The Clash Between William Herschel and the Great German 'Amateur' Astronomer Johann Schroeter

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Abstract A distinction will first be made between the terms 'amateur' and 'professional' astronomer in the late eighteenth and early nineteenth century. William Herschel, who began his career as a musician but became a salaried employee of the British Crown, clashed metaphorical swords for many years with Germany's greatest amateur astronomer, Johann Schroeter. Each possessed the largest telescope in England and Germany, respectively. Schroeter began in the 1780s by purchasing telescopes made by Herschel, but his larger instruments were eventually made in Germany. Herschel began using his 20-foot telescope in 1783, but it would be another decade before Schroeter had a comparable instrument.

After briefly reviewing their correspondence from 1783 to 1804, their disagreements will be surveyed. These include very different measures of the diameter of Mars, and Herschel's critique of Schroeter's lunar, Venusian and Saturnian work. Their very different world views, as revealed by their telescopes, was the subject of a book by August Gelpke. Nowhere were these world views in starker juxtaposition than in their observations of and conclusions about Ceres and Pallas. They measured diameters in the same way, but came up with very different results. Schroeter also made a claim for a vast atmosphere around the objects, that caused variations in their light. These dual issues caused controversy and consternation among the entire astronomical community, and critiques from Carl Gauss, Wilhelm Olbers and Giuseppe Piazzi are noted. Schroeter's rejoinder to the diameter measurement debate is also given. Finally, Herschel and Schroeter clashed about the very nature of Ceres and Pallas. The former named them 'asteroids,' but Schroeter explicitly stated that they were planets, not asteroids.

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1 Introduction

By the late eighteenth century the divide between amateur and professional astronomers was becoming more clearly defined, although gray areas still existed. If one defines a professional astronomer as one employed at a state-run or university-run observatory, the list would include the following: Johann Bode (Berlin), Franz von Zach (Gotha), Nevil Maskelyne (Greenwich), Giuseppe Piazzi (Palermo), Barnaba Oriani (Milan), Joseph-Jerome Lalande (Paris), Marcin Poczobut (Vilnius) and Jan Sniadecki (Cracow).

Notable amateurs, namely those who operated their own observatories, included Friedrich von Hahn, Gottlieb Schrader, Heinrich Wilhelm Olbers and Ferdinand von Ende (all in Germany), and the Duke of Marlborough and Hans von Bruhl (in England). Straddling the divide was William Herschel (1738–1822; Fig. 1) who received funds from the state as the Court Astronomer to King George III of Great Britain, but who retained some independence by manufacturing telescopes for profit (see Cameron 2012), and making observations from his own property (Spaight 2004). In Germany, Johann Hieronymous Schroeter (1745–1816; Fig. 2) also drew

Fig. 1 William Herschel (en.wikipedia.org)

Fig. 2 Johann Schroeter (commons.wikimedia.org)

a salary in his position as a Government official (he was the Chief Magistrate of Lilienthal), but unlike Herschel’s situation, his job was not related to astronomy. Thus, Schroeter may fairly be said to fall under the classification of an amateur astronomer, while Herschel may be classed as a professional astronomer.

2 The Telescopes of Herschel and Schroeter

By the size and power of the telescopes they possessed, Herschel and Schroeter obtained insights into the heavens that other astronomers of the age were unable to achieve. Their often contradictory observational results were reported in the journals and magazines of the day, and quoted as the most reliable data well into the nineteenth century (Hughes 1994) in everything from scientific journals to popular novels, including the work of Jules Verne (1865).

There were many parallels between the lives of William Herschel and Johann Schroeter. Both were German-born, and knew from their childhoods the meaning of penury. Both had a passionate fondness for music, and each enjoyed the tender care of a devoted sister. Each had command of the greatest telescope of his own country. Both were experts at mechanical contrivances; each was supremely energetic, patient, industrious and conscientious (Cunningham 2007).

Herschel began work with his 20-foot telescope (18.7-in mirror) in 1783, and used it (Fig. 3) for most of his observations, including the first scientific studies of Ceres and Pallas in early 1802. Herschel actually made Schroeter’s first telescope, which was obtained through his brother, Dietrich Herschel, in 1779. In 1782 Schroeter bought two mirrors from William, with diameters of 4.7 and 6.5 inches. Immensely proud of the 7-foot telescope he made with the 6.5-inch, Schroeter (1788) devoted 55 pages to a description of it. Although quite modest by modern standards, it was the largest telescope in Germany at the time (Gargano 2012).

It was not until 1793 that Schroeter had a telescope to rival the one Herschel used. Although this 27-foot instrument had a mirror of 19.2 inches, it was a smaller 13-foot telescope with a 9.5-inch mirror that he employed to study Ceres and Pallas in 1802 (Leue 2002).

