

things, have entrusted the eternal celebration of the greatest men not to marbles and metals but rather to the care of the Muses and to incorruptible monuments of letters. But why do I mention these things as though human ingenuity, content with these [earthly] realms, has not dared to proceed beyond them? Indeed, looking further off, and knowing full well that all human monuments perish in the end through violence, weather, or old age, this human ingenuity contrived more incorruptible symbols against which voracious time and envious old age can lay no claim. And thus, moving to the heavens, it assigned to the familiar and eternal orbs of the most brilliant stars the names of those who, because of their illustrious and almost divine exploits, were judged worthy to enjoy with the stars an eternal life. As a result, the fame of Jupiter, Mars, Mercury, Hercules, and other heroes by whose names the stars are called will not be obscured before the splendor of the stars themselves is extinguished. This especially noble and admirable invention of human sagacity, however, has been out of use for many generations, with the pristine heroes occupying those bright places and keeping them as though by right. In vain Augustus's piety tried to place Julius Caesar in their number, for when he wished to name a star (one of those the Greeks call *Cometa* and we call hairy)[7] that had appeared in his time the Julian star, it mocked the hope of so much desire by disappearing shortly.[8] But now, Most Serene Prince, we are able to augur far truer and more fe-

7. Both the Greek *cometes* and Latin *crinitus* mean *hairy*. The original meaning was thus *hairy star*, describing the appearance of these celestial objects.

8. In an English translation of Suetonius's biographies of the first twelve caesars made during Galileo's lifetime, we read, in the 88th section of the life of Julius Caesar: "He died in the 56 yeare of his age and was canonized among the Gods, not onely by their voice who decreed such honour unto him, but also by the perswasion of the common people. For at those Games and playes which were the first that Augustus his heire exhibited for him thus deified, there shone a blazing starre for seven dayes together, arising about the eleventh houre of the daye; and beleeved it was to be the soule of Caesar received up into heaven. For this cause also uppon his Image there is a starre set to the verie Crowne of his head." See *Suetonius History of Twelve Caesars translated into English by Philemon Holland anno 1606*, 2 vols. (London: David Nutt, 1899), 1:80. See also Wilhelm Gundel and Hans Georg Gundel, *Astrologumena: Die Astrologische*

licitous things for Your Highness, for scarcely have the immortal graces of your soul begun to shine forth on earth than bright stars offer themselves in the heavens which, like tongues, will speak of and celebrate your most excellent virtues for all time. Behold, therefore, four stars reserved for your illustrious name, and not of the common sort and multitude of the less notable fixed stars, but of the illustrious order of wandering stars, which, indeed, make their journeys and orbits with a marvelous speed around the star of Jupiter, the most noble of them all, like his own children, with mutually different motions, while meanwhile all together, in mutual harmony, complete their great revolutions every twelve years about the center of the world, that is, about the Sun itself.[9] Indeed, it appears that the Maker of the Stars himself, by clear arguments, admonished me to reserve for these new planets the illustrious name of Your Highness before all others. For as these stars, like the offspring worthy of Jupiter, never depart from his[10] side except for the smallest distance, so who does not know the clemency, the gentleness of spirit, the agreeableness of manners, the splendor of the royal blood, the majesty in actions, and the breadth of authority and rule over others, all of which qualities find a domicile and home for themselves in Your Highness? Who, I say, does not know that all these emanate from Jupiter, the most beneficent star according to the plan of God, who is the source of all good? It was Jupiter, I say, who at Your Highness's birth, having already passed through the murky vapors of the horizon, and occupying the midheaven[11] and illuminating the eastern angle[12]

Literatur in der Antike und ihre Geschichte, beiheft 6, *Sudhoffs Archiv* (Wiesbaden: Franz Steiner, 1966), 127–28.

9. Clearly Galileo is referring here to the Copernican system.

10. While in recent times it has become customary in the English language to refer to heavenly bodies with the personal pronoun *it*, until the nineteenth century the Sun, Mercury, Mars, Jupiter, and Saturn were referred to as *he* and the Moon and Venus as *she*.

