DOI: 10.6093/978-88-6887-270-0

Was Galileo accurate in recording Moon's images in *Sidereus Nuncius*?

Pasquale Tucci[1]

[1] Retired, in 2013. Università degli Studi di Milano, ptucci@icloud.com

Abstract: The four different Moon's images in the *Sydereus Nuncius* were analysed by Guglielmo Righini to date them with purely astronomical methods. The first image was dated with usual astronomical methods. For dating the second and the third image, G. Righini used a very original method. He claimed that lunar libration was detectable in Galileo's images. Gingerich criticised these results as they refer to images which were too inaccurate for a quantitative analysis. Drake moved Righini's date 2 October 1609 to 1° January 1610, and accepted other G. Righini's dates. Whitaker confirmed Righini's dates for the second and fourth image; for the third image he confirmed Righini's date if for "shortly before the last quarter", we mean one day before. For the first image, Whitaker proposed a different date: 30 November 1609. Gingerich and Van Helden took Whitaker's chronology as definitive, except for the date of the second image (2 December 1609 instead of 3 December 1609). After Whitaker, neither astronomers nor historians of astronomy have addressed in a complete way the problem of dating. A. Righini revised G. Righini's dates, using the JPL Horizon project website and the Stonyhurst disc, and corrected G. Righini's date of the first image from October 2, 1609 to December 1, 1609, with a mean absolute error of 2.5% in units of lunar diameter. In my paper, I will point out that the analysis of the images carried out by Righini with astronomical methods highlighted a good agreement with the libration data. So Galileo's images, at least according to G. Righini, were accurate enough to allow quantitative predictions.

Keywords: Galileo, Astronomy, Moon, G. Righini

1. Introduction

In a Conference held in Capri in 1974 Guglielmo Righini (1908-1978) read the paper "New Light on Galileo's Lunar Observations" (Righini 1975) in which, for the first time, the four different printed images in the *Sidereus Nuncius* (Fig. 1) were analysed in order to date them with purely astronomical methods.

Owen Gingerich (1930-2023) replied with the paper "Dissertatio cum Professore Righini et Sidereo Nuncio" (Gingerich 1975) in which he argued that the Galilean images of the Moon were so little detailed and so heavily theory-laden to prevent anyone to extract quantitative conclusions from them. According to Gingerich, the images represented the psychological impact of the telescopic images of the Moon on Galileo and could not be used for specific measurements.

In 1974 Guglielmo Righini was the director of the Arcetri Astronomical Observatory which, under the previous direction of Giorgio Abetti (1882-1982), had become an advanced scientific research center in solar astrophysics. Under Righini's direction, the Observatory reached a further level of specialization. Righini also held the chair of Astronomy at the University of Florence. Righini's interest in Galilean astronomy arose around 1964, when Righini created a report for the International Congress on Galileo Galilei, on the occasion of the fourth centenary of the birth of the Pisan scientist (Righini 1978).[1]

[1] As Maria Luisa Bonelli and Leonida Rosino recalled in their presentation of the *Supplemento agli Annali dell'Istituto e Museo di Storia della Scienza* (Righini 1978), Righini could not update his contribution in the light of the recent publications.

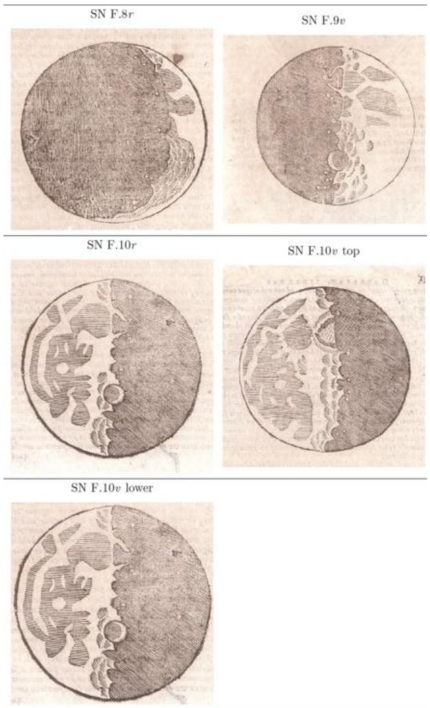

Fig. 1. Moon's images of the Moon inserted by Galileo Galilei in his *Sidereus Nuncius*.

