Franz von Paula Gruithuisen and the discovery of the polar spots of Venus

Richard Baum

From a series of observations extending over thirteen years, the distinguished director of the Milan Observatory, G. V. Schiaparelli (1835–1910), announced early in 1890 that Venus was locked in synchronous rotation. In other words it spun on its axis in the same interval of time as it took to complete one revolution of its orbit, namely 224.70 days.[1] It was a shock result that broke the regime of terrestrial analogy imposed by the elder Cassini in 1667.[2] Nevertheless it was well-grounded, and any qualifying doubts were finally removed by a fresh determination in July 1895.[3]

Convinced earlier observers had been misled in their attempt to determine the rate of axial spin, Schiaparelli had sought and found what seemed to be sure anchorage in a configuration of markings near the southern horn. This was discovered in 1813 by the German astronomer Franz von Paula Gruithuisen (1774–1852), who concluded it to represent the polar snow cap. As rendered by Schiaparelli it consisted of two luminous patches, which appeared as if 'separated by a sharp dark shadow, such as would be thrown on a valley dividing two mighty systems of elevation.'[4]

E. M. Antoniadi (1870–1944) the Greek-born French astronomer, did not share Schiaparelli's confidence in the cusp caps. As he remarked in the *Monthly Notices of the Royal Astronomical Society,* March 1898:

'White cusp spots... have been repeatedly seen, especially by Trouvelot. But the superior brightness of the limb, to which Sir William Herschel called attention in 1793, can satisfactorily account for them by stopping in the vicinity of the cusps the darkness along the terminator. Supposing, however, for one moment that [the polar spots] are real, then analogies with the planet *Mars* would lead us to consider them as snow caps, *dimmed* in the case of *Venus* by the atmospheric effect. But the presence of snow caps on *Venus* would obviously be the *coup de grace* to the 224d.70 rotation period. The snow on the illuminated hemisphere of a planet presenting always the same face to the Sun would not confine itself to a cap, but would rather distribute itself along the terminator. It is, then, evident from our reasoning that the foundations of the 224d.70 rotation period of *Venus* are delicate. The markings on which it rests would seem to be contrast effects arising from solar illumination.'[5]

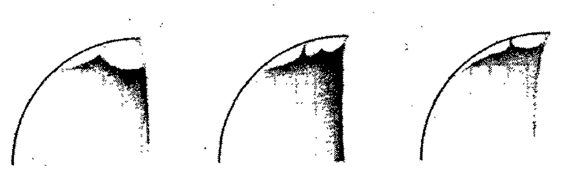

Figure 1. The South Polar Hood of Venus in 1956. Left to right: March 28, April 16, April 18. Drawings by R. M. Baum, 4.5 inch refractor, ×100.

Antoniadi reaffirmed his doubts in 1934, following further studies of Venus with the great refractor at Meudon.[6] But already the pendulum had swung against him. At the exceptionally favourable elongation of June 1927 Venus was photographed in the ultraviolet by Frank Elmore Ross with the 60- and 100-inch reflectors at Mount Wilson Observatory. His images gave credence to many of the features described by visual observers, most notably the polar brightenings.[7]

Scepticism evaporated and today they rank among the most frequently observed features on the planet (see Figure 1), and are known to correspond to the very bright polar cloud swirls imaged in the UV by the space probes *Mariner 10* and *Pioneer Venus*. Given the notorious difficulties experienced by visual observers of Venus it is not irrelevant to recall how Gruithuisen came to discover them.

Franz von Paula Gruithuisen

Gruithuisen, the lynx-eyed observer of the Moon and the planets who clouded his reputation with fanciful advocacy of a plurality of inhabited worlds, was born in the romantic setting of Haltenberg Castle, near Kaufering am Lech, Bavaria, on 1774 March 19, where his father was employed as a falconer by the Elector of Bavaria. Money was short, and his education limited to a meagre training in surgery.[8,9] At 14 he saw service as a field surgeon in the Austro–Turkish War. What effect that experience had upon him can only be imagined. But his detachment and intellectual strength can be surmised from his future activities. A year or so later, we find him, window thrown open to the night, inspecting the craters of the Moon. For in an autobiographical aside he tells us that while employed as a servant at the court of the Elector Karl-Theodor in Munich, he obtained his first small telescope, and by his eighteenth year had, 'readily located... all the features that appeared in Hevelius's and Riccioli's charts.'[10]