11. The midheaven is the intersection of the ecliptic and the meridian.

12. This is the *horoscopus*, the point of the ecliptic rising at the eastern horizon marking the beginning of the first house.

from his royal house, looked down upon Your most fortunate birth from that sublime throne and poured out all his splendor and grandeur into the most pure air, so that with its first breath Your tender little body could drink in, together with Your soul (already decorated by God with noble ornaments), this universal power and authority. But why do I use probable arguments when I can deduce and demonstrate it from all but necessary reason? It pleased Almighty God that I was deemed not unworthy by Your serene parents to undertake the task of instructing Your Highness in the mathematical disciplines, which task I fulfilled during the past four years, at that time of the year when it is the custom to rest from more severe studies. Therefore, since I was evidently influenced by divine inspiration to serve Your Highness and to receive from so close the rays of your incredible clemency and kindness, is it any wonder that my soul was so inflamed that day and night it reflected on almost nothing else than that I, who am not only in soul but also by origin and nature under Your dominion, be recognized as full of ardor for Your glory and the utmost gratitude toward Your person. And hence, since under Your auspices, Most Serene Cosimo, I discovered these stars unknown to all previous astronomers, I decided by the highest right to adorn them with the very august name of Your family. For if I first discovered them, who will deny me the right if I also assign them a name and call them the Medicean Stars,[13] hoping that perhaps so much honor will accrue to these stars from this naming as the other stars brought to the rest of the Heroes? For, to be silent about Your Most Serene Highness's ancestors to whose eternal glory the monuments of all histories testify,[14] Your virtue alone, Greatest of

13. The telescope inaugurated a new chapter in celestial discovery. By claiming the right to name his discoveries, Galileo set a trend that others were to follow, with varying degrees of success, into the twentieth century. Systems of naming celestial objects are now regulated by international agreement, and names are often assigned by a committee of the International Astronomical Union.

14. For a history of the Medici family, see Ferdinand Schevill, *The Medici* (New York: Harcourt, Brace & Co., 1949; New York: Harper, 1960); and J. R. Hale, *Florence and the Medici: The Pattern of Control* (London: Thames & Hudson, 1977).

Heroes, can confer on these stars an immortal name. For who can doubt that the expectation of Yourself which you have aroused by the most blessed beginning of Your reign—even though it is of the highest—not only will you sustain and preserve, but that Your destiny is to surpass it by a great margin? So that having vanquished your compeers, even so You vie with Yourself and day by day emerge ever greater than Yourself and Your grandeur.

Therefore, Most Merciful Prince, receive from the stars this glory reserved for Yourself and Your family; and may You enjoy that divine good bestowed on You not so much by the stars as by the Maker and Governor of the stars, namely God, for as long a time as possible.

Written in Padua on the fourth day before the Ides of March,[15] 1610.

Your Highness's most loyal servant,

Galileo Galilei

15. In formal letters such as this one, writers often used the Roman manner of designating days of the month, in which days were counted backward from the kalends, nones, or ides, beginning with the day of the kalends, nones, or ides itself. The ides occurred on the fifteenth day of March, May, July, and October, and on the thirteenth day of all other months. The fourth day before the Ides of March is therefore 12 March.

The undersigned Gentlemen, Heads of the Council of Ten,[16] having received certification from the Reformers of the University of Padua,[17] by report from the Gentlemen deputized for this matter, that is, from the Most Reverend Father Inquisitor and from circumspect Secretary of the Senate, Giovanni Maraviglia, with an oath, that in the book entitled *Sidereus Nuncius* by Galileo Galilei there is nothing contrary to the Holy Catholic Faith, Principles, or good customs, and that it is worthy of being printed, allow it a license so that it can be printed in this city.