Owen Gingerich, an astronomer by training, since 1971 had addressed his research to the History of Astronomy, with particular attention to Copernicus and Kepler.

In the 1960s, the observations of the Moon made by Galileo had been examined, among others, by the polish astronomer Zdeněk Kopal (1914-1993) who questioned Galileo's ability to carry out astronomical observations. In 1969, Kopal argued that it was sufficient to give a look at Galileo drawings of the Moon for disclosing that

> Galileo was not a great astronomical observer; or else that the excitement of so many telescopic discoveries made by him at that time had temporarily blurred his skill or critical sense; for none of the features recorded on this (and other) drawings of the Moon can be safely identified with any known markings of the lunar landscape (Kopal & Carder 1974, p. 5).

Righini knew the motivations that had led Kopal, quoted by Righini himself, to question Galileo's observational skills (Righini 1974, pp. 65-66).

Also Johannes Classen (1908-1987), quoted by Righini, had claimed: "Galileo was not much an artist and his sketches of the lunar surface bear little resemblance to nature" (Classen 1969, p. 82).

Kopal's and Classen's argument against Galileo observer, not new, was questioned by William R. Shea (1974):

> Galileo has been roundly condemned as a second-rate observer whose perception was blurred by the excitement of discovery when, on closer inspection, it can be shown that he was remarkably

Bonelli and Rosino published "Note di aggiornamento" (Update Notes) on p. 110 of the *Supplemento* itself. Maria Luisa Bonelli, an historian of science, director of the Institute and Museum of the History of Science in Florence, was the second wife of Righini. It's very likely that Righini discussed with her some topics addressed in his historical memoirs. Righini (1978) discussed the Moon's Librations at the pages 24-41.

> faithful in his description of the main features of the Moon. The indictment of Galileo as a poor experimentalist because of his diagrams of the lunar landscape turns out to have been a hasty generalization, made for philosophical rather than historical reasons (Shea 1974, p. 17).

Galileo drew, moreover, seven ink-and-wash drawings, kept in the 'Biblioteca Nazionale di Firenze'. They were probably made by Galileo during his telescopic observations but, more likely, they were drawn from a sketch after observations. A discussion about these drawings can be found in Tucci (2022, pp. 37-39, p. 42, p. 45); Gingerich & Van Helden (2003, pp. 256-257) However, they did not enter into the discussion between Righini and Gingerich, dealing it only with the images printed in the *Sidereus Nuncius*.[2]

2. Righini's date calculations of the first image of the Moon in *Sidereus Nuncius*

According to Righini, the five drawings in the *Sidereus Nuncius* seemed placed in chronological order.

- drawing no. 1: waxing Moon on probably the fourth or fifth day after new Moon;
- drawing no. 2: the Moon at first quarter;
- drawing no. 3: the Moon at last quarter;
- drawing no. 4: the Moon a few days before this last phase;
- drawing no. 5: the Moon once more at last quarter.

If the Moon were a perfectly spherical globe, without heights and depressions, the age of the Moon, namely the period between new Moon (the conjunction of the Sun and the Moon) and the time of a later observation could be determined exactly from the amount of the diameter of the Moon that lies in its illuminated part. But since the Moon is covered with mountains and craters, this is clearly not the case. Furthermore, Galileo had only meagre telescopic means at his disposal (Drake 1976, p. 159), and hence the date of his drawings can only be ascertained within a certain margin of error. Righini calculated that for drawing no. 1, the age of the Moon at the time of observation was $4^d.62 \pm 0^d.08 = 4^d\ 14^h\ 53^m \pm 1^h\ 55^m$.

Righini then proceeded to establish the dates when the new Moon occurred between July and December 1609, and he added in each case $4^d.62 \pm 0^d.08$, the time interval between the new Moon and Galileo's observation. This gave a list of dates on which Galileo could have made his observations. But since the Moon is visible after sunset when it is four or five days old, the next step was to calculate the time of sunset and the corresponding age of the Moon in Padua, where Galileo made his observations. The results are summarized in the Table 1.