Already Gruithuisen's abilities had attracted patronage and in 1801 he enrolled as a medical student at Landshut University. Seven years later, having graduated as a 'Doctor of General Medicine', he became a staff member of the Landarztlichen Schule, Munich, where he lectured on physics, chemistry, anthropology and zoology. Gruithuisen eagerly accepted the challenge of this 'splendid multiplicity', and as a young faculty member was extremely busy. In addition to his lectures, he wrote prolifically on a wide range of subjects.[11] For sheer intellectual energy

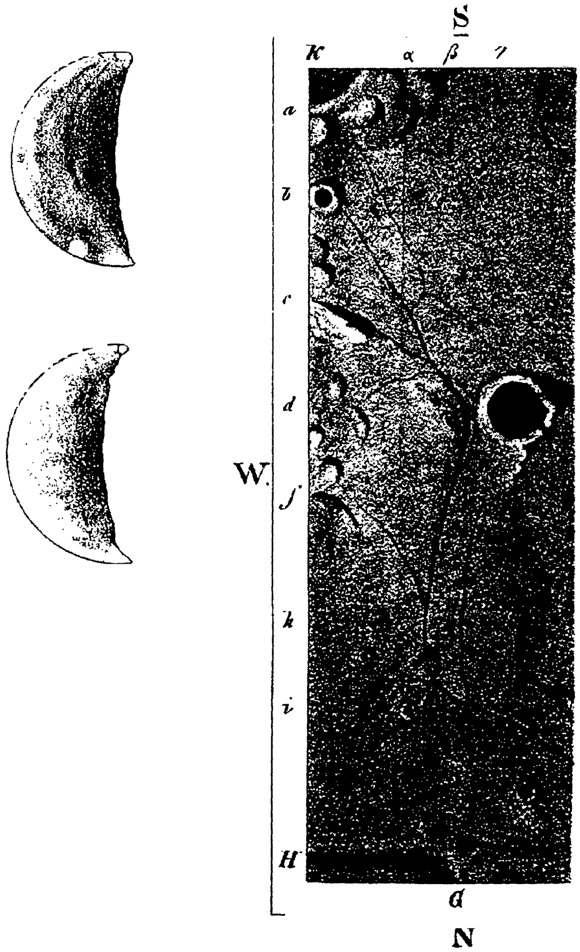

Figure 2. Venus and the Triesnecker cleft system on the Moon, drawn by Franz von Paula Gruithuisen using a 2.5 inch OG ×135 and ×172. Venus upper: 1813 December 29; lower: 1814 January 14. From *Astronomisches Jahrbuch.... Himmelsforscher und Geologen*, 1842.

he had few rivals. In 1826 Gruithuisen, the physician, became professor of astronomy at the University of Munich.[12]

The subject had fascinated him as a boy, but it was the great comet of 1811 that really awakened his interest, and resulted in his first astronomical publication.[13] A year later he purchased two tiny Fraunhofer achromatic refractors, of which the larger was but 2.4 inches in aperture.[14] Having thus equipped himself, and observing from his Munich home, he very quickly surpassed the lunar discoveries of Schroeter, adding dozens of new rilles to the handful already known, in addition to fine detail on the floors of the craters Archimedes and Plato.[15] Gruithuisen's rendition of the delicate Triesnecker rille system accompanying this note is taken from his *Jahrbuch* for 1842 (see Figure 2). The most significant of his early observations however, was his discovery of the bright polar hoods of Venus.

The polar hoods discovered

'I should not have discovered them,' Gruithuisen reflected in 1842, 'had I not had the small 1½ foot refractor with me on 29 Dec., 1813.' In this instrument, between 3 and 4 o'clock, with the planet at culmination, he noted the somewhat swollen appearance of its southern horn. 'It was this that led me to the discovery of the polar spots,' he tells us. Switching to the larger refractor at a power of ×135, he saw two very small round bright spots near the southern horn. A similar spot in the vicinity of the north pole gave the impression of being an actual projection (see Figure 2). 'Around 5 in the afternoon the north polar spot was more distinct than it had been two hours earlier, while at the south pole the bright spot no longer showed as two distinct parts.'[16] That same month, on the 30th and the 31st, the south spot was again clearly seen. On January 3 it looked oval, indeed just like the polar caps of Mars. A single spot was visible on the 14th. Little more than a month later, at 3 o'clock in the afternoon of February 21, the hood was 'divided into two small, distinct points of light', while on July 25 of that year he 'saw with the 1½ foot refractor the south polar spot just as it had first appeared.'[17] Variations in size and shape were frequently noted, as on 1820 November 22, when at 0730 a.m. he found 'the polar spots smaller than days before.'[18]