Written on the first day of March 1610

M. Ant. Valaresso
Nicolo Bon
Lunardo Marcello
} Heads of the Council of Ten

The Secretary of the Most Illustrious Council of Ten

Bartholomaeus Cominus

1610, on 8 March. Registered in the book on p. 39

Ioan. Baptista Breatto
Coadjutor of the Congregation on Blasphemy

16. The Council of Ten, first instituted in 1310 as a committee of public safety and made a permanent institution in 1335, dealt with all criminal and moral matters. It also exercised power in foreign affairs, finance, and war. Its heads granted permission to print books.

17. The *Riformatori dello Studio di Padova* constituted the body of overseers of the university. Since 1517 it had been made up of three members of the Venetian Senate. The *riformatori* were charged by the government with censorship of the press in the Venetian territories. They made recommendations to the Council of Ten. See Paul F. Grendler, "The Roman Inquisition and the Venetian Press, 1540–1605," *Journal of Modern History* 47 (1975): 48–65; reprinted in *Culture and Censorship in Late Renaissance Italy and France* (London: Variorum Reprints, 1981), no. 9.

ASTRONOMICAL MESSAGE

Containing and Explaining Observations Recently Made, With the Benefit of a New Spyglass, About the Face of the Moon, the Milky Way, and Nebulous Stars, about Innumerable Fixed Stars and also Four Planets hitherto never seen, and named MEDICEAN STARS

In this short treatise I propose great things for inspection and contemplation by every explorer of Nature. Great, I say, because of the excellence of the things themselves, because of their newness, unheard of through the ages, and also because of the instrument with the benefit of which they make themselves manifest to our sight.

Certainly it is a great thing to add to the countless multitude of fixed stars visible hitherto by natural means and expose to our eyes innumerable others never seen before, which exceed tenfold the number of old and known ones.[18]

It is most beautiful and pleasing to the eye to look upon the lunar body, distant from us about sixty terrestrial diameters,[19] from so near as if it were distant by only two of these measures, so that the diameter of the same Moon appears as if it were thirty times,

18. In the star catalog in his *Almagest*, Ptolemy listed 1022 stars. See G. J. Toomer, *Ptolemy's Almagest* (London: Duckworth, 1984), 341–99.

19. The distance of the Moon was commonly known to be about sixty terrestrial *radii*. In the manuscript as well as the printed version of *Sidereus Nuncius*, Galileo mistakenly uses *diameters*, as he does in his letter of 7 January 1610 (*Opere*, 10:273, 277). A slip of the pen therefore appears to be ruled out. See Edward Rosen, "Galileo on the Distance between the Earth and the Moon," *Isis* 43 (1952): 344–48.

the surface nine-hundred times, and the solid body about twenty-seven thousand times larger than when observed only with the naked eye.[20] Anyone will then understand with the certainty of the senses that the Moon is by no means endowed with a smooth and polished surface, but is rough and uneven and, just as the face of the Earth itself, crowded everywhere with vast prominences, deep chasms, and convolutions.

Moreover, it seems of no small importance to have put an end to the debate about the Galaxy or Milky Way and to have made manifest its essence to the senses as well as the intellect; and it will be pleasing and most glorious to demonstrate clearly that the substance of those stars called nebulous up to now by all astronomers is very different from what has hitherto been thought.

But what greatly exceeds all admiration, and what especially impelled us to give notice to all astronomers and philosophers, is this, that we have discovered four wandering stars, known or observed by no one before us. These, like Venus and Mercury around the Sun,[21] have their periods around a certain star[22] notable among the number of known ones, and now precede, now follow, him, never digressing from him beyond certain limits. All these things were discovered and observed a few days ago by means of a glass contrived by me after I had been inspired by divine grace.

Perhaps more excellent things will be discovered in time, either by me or by others, with the help of a similar instrument, the form and construction of which, and the occasion of whose invention, I shall first mention briefly, and then I shall review the history of the observations made by me.

20. Galileo implies here that in these observations he used an instrument that magnified thirty times. In his letter of 7 January 1610, he stated that he was about to finish a thirty-powered instrument *(Opere,* 10:277), but there is no evidence that he made much use of this instrument. See Drake, *Galileo at Work,* 147–48.