Table 1: Day, month and time when the age of the Moon was $4^d.62$; sunset in Padua; age of the Moon at sunset

Dates in 1609 when the age of the Moon = $4^d.62$	Time of sunset	Age of the Moon
5 July, $2^h\ 58^m$	$19^h\ 42^m$	$5^d.32$
4 August, $13^h\ 02^m$	$19^h\ 24^m$	$4^d.88$
2 September, $1^h\ 17^m$	$18^h\ 30^m$	$5^d.34$
2 October, $1^h\ 17^m$	$17^h\ 48^m$	$4^d.68$
2 November, $9^h\ 16^m$	$17^h\ 00^m$	$4^d.94$
1 December, $4^h\ 10^m$	$16^h\ 24^m$	$5^d.13$

[2] In a Post Script to his contribution to the Conference, Gingerich claimed that he had had the opportunity to examine the seven Galileo's ink-and-wash drawings after the Conference. In the Proceedings of the Conference, Gingerich quoted the ink-and-wash drawings (Gingerich 1974, pp. 80-83 and pp. 87-88).

Table 1 clearly showed that the only day on which the age of the Moon at sunset agreed (within a very narrow margin of error) with the age of the Moon inferred from Galileo's drawing was 2 October 1609. On that day, the age of the Moon was $4^d.68$, almost exactly the value of $4^d.62$ required by drawing no. 1 (Fig. 1).

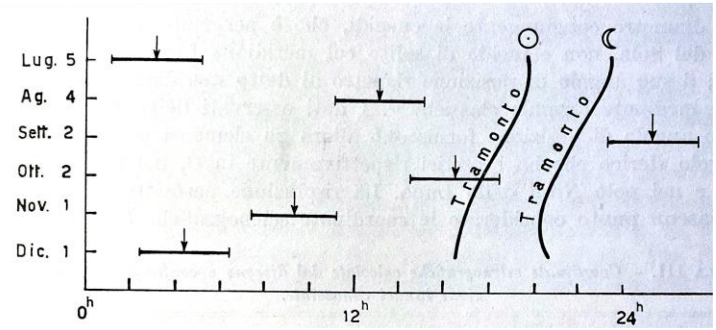

Fig. 1. Age of the Moon at 4.62 days and time of sunset of the Sun and Moon for Padua. Year 1609; age of the Moon = $4^d.62 \pm 0.08$

The result was confirmed by calculating the longitude and the latitude (known as the selenographic coordinates) of some of the lunar configurations observed by Galileo. Righini chose for this purpose six individual points (Fig. 2) and he determined the polar coordinates with respect to the centre of the lunar disc and the vertical diameter that joins the cusps.

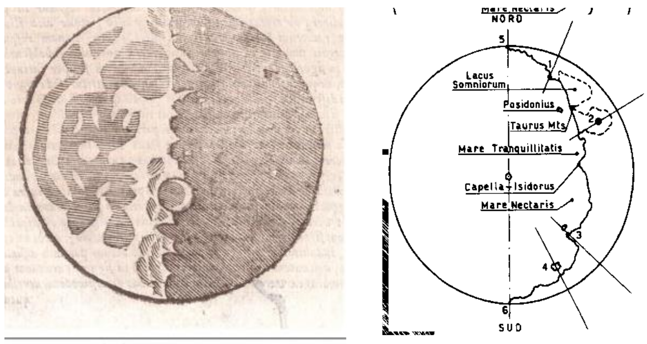

Fig. 2. Lunar structures identified by Righini in the image no. 1 published in the Sidereus Nuncius.

1. Group of craters Plana, Mason, Airy between Lacus Somniorum and Sea Frigoris
2. Center of the Mare Crisium
3. Rabbi Levi Crater
4. Group of craters Baco, Breislak, Clairaut, Cuvier of South Plateau
5. North Pole beyond the visible edge
6. South Pole visible facing the Earth inside the lunar edge

The results of his calculation were summarized by Righini in the following Table 2. As Righini wrote:

> Le differenze fra la posizione misurata sul disegno e quella individuata sulla mappa lunare sono contenute entro limiti accettabili; particolarmente sicura è l'individuazione del punto 2 che corrisponde al centro del Mare Crisium (Righini 1978, p. 30).[3]

[3] Translation: "The differences between the position measured on [Galileo's] picture and that one identified on the lunar map are contained within acceptable limits; particularly safe is the identification of the point 2 which corresponds to the centre of the Mare Crisium". Righini used the lunar map of Kopal (Kopal *et al.* 1965).