Of course, it is possible Francesco Bianchini (1662–1729)[19] and Johann Hieronymous Schroeter (1745–1816) pre-empted the discovery in their studies of the planet but confused the hoods with the brightness of the limb light. Gruithuisen himself considered this possibility: 'I myself made the objection that the limb of Venus shines so brilliantly, that the bright polar spots were probably no more than this limb light extended on to the poles. But I resolved my doubts as follows. As often as Venus stood low near the horizon at twilight the limb light appeared yellow like the Moon, while the polar spots, always remained brilliant white; also, with higher elevation of the planet, the limb light failed to approach the brilliance of the polar spots, further the polar spots were not seldom seen to be clearly bounded..., and finally, the limb light was most brilliant at the equator and actually fell off toward the poles (as is also observed on Mars).'[20]

Further observations

From their brilliance and immobility Gruithuisen concluded the spots were truly polar, and by continued observation attempted to determine the planet's axial tilt. Schroeter had suspected a considerable inclination of the equator, and gave a range of values between 10° and 40°. But as Gruithuisen noted, that left room for considerable uncertainty, 'especially if one takes account of his later determinations in his supplement to the *Aphroditographische Fragmente* (sections 7–9, pp. 14–21).' Faced with this dilemma, Gruithuisen explained: 'I referred to my own observations of Venus, and in particular to those which relate to the visibility, position, and extent of the bright polar spots of the planet. To my great satisfaction, I concluded that the midpoint of the polar spots is never found beyond a line that is at most 15° outside of a line drawn between the horns, and it follows that the inclination of the equator of

Venus relative to the plane of its orbit must be approximately the same.'[21]

He considered this result to be far more reliable than Schroeter had inferred from his observations of 'the hazy dark atmospheric streaks'. Thus, Gruithuisen concluded, Venus must have seasons not unlike those of the Earth. (A fact that induced one of his notorious flights of fancy, and which therefore has no place within the context of this note.) Although he thought the spots marked the poles of the planet, he did so only by analogy with the Earth and Mars. It was not until 1962 when *Mariner 2* visited Venus, and it became possible to measure the axial tilt of the planet, that their true character really became evident.

One of the earliest arguments in favour of rejecting the spots as illusion focused on their relative prominence in small telescopes. Antioniadi especially was highly sceptical about this. The matter did not escape Gruithuisen. On 1821 November 27 he reported that: 'I attempted to investigate whether the bright polar spots were more readily recognised in small or large telescopes. I therefore looked at Venus with 5 foot, 2½ foot, and 1½ foot refractors, and found that the polar spots were more easily seen in the smallest telescopes than in the largest. This led me to suspect that this was the reason earlier observers had failed to discover them, despite having larger telescopes with powerful light grasp. In general such telescopes, because of the indistinctness of their images, hardly serve to reveal subtle differences of shade.'[22]

Here Gruithuisen hints that sensitivity rather than visual acuity is paramount in the visual study of Venus. Percival Lowell made the same point in a 1905 lecture, while in 1961 Audouin Dollfus stated: 'The observation of the shaded regions on Venus does not depend on the telescopic resolving power in the same critical manner as that of contrasty planetary or lunar detail; instead, telescopic and seeing conditions are desired that result in maximum contrast.'[23]

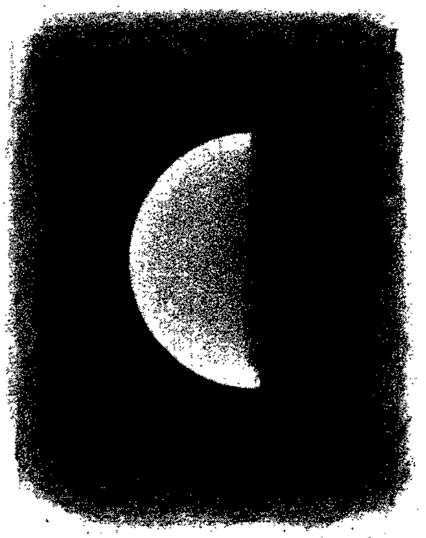

Figure 3. A typical small telescopic view of Venus, 1993 January 14, 1730 UT. 63mm OG ×140. Seeing Antoniadi IV. *E.T.H. Teague, Chester*

In 1842 Gruithuisen wrote: 'I find that spots were seen sometimes at both poles, at other times at one pole alone.'[24] Here again he anticipated modern discovery. Compare that observation with what Dollfus concluded in 1973: 'The *Mariner 10* pictures represent a configuration in which the two polar areas appear bright. Though this pattern has often been recorded during past years, it does not at all represent a typical permanent situation.'[25] Just what this implies has yet to be determined, but Gruithuisen's observations made as they were with tiny refractors suggest a partial reconciliation between low resolution historical data and modern UV photographic findings, a possibility that could have important consequences for long term studies of the dynamics of the Venus atmosphere.