21. In the traditional Ptolemaic scheme, all planets were thought to orbit the Earth. In a well-known variation of this scheme that may well have been suggested in Greek Antiquity, Mercury and Venus were thought to orbit the Sun. This explained the fact that they never stray far from the Sun.

22. See p. 16, note 32, above.

About 10 months ago a rumor came to our ears that a spyglass had been made by a certain Dutchman[23] by means of which visible objects, although far removed from the eye of the observer, were distinctly perceived as though nearby. About this truly wonderful effect some accounts were spread abroad, to which some gave credence while others denied them. The rumor was confirmed to me a few days later by a letter from Paris from the noble Frenchman Jacques Badovere.[24] This finally caused me to apply myself totally to investigating the principles and figuring out the means by which I might arrive at the invention of a similar instrument, which I achieved shortly afterward on the basis of the science of refraction.[25] And first I prepared a lead tube in whose ends I fitted two glasses,[26] both plane on one side while the other side of one was spherically convex and of the other concave. Then, applying my eye to the concave glass, I saw objects satisfactorily large and close. Indeed, they appeared three times closer and nine times larger than when observed with natural vision only.[27] Afterward I made another more perfect one for myself that showed objects more than sixty times larger.[28] Finally, sparing no labor or expense, I progressed so far that I constructed for myself an instrument so excellent that things seen through it appear about a thousand times larger and more than thirty times closer

23. The Latin word *Belga* should be translated as *Dutchman* or *Netherlander*. See "A Note on the Word 'Belgium,'" in Pieter Geyl, *The Netherlands in the Seventeenth Century, Part I, 1609–1648* (London: Ernest Benn, 1961), 260–62.

24. See pp. 5–6, above.

25. As a professor of mathematical subjects, Galileo was thoroughly grounded in the optical theory of his day. This theory could not, however, give him much guidance in duplicating the invention. In *The Assayer* of 1623, Galileo more fully described the process by which he figured out how to make his first spyglass. See Stillman Drake and C. D. O'Malley, *The Controversy on the Comets of 1618* (Philadelphia: University of Pennsylvania Press, 1960), 211–13.

26. The Latin word *perspicillum* was here clearly meant to denote a common spectacle lens.

27. This was the greatest magnification that could be achieved with a spyglass made with lenses for sale in the shops of spectacle makers.

28. This is the instrument Galileo presented to the Venetian Senate. See pp. 7–9, above.

than when observed with the natural faculty only.[29] It would be entirely superfluous to enumerate how many and how great the advantages of this instrument are on land and at sea. But having dismissed earthly things, I applied myself to explorations of the heavens. And first I looked at the Moon from so close that it was scarcely two terrestrial diameters[30] distant. Next, with incredible delight I frequently observed the stars, fixed as well as wandering,[31] and as I saw their huge number I began to think of, and at last discovered, a method whereby I could measure the distances between them. In this matter, it behooves all those who wish to make such observations to be forewarned. For it is necessary first that they prepare a most accurate glass that shows objects brightly, distinctly, and not veiled by any obscurity, and second that it multiply them at least four hundred times and show them twenty times closer. For if it is not an instrument such as that, one will try in vain to see all the things observed in the heavens by us and enumerated below. Indeed, in order that anyone may, with little trouble, make himself more certain about the magnification of the instrument, let him draw two circles or two squares on paper, one of which is four hundred times larger than the other, which will be the case when the larger diameter is twenty times the length of the other diameter. He will then observe from afar both sheets fixed to the same wall, the smaller one with one eye applied to the glass and the larger one with the other, naked eye. This can easily be done with both eyes open at the same time. Both figures will then appear of the same size if the instrument multiplies objects according to the desired proportion. After such an instrument has been prepared, the method of measuring distances is to be investigated, which is achieved by the following procedure. For the sake of easy comprehension, let *ABCD* be the tube and *E* the eye of the observer. When there are no glasses in the tube, the rays proceed