Table 2: Latitude *b* and Longitude *l* of the six points identified by Righini

Points n.	From the first image of the Moon in the *Sidereus Nuncius*		From lunar map	
	l	*b*	*l*	*b*
1	+35°	+40°	+30°	+45°
2	+55°	+14°	+59°	+16°
3	+27°	–37°	+23°	–35°
4	+19°	–53°	+17°	–50°
5	+9°	+79°	Cusp N	
6	–14°	–79°	Cusp S	

3. Righini's date calculations of the second and third image of the Moon in *Sidereus Nuncius*

Righini could not proceed in the same way to date the other drawings, because the time that the Moon could be observed after sunset at the first quarter (when it sets at about midnight) and at the last quarter (when it rises at about midnight and crosses the meridian about sunrise) was too large to allow a precise determination of the day on which Galileo made his observations. To date the images n. 2 and n. 3 of the Moon, Righini noted that in the second and third images the circular spot was about 5 mm away from the center of the lunar disc, 9°.7 degrees (on Galileo's scale). According to Righini the circular structure was a real feature of the Moon and not an optical illusion. Gingerich, on the contrary, believed that Galileo recorded the image commensurate with the psychological impact of his sighting. According to Gingerich, Galileo saw the big crater with the mind's eye rather than with his telescope (Gingerich 1974, pp. 86-87). Righini thought that 9°.7 degrees was too large an amount to be ascribed to error or to uncertainty in the determination of the distance. A possible explanation was that Galileo had unwittingly noticed and recorded an effect of libration in latitude, which Righini calculated with the aid of appropriate formulae, and for the first and the last quarter between the beginning of October and the end of December 1609. He obtained the results shown in Table 3. It was only many years later that Galileo recognized them and called the "apparent titubation of the Moon".

Table 3: Libration in latitude of the Moon at the first and last quarter

Date (1609)	First quarter	Date (1609)	Last quarter	First quarter–last quarter
5 October	–1°.7	20 October	–0°.9	–0°.8
3 November	+0°.1	18 November	–3°.4	+3°.5
3 December	+3°.8	18 December	–5°.0	+8°.8

Table 3 showed, according to Righini, that the amount of 9°.7 was satisfied "if we assign December 3rd as the date of drawing no. 2 and December 18th for the drawing no. 3" (Righini 1974, p. 74). He claimed that the calculated 8°.8 is a fair approximation to the difference of 9°.7 measured on the drawings.

4. Righini's date calculations of the fourth image of the Moon in *Sidereus Nuncius*

Since many features on the drawing are detectable, Righini used their selenographic coordinates. In drawing no. 4 (Tab. 4) point 1 corresponded to the Maurilius crater and its selenographic coordinates are: longitude l = +10°, latitude b = +15°. Point 2 corresponded to Apianus crater with the following coordinates: longitude l = +6° and latitude b = –28°. The arc a_1 of the great circle that passes through the Maurilius crater and the center of the lunar disc is equal to 20° and the one a_2 which passes through

Apianus is equal to 24°.7. Having the selenocentric coordinates of the two craters and their angular distance from the center of the Moon disc, Righini computed the libration in latitude and found that the no. 4 was made shortly before the last quarter on 18 December 1609. Righini concluded his reasoning with these words:

> In the light of these measurements, it is fair to conclude that Galileo was a much better observer that Classen and Kopal have suggested and that he was, in fact, a remarkably faithful recorder of his visual experiences (Righini 1974, p. 76).

5. Gingerich's argumentation against Righini

Gingerich admired Righini's method but disagreed with its validity (Gingerich 1974, p. 86). He started from the assumption

> that what we see is strongly conditioned by what we have already seen, and (as a corollary) even what we choose to look at is already heavily theory-laden. The image of the astronomer continually surveying the heavens and objectively documenting all he finds as the foundation for future theories is demonstrably false (Gingerich 1974, p. 77).