The afterglow

Obviously Gruithuisen deserves better than he is usually accorded. Today there is much discussion about objectivity in observation and the subordination of observation to theory. It is therefore surprising to note how well his observations compare with the reality, especially when we consider his highly coloured response to what he saw. Moreover his skilled use of small apertures cannot be doubted. His observations of the Moon and of Venus are models of accuracy and clarity. His interpretations may have been works of pure fantasy. Yet remarkably, they do not scar the visual record as in the case of Percival Lowell, W. H. Pickering and others. There is no 'city in the moon' as he believed he saw in 1822, no snow on Venus or ritual bonfires to illuminate its dark side. But the phenomena that elicited such fancies do exist and may be verified by anyone willing to look. 'That peculiar Gruithuisen' as he was pigeonholed by Olbers, may have been an anachronism. His chatter too may have irritated Gauss, but it was far from idle.

Acknowledgements

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Address: 25 Whitchurch Road, Chester CH3 5QA

References and notes

1 Schiaparelli G. V., *Rendiconti del R. Istituto Lombardo* série II, **23** (1890). Translated into French by F. Terby, *Ciel et Terre,* **11,** 49–62, 125–143, 183–190 and 259–269 (1890–91)

2 Giovanni Domenico Cassini (1652–1712) founded a dynasty of astronomers. Professor of Astronomy at Bologna where on the basis of some uncertain observations in 1666–67 he made the first attempt on the rotation period of Venus, concluding it to be about 23 hours in length. Sixty years later, in 1726, Bianchini at Rome increased this to 24d 8h. But in 1742 Cassini's son demonstrated that both data sets were consistent with a rotation of 23h 20m. After nine years of patient watching J. H. Schroeter verified in 1788 the periodical return of a marking at intervals of 23h 28m, a value modified to 23h 21m 22s by De Vico at Rome, 1839–41. These values have two things in common. First, they were almost certainly influenced by terrestrial analogy, and second, in each instance deduced from the supposed movement of markings of dubious character. There is confusion in the popular descriptive literature about Cassini's determination, see Baum R. & Sheehan W., *J. Hist. Astron.,* **23,** 299–301 (1992)

3 Schiaparelli G. V., *Astron. Nachrichten,* **138**, 3304, cols. 249–252 (1895). See also letter from Schiaparelli in *Bullétin de l'Acad. Roy. de Belgique,* 3rd series, **30**, 204–205 (1895)

4 Clerke E. M., *The Planet Venus* (London 1893), p. 34

5 Antoniadi E. M., *Mon. Not. R. Astron. Soc.,* **58**, 313–320: 314–315 (1898). He first criticised Schiaparelli's results in *J. Brit. Astron. Assoc.,* **7**, 43–46 (1897). Herschel wrote: 'With regard to the cause of this appearance [limb brightening], I believe that I may venture to ascribe it to the atmosphere of Venus, which, like our own, is probably replete with matter that reflects and refracts light copiously in all directions. Therefore on the border, where we have an oblique view of it, there will of consequence be an increase of this luminous appearance.' *Phil. Trans.*, **lxxxiii**, 201–219: 218 (1793). For Trouvelot's important memoir see *Bull. Soc. de Astron. France,* **6**, 61–147 (1892)

6 Antoniadi E. M., *J. Brit. Astron. Assoc.,* **44**, 341–347 (1934)

7 Ross F. E., *Astrophys. J.,* **68**, 57–92 (1928). A landmark work.

8 Gruithuisen's success was primarily due to his keen sight, an advantage he took every precaution to retain: 'In the matter of visual acuity, I have known only one, now no longer living, who was my equal. As a rule, a third need a telescope twice as powerful in order to see features as fine or as numerous as I can see, not least, perhaps, because I take every dietary measure to protect my eyes, and always shield them from dust and wind.' Gruithuisen, 'Entdeckung vieler deutlichen Spuren der Mondbewohner, besonders eines colossalen Kunstgebaudes derselben' (The discovery of many evidences of Lunar inhabitants, in particular a colossal artificial structure built by the same). *Archiv fur die gesammte Naturlehre,* ed. K. W. G. Kastner (Nürnberg, 1824), vol. 1, 129–171, 257–322

9 An adequate biography of Gruithuisen has yet to be written. However it would be a daunting task. Gruithuisen was prolific and disparate in his literary output. Even the production of a bibliography presents major obstacles.