29. See note 20.
30. See note 19.
31. That is, stars and planets.

to the object *FG* along the straight lines *ECF* and *EDG*, but with the glasses put in they proceed along the refracted lines *ECH* and *EDI*. They are indeed squeezed together and where before, free, they were directed to the object *FG*, now they only grasp the part *HI*. Then, having found the ratio of the distance *EH* to the line *HI*, the size of the angle subtended at the eye by the object *HI* is found from the table of sines, and we will find this angle to contain only some minutes, and if over the glass *CD* we fit plates perforated some with larger and some with smaller holes, putting now this plate and now that one over it as needed, we form at will angles subtending more or fewer minutes. By this means we can conveniently measure the spaces between stars separated from each other by several minutes with an error of less than one or two minutes.[32] Let it suffice for the present, however, to have touched on this so lightly and to have, so to speak, tasted it only with our lips, for on another occasion we shall publish a complete theory of this instrument.[33] Now let us review the observations made by us during the past 2 months, inviting all lovers of true philosophy to the start of truly great contemplation.

Let us speak first about the face of the Moon that is turned toward our sight, which, for the sake of easy understanding, I divide into two parts, namely a brighter one and a darker one. The

32. The relationship between the size of the aperture of the objective lens and the field of view of the instrument is, in fact, rather more complicated than Galileo implies here, and for this reason all efforts to turn this form of telescope into a measuring instrument failed. See John North, "Thomas Harriot and the First Telescopic Observations of Sunspots," in John W. Shirley, ed., *Thomas Harriot; Renaissance Scientist* (Oxford: Clarendon Press, 1974), 129–65, at 158–60.

33. Galileo never published such a theory.

brighter part appears to surround and pervade the entire hemisphere, but the darker part, like some cloud, stains its very face and renders it spotted. Indeed, these darkish and rather large spots are obvious to everyone, and every age has seen them. For this reason we shall call them the large or ancient spots, in contrast with other spots, smaller in size and occurring with such frequency that they besprinkle the entire lunar surface, but especially the brighter part. These were, in fact, observed by no one before us.[34] By oft-repeated observations of them we have been led to the conclusion that we certainly see the surface of the Moon to be not smooth, even, and perfectly spherical, as the great crowd of philosophers have believed about this and other heavenly bodies,[35] but, on the contrary, to be uneven, rough, and crowded with depressions and bulges. And it is like the face of the Earth itself, which is marked here and there with chains of mountains and depths of valleys. The observations from which this is inferred are as follows.

On the fourth or fifth day after conjunction,[36] when the Moon displays herself to us with brilliant horns,[37] the boundary dividing the bright from the dark part does not form a uniformly oval line, as would happen in a perfectly spherical solid, but is marked by an uneven, rough, and very sinuous line, as the figure shows. For several, as it were, bright excrescences extend beyond the border between light and darkness into the dark part, and on the other hand little dark parts enter into the light. Indeed, a great number of small darkish spots, entirely separated from the dark