Gingerich focused his attention on the two images (no. 2 and no. 3) of the Moon in which a large crater is visible. According to Gingerich, the crater was impossibly immense. Its diameter exceeded 12°, whereas the largest craters in this part of the Moon rarely reached 5°. Furthermore, the curvature of the Moon was such that the opposite edges of Galileo's crater could not possibly be so well illuminated at this extended distance from the terminator unless they were incredibly high. And he concluded that "this fact, plus the sharpness of its outline, precludes its identification with a cluster of actual craters" (Gingerich 1974, p. 84). In attempting to provide some satisfactory explanation for the large crater in the printed drawing, Gingerich examined the appearance of a pair of modern photographs of the first and last quarter Moon as seen from various distances. Gingerich concluded that the only crater that could have anything to do with the one drawn by Galileo was the Albategnius crater that must have made an indelible impression on Galileo's mind: "I believe that he recorded the images commensurate with the psychological impact of his sightings" (Gingerich 1974, p. 86). Gingerich examined the manuscript of the *Sidereus Nuncius* on Favaro edition of Galileo's works, and pointed out that the printed drawing was a highly distorted and derivative version of the manuscript drawing (Gingerich 1974, p. 86). In conclusion, Righini's date of December 1609 for drawings no. 2 and no. 3 rested primarily on the position of the large crater. "If, as I have argued, Galileo intended this as a symbolic illustration of a crater and not as an exact map, then it cannot be used for specific measurements" (Gingerich 1974, p. 86).

Similarly, the rather ambiguous features measured by Righini on image no. 4 of the *Sidereus nuncius* appeared in quite different positions on the manuscript drawing, thus shattering any confidence in their reliability for quantitative argument. In light of these discrepancies, Gingerich "was reluctant to believe that the accuracy required for Righini's method could be extracted from the first drawing. (In any event, the age of the Moon versus time of sunset is as well satisfied for 29 January or 29 March 1610 as for 2 October 1609)" (Gingerich 1974, p. 86). According to Gingerich, we can not only say that Galileo discovered the craters on the Moon, but that at the time of the *Sidereus nuncius* he had invented them in the sense that from a single crater seen well enough he recognized the additional profusion of circular features far more clearly in the mind's eye than with his telescope.

6. Drake's argumentation

Drake re-examined Righini's chronology in a paper published in 1976. His aim was to support by evidence of a biographical character Righini's findings on purely astronomical grounds (Drake 1976). On the basis of his knowledge of Galileo's biography, he observed that Galileo could not have started his observations before 1 December 1609, shortly after sunset when the age of the Moon was 5 days. He moved Righini's date 02.10.1609 to 29.01.1610 (Drake 1976, p. 154), and accepted other Righini's dates.

Gingerich had stated that the same configuration of the Moon was compatible not only with the date of October 2, 1609 but also with the dates 29 January 1610 or 29 March 1610. But

> here Professor Owen Gingerich in attacking the whole analysis by Professor Righini unwittingly came to its aid. For in pointing out that on 29 January 1610 Galileo could have seen at Padua a Moon as young as on 2 October 1609, he granted for purposes of argument Professor Righini's analysis and simultaneously offered the biographer a probable account of the whole matter (Drake 1979, p. 153).

While for Gingerich the possibility of three dates excluded that the calculation made by Righini was acceptable, Drake instead found the date of 29 January 1610 was plausible and justified it by stating that Galileo had begun his observations of the Moon on December 1° 1609 just after sunset when the age of the Moon was about 5 days (as Righini had supposed). According to Drake the drawings he had then made of the event were not very accurate, but that he had successively improved his skills so that the drawings made for December 3 and 18 were included in the *Sidereus nuncius*, while "for the published thin crescent of four or five days, however, I believe he made a new drawing on 29 January1610, and that that is the one Professor Righini analyzed - the diagram in the *Sidereus nuncius*, published early in March" (Drake 1979, p. 154).

Ultimately Drake appreciated Righini's work and supported it with biographical considerations. In Righini's obituary Drake, referring to Righini's contribution to dating of Galileo's observations of the Moon with purely astronomical methods published on *Supplemento agli Annali dell'Istituto e Museo di Storia della Scienza* (Righini 1978) was "without rival in scope and scholarship in the vast literature regarding this important phase of Galileo's activities" (Drake 1979, p. 552).