10 Gruithuisen F. von P., *op. cit.* (ref. 8) 257–322: 309n

11 For some account of German academic life and expectations of this time see Heinrich von Treitschke, *History of Germany in the Nineteenth Century,* ed. Gordon A. Craig (University of Chicago Press, 1975), p. 63.

12 In June 1825 he left Munich for an extended tour of Northern Germany. When he returned in September 1826 he found the university at Landshut had been amalgamated with the Munich Academy. Seemingly King Ludwig I of Bavaria aimed to create a centre for the scientific life of Catholic Germany in the way Berlin was for the Protestant North. Gruithuisen who had turned down offers from the universities at Breslau and Freiburg, accepted the post of professor of astronomy at Munich. He was relieved of all administration and concentrated on research.

13 Gruithuisen F. von P., *Ober die Naturder Kometen mit Reflexionen auf ihre Bewohnbarkeit und Schicksale, bei Gelegenheit des Kometen von 1811* (Munich, 1811). Short title *On the Nature of Comets.*

14 In 1812 Gruithuisen purchased from Fraunhofer two small achromatic refractors of 18 and 30 inches focal length. He later bought one of 60 inches focal length.

15 Schroeter always depicted the floors of the lunar craters Archimedes and Plato as completely uniform. On the former Gruithuisen found 'four to eight small bright elevations,' and five on the latter. These were probably craterlets.

16 Gruithuisen F von P., *Astronomisches Jahrbuch fur physische und naturhistorische Himmelsforscher und Geologen mit den fur das Jahr 1842 vorausbestimmten Erscheinungen am Himmel* (Munich, 1842), p. 155. Hereafter *Astron. Jahr. phys. naturhist.* 1842. See also his article on Venus in *Neue Analekten fur Erd und Himmels Kunde,* vol. 1, 4, 40–55 (1833), hereafter *Neue Anal. Erd. und Himmels.* His observations of the polar spots were first published in 'Physikalisch-Astronomische Beobachtungen,' *Nova Acta Physico-Medica Academiae Caesareae Leopoldino Carolinae Naturae Curiosorum* (Bonn, 1821), **X,** 239–256

17 Gruithuisen F. von P., *Astron. Jahr. phys. naturhist.* 1842, 155

18 *ibid.,* 154

19 *ibid.,* 155–56, footnote. Gruithuisen on Bianchini: 'The drawings of Bianchini show the polar spots dark, so there is no proof that he ever saw the bright spots; only if in his representations he substituted black for white, which is not seen in Schroeter's communication. Moreover one of Doppelmeyer's planetary charts shows that dark spots were designated by Bianchini as maria – thus the polar spots were given the names Mare boreum s. Marci Poli and M. austr. s. Magellanicum, in the same great and important manner as the equatorial spots... the rest of his spots are not at all of the type actually seen on the planet, and his rotation period of 24 days 8 hours is equally false.'

20 *ibid.,* 156–157

21 Gruithuisen F. von P., *Neue Anal. Erd. und Anal.,* 42

22 Gruithuisen F. von P., *Astron. Jahr. phys. naturhist.*, 1842, 155–56, footnote

23 Dollfus A., in *The Solar System, Vol. iii, Planets and Satellites,* edited by G. P. Kuiper and B. M. Middlehurst (University of Chicago Press, 1961), 552. The detection of fine detail on the Moon, Mars and Jupiter depends critically on sharpness of vision. This does not apply in the case of Venus where the markings are very elusive and more certainly glimpsed by averted vision. Interestingly De Vico at Rome (1839–41) reported the most successful observers were those who had difficulty in spotting minute companions to bright stars. There is also evidence to suggest that some observers may be unusually sensitive in the ultraviolet and near infrared. See Baum R., *J. Brit. Astron. Assoc.,* **103**, 171–176: 171 (1993), and ref. 6

24 Gruithuisen F. von P., *op. cit.* (ref. 17)

25 Dollfus A., *J Atmos. Sci.,* **32**, 1060–1070: 1067 (1975)

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