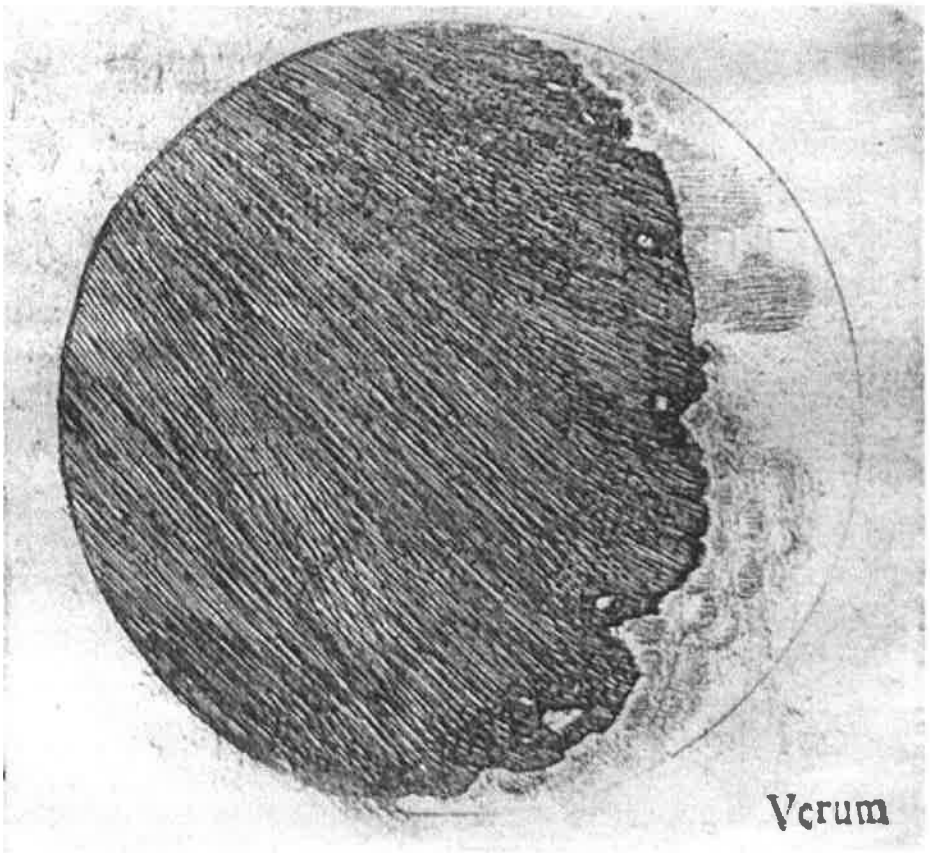
34. On Thomas Harriot's telescopic observation of the Moon in August 1609, see p. 10, above.

35. See pp. 11–12, above.

36. That is, conjunction with the Sun, when the Moon is invisible because its illuminated hemisphere is turned away from the Earth. The current astronomical term is "new moon." It is at this point that solar eclipses can occur.

37. That is, the Moon shows only a thin crescent of light.

part, are distributed everywhere over almost the entire region already bathed by the light of the Sun, except, at any rate, for that part affected by the large and ancient spots. We noticed, moreover, that all these small spots just mentioned always agree in this, that they have a dark part on the side toward the Sun while on the side opposite the Sun they are crowned with brighter borders like shining ridges. And we have an almost entirely similar sight on Earth, around sunrise, when the valleys are not yet bathed in light but the surrounding mountains facing the Sun are already seen shining with light. And just as the shadows of the earthly valleys are diminished as the Sun climbs higher, so those lunar spots lose their darkness as the luminous part grows.



Not only are the boundaries between light and dark on the Moon perceived to be uneven and sinuous, but, what causes even greater wonder, is that very many bright points appear within the dark part of the Moon, entirely separated and removed from the illuminated region and located no small distance from it. Gradually, after a small period of time, these are increased in size and brightness. Indeed, after 2 or 3 hours they are joined with the rest of the bright part, which has now become larger. In the meantime, more and more bright points light up, as if they are sprouting, in the dark part, grow, and are connected at length with that bright surface as it extends farther in this direction. An example of this is shown in the same figure. Now, on Earth, before sunrise, aren't the peaks of the highest mountains illuminated by the Sun's rays while shadows still cover the plain? Doesn't light grow, after a little while, until the middle and larger parts of the same mountains are illuminated, and finally, when the Sun has risen, aren't the illuminations of plains and hills joined together? These differences between prominences and depressions in the Moon, however, seem to exceed the terrestrial roughness greatly, as we shall demonstrate below. Meanwhile, I would by no means be silent about something deserving notice, observed by me while the Moon was rushing toward first quadrature,[38] the appearance of which is also shown in the above figure. For toward the lower horn[39] a vast dark gulf projected into the bright part. As I observed this for a long time, I saw it very dark. Finally, after about 2 hours, a bit below the middle of this cavity a certain bright peak began