7. Whitaker'dates of Galileo's observations

In a paper published in 1978, Whitaher addressed the problem of dating Galilean images of the Moon. The images taken into consideration are those of the *Sidereus Nuncius*, as Righini had done. Moreover, Whitaker took into account Galileo's 7 ink-and-wash images of the Moon kept in the 'Biblioteca Nazionale di Firenze' (Tucci 2022, p. 35).

In 1978, Ewen A. Whitaker (1922-2016) had just retired from the Lunar and Planetary Laboratory of the University of Arizona. He was considered a leading expert on lunar photography. His aim, in the paper in question, is to re-examine the whole subject of Galileo's lunar observations; mainly a) the dating of the four lunar drawings in *Sidereus Nuncius* and b) the lunar libration in latitude, unwittingly recorded by Galileo.

After identifying from the Galilean biography some limiting dates within which Galileo would have made observations of the Moon, namely November 1, 1609 and January 7, 1610 Whitaker criticized Righini's approach regarding the use of either the age or the phase of the Moon as an accurate indicator of the position of the terminator with respect to the surface features, since the lunar orbit was eccentric and this could give rise to an error on the day of almost 10%.

According to Whitaker, the only correct method was to draw up a table giving the Sun's selenographic colongitude for the examined period. But the colongitude of the Sun needed the longitude of the terminator for each image of the Moon. Whitaker noticed that a change of only 2° in the position of the terminator produced marked differences in its shape. So his procedure was to compare each drawing with all suitable photographs in which the terminator was lying about 10° of the apparent phase as drawn, and to choose the one which most nearly duplicated the terminator features. The results are summarized in following Table 4, where I have added the comparison among the date given by Righini, Drake and Whitaker.

Table 4: Dates according to Righini, Drake and Whitaker[4]

Sidereus Nuncius images of the Moon	Righini dates	Drake dates	Whitaker dates
 no. 1	02.10.1609 (Righini 1974, p. 71; Righini 1978, p. 28)	01.12.1609 “Shortly after sunset when the age of the Moon was 5 days.” (Drake 1976, p. 154)	30.11.1609 h. 20 Padua Mean Time (Whitaker 1978, p. 159) E1
 no. 2	03.12.1609 (Righini 1974, p. 74; Righini 1978, p. 33)		03.12.1609 h. 20 Padua Mean Time (Whitaker 1978, p. 159) E2
 no. 3	18.12.1609 (Righini 1974, p. 74; Righini 1978, p. 33)		18.12.1609 h. 20 Padua Mean Time (Whitaker 1978, p. 159) E4
 no. 4	18.12.1609 Shortly before the last quarter. (Righini 1974, p. 76; Righini 1978, p. 35)	29.01.1610 (Drake 1976, p. 154)	17.12.1609 h. 05 Padua Mean Time (Whitaker 1978, p. 159) E3
 no. 5	18.12.1609 “Printed by mistake” (Righini 1974, p. 76) “Infortunio editoriale” (Righini 1978, p. 35)		

[4] Whitaker’s numbering of images (E1, E2, E3, E4) of the Moon published in *Sidereus Nuncius* was different from that one of Righini (no.1, no. 2, no. 3, no. 4, no. 5) who numbered the images as in the sequence given by Galileo. Whitaker reversed no. 3 and no. 4.

Whitaker could therefore state: "I believe, therefore, that Galileo did not record the effects of the libration in latitude" (Whitaker 1978, p. 164).

A. Righini revised G. Righini's dates, using the JPL Horizon project website and the Stonyhurst disc, and corrected the date provided by G. Righini of the first image of the *Sydereus Nuncius* from 2 October 1609 to 1 January 1609, with a mean absolute error of 2.5% in unit of lunar diameter. A so little error means, according to the author, that Galileo's images were accurate enough to perform measurements on them and, contrary to what Gingerich claimed, they were not just attempts to give the idea of mountains and plains (Righini 2009, pp. 10-11; Righini 2010, p. 30).