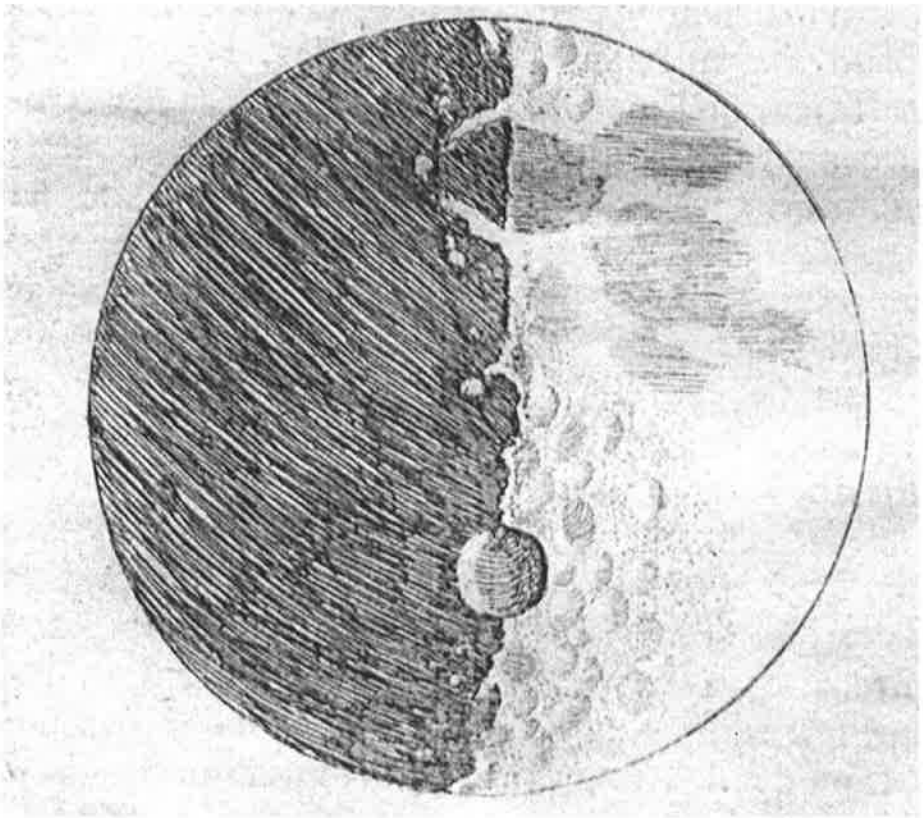
38. The Moon or a planet is at quadrature when its angular separation from the Sun is 90 degrees. The first quadrature of the Moon after new moon is called "first quarter."

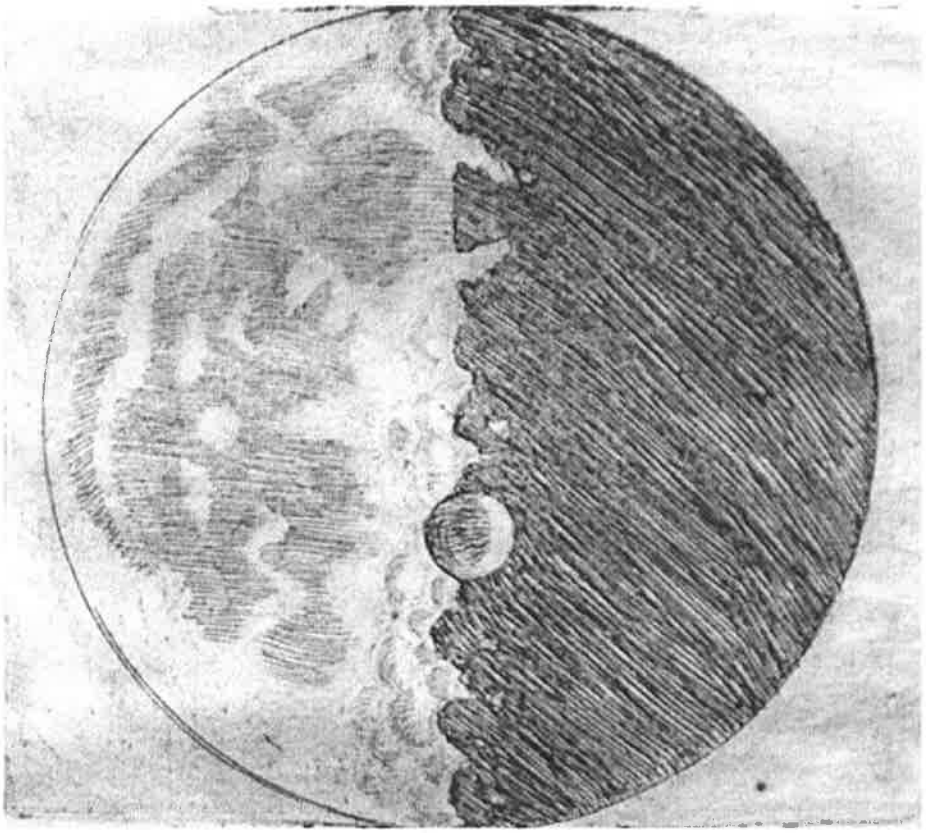
39. On modern moonmaps, until recently, this would be the upper horn. While Galileo's telescope showed an erect (right-side up) image, modern instruments show an inverted (upside-down) image and for this reason modern Moon maps are drawn upside down. Note, however, that since spacecraft started sending back erect planetary images, more and more moonmaps are not inverted.

to rise and, gradually growing, it assumed a triangular shape, still entirely removed and separated from the bright face. Presently three other small points began to shine around it until, as the Moon was about to set, this enlarged triangular shape, now made larger, joined together with the rest of the bright part, and like a huge promontory, surrounded by the three bright peaks already mentioned, it broke out into the dark gulf. Also, in the tips of both the upper and lower horns, some bright points emerged, entirely separated from the rest of the light, as shown in the same figure. And there was a great abundance of dark spots in both horns, especially in the lower one. Of these, those closer to the boundary between light and dark appeared larger and darker while those farther away appeared less dark and more diluted. But as we have mentioned above, the dark part of the spot always faces the direction of the Sun and the brighter border surrounds the dark spot on the side turned away from the Sun and facing the dark part of the Moon. This lunar surface, which is decorated with spots like the dark blue eyes in the tail of a peacock, is rendered similar to those small glass vessels which, plunged into cold water while still warm, crack and acquire a wavy surface, after which they are commonly called ice-glasses. The large [and ancient] spots of the Moon, however, when broken up in a similar manner, are not seen to be filled with depressions and prominences, but rather to be even and uniform, for they are only here and there sprinkled with some brighter little places. Thus, if anyone wanted to resuscitate the old opinion of the Pythagoreans that the Moon is, as it were, another Earth, its brighter part would represent the land surface while its darker part would more appropriately represent the water surface.[40] Indeed, for me there has never been any doubt that when the terrestrial globe, bathed in sunlight, is observed from a distance, the land surface will present itself brighter to

40. For Kepler's discussion of this aspect, see p. 97, below.

the view and the water surface darker. Moreover, in the Moon the large spots are seen to be lower than the brighter areas, for in her waxing as well as waning, on the border between light and dark, there is always a prominence here or there around these large spots, next to the brighter part, as we have taken care to show in the figures; and the edges of the said spots are not only lower, but more uniform and not broken by creases or roughnesses. Indeed, the brighter part stands out very much near the ancient spots, so that both before the first and near the second quadrature some huge projections arise around a certain spot in the upper, northern part of the Moon, both above and below it, as the adjoining figures show.





Before the second quadrature this same spot is seen walled around by some darker edges which, like a ridge of very high mountains turned away from the Sun, appear darker; and where they face the Sun they are brighter. The opposite of this occurs in valleys whose part away from the Sun appears brighter, while the part situated toward the Sun is dark and shady. Then, when the bright surface has decreased in size, as soon as almost this entire spot is covered in darkness, brighter ridges of mountains rise loftily out of the darkness. The following figures clearly demonstrate this double appearance.