8. Conclusions

Righini was the first, and probably the only one, who dated Galilean images of the Moon with purely astronomical methods and detected in them the phenomenon of the libration in latitude. Gingerich, Drake and Whitaker credited him for this pioneering research, but Whitaker's dating is what is eventually recognized as the definitive one. But, as we have seen, Righini, to date images no. 2 and no. 3, claimed that Galileo had reported, unknowingly, lunar libration. Gingerich, Drake and Whitaker rule out that Galileo could have drawn libration in latitude. But if we look at Tab. 4 we realize that the dates given by Righini, except for the date of the first observation, are quite close to those given by Whitaker and considered definitive. In fact, Whitaker stated:

> Righini concludes that Galileo recorded, but did not notice, the Moon's libration in latitude from the positioning of this large crater in E2 and E4. This certainly agrees with the libration data. But what if that crater had not been common to the two drawings? (Whitaker 1978, p. 164).

Ultimately, Whitaker argued that the agreement between the data provided by Righini and the ones of libration in latitude was purely coincidental. In the following years the problem was no longer addressed, a part some exceptions, by either astronomers or historians of astronomy.

Bibliography

Classen, J. (1969). "The first Maps of the Moon", *Sky and telescope*, 37, pp. 82-83.

Drake, S. (1976). "Galileo's first telescopic observations", *Journal for the History of Astronomy*, 7(3), pp. 153-168.

Drake, S. (1979). "Éloge. Guglielmo Righini", *ISIS*, 70, pp. 552-554.

Gingerich, O. (1975). "Dissertatio cum Professore Righini et Sidereo Nuncio", in Bonelli Righini, M.L. & Shea, W.R. (eds.) *Reason, Experiment, and Mysticism in the Scientific Revolution*, Proceedings of the Symposium held in Capri in April 1974. New York: Science History Publications, pp. 77- 88.

Gingerich, O. & Van Helden, A. (2003) "From Occhiale to printed page: the making of Galileo's Sidereus Nuncius", *Journal for the History of Astronomy*, 34, pp. 251-267.

Kopal, Z., Klepešta, J. & Rackam, T.W. (1965). *Photograhpic Atlas of the Moon*. NewYork and London: Academic Press.

Kopal, Z. & Carder, R.W. (1974). *Mapping the Moon. Past and present*. Dordrecht: Springer-Science+Business Media.

Righini, A. (2009). "Sulle date delle prime osservazioni lunari di Galileo", *Giornale di Astronomia*, 35(3), pp. 7-12.

Righini, A. (2010). "The telescope in the making, the Galileo first telescopic observations" in Barbieri, C. *et al.* (eds), *Galileo's Medicean Moons: their impact on 400 years of discovery*. Cambridge:

Cambridge University Press, pp. 26-32.

Righini, G. (1970). “Zdneck Kopal: An introduction to the study of the moon (Recensione)”, *Memorie della Società Astronomica Italiana*, 41, pp. 145-146.

Righini, G. (1975). “New light on Galileo’s Lunar observations”, in Bonelli Righini, M.L. & Shea, W.R. (eds.) *Reason, Experiment, and Mysticism in the Scientific Revolution*, Proceedings of the Symposium held in Capri in April 1974. New York: Science History Publications, pp. 59-76.

Righini, G. (1978). “Contributo alla interpretazione scientifica dell’opera astronomica di Galileo”, *Supplemento agli Annali dell’Istituto e Museo di Storia della Scienza*, 2, pp. 5-110.

Shea, W.R. (1974). “Introduction: Trends in the Interpretation of Seventeenth Century Science”, in Bonelli Righini, M.L. & Shea, W.R. (eds.) *Reason, Experiment, and Mysticism in the Scientific Revolution*, Proceedings of the Symposium held in Capri in April 1974. New York: Science History Publications, pp. 1-17.

Tucci, P. (2022). “The Moon’s ashen light and libration in Leonardo and Galileo”, *Quaderni di Storia della Fisica*, 26(1), pp. 21-60.

Whitaker, E.A. (1978). “Galileo’s lunar observations and the dating of the composition of “Sidereus Nuncius”, *Journal for the History of Astronomy*, 9, pp. 155-169.