3 Correspondence Between Herschel and Schroeter

The Herschel Archives in the Royal Astronomical Society in London holds the extant correspondence between Schroeter and Herschel. Some of these letters, such as one dated 2 May 1792 (see Sect. 6.1 below), were written by Herschel to Schroeter, a copy having been made for Herschel’s own records. Schroeter’s own papers were destroyed long ago (Baum 1991; Denning 1904), so most of the existing correspondence is one-sided. The letter discussed in Sect. 6.3 was sent by Schroeter to Baron George Best (13.S.47). This begins with a cover letter from Best to

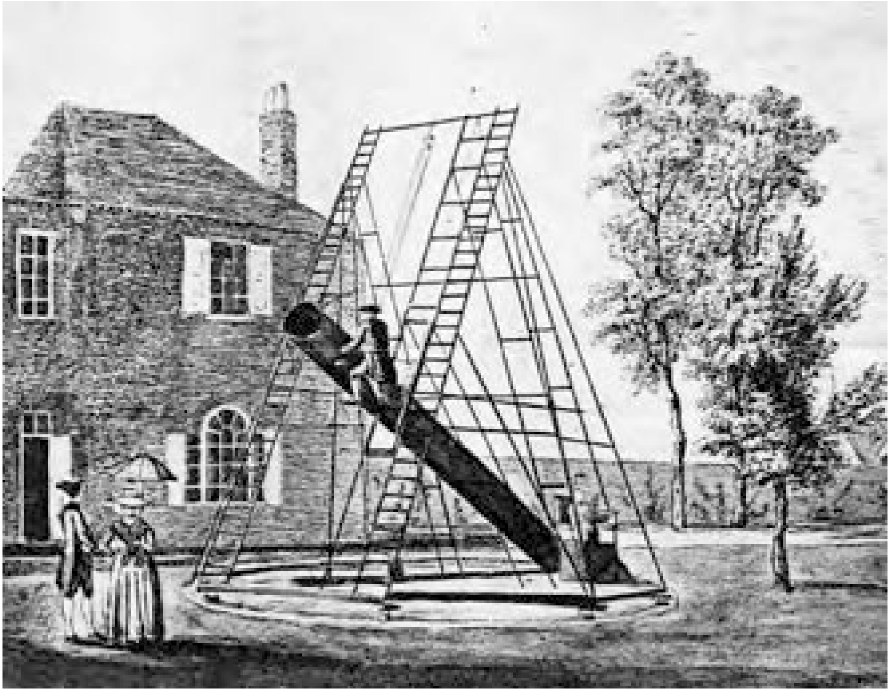


Fig. 3 Herschel's 20-foot telescope on the grounds of his residence at Slough, near Windsor (courtesy: Royal Astronomical Society Library)

Herschel dated 22 September 1804; what follows is a 2-page letter by Schroeter dated 11 September 1804. It is rendered in English by Best, and includes a page of positional data on Juno dating from 1 through 10 September 1804.

The letters are designated in the Archives as Herschel W. 1/13. S. 12–48, and listed in the official index as follows:

2 February 1783, 13.S.12; 27 February 1783, 13.S.13; 31 July 1783, 13.S.14; 14 January 1784, 13.S.15; 17 July 1784, 13.S.16; 27 October 1784, 13.S.17; 7 February 1785, 13.S.18; 1 June 1785, 13.S.19; 20 July 1785, 1, pp. 136–38; 29 August 1785,13.S.21; 12 September 1785, 13.S.20; 14 September 1785, 13.S.22; 29 October 1785, 13.S.23; 22 November 1785, 13.S.24; 24 January 1786, 13.S.25; 28 February 1786, 13.S.26; 20 July 1786, 13.S.27; 20/25 December 1786, 13.S.28; [February 1787], 1, pp. 156–57; 12 November 1787, 13.S.29; 2 May 1788, 13.S.30; 18 June 1788, 13.S.31; 15 September 1789, 13.S.32; 31 January 1790, 13.S.33; 12 May 1791, 13.S.34; 8 June 1791, 13.S.35; 16 December 1791, 13.S.36; 2 May 1792, 1, pp. 191–92; 16 September 1792, 13.S.37; 10 August 1793, 13.S.38; 20 August 1793, 1, pp. 195–96; 29 November 1793, 13.S.39; 4 January 1794, 1, pp. 198–99; 30 September 1796, 13.S.42; 30 March 1797, 13.S.43; a note concerning a letter of 22 May 1802, 1, p. 249; 30 October 1802 (attribution uncertain), 13.S.59; 12 February 1803, 13.S.45.

13.S.40, 13.S.41, and 13.S.44 are autograph tracts by Schroeter; another is included with 13.S.29. 13.S.47 is a copy of Schroeter's account of Harding's discovery of the planet Juno, sent to WH by G. Best on 22 September 1804. 13.S.48 is a single page, which is not in Schroeter's hand, but was with his letters.

4 Gelpke's Book About Herschel and Schroeter

The fact that these were the two most celebrated observational astronomers of their day is not in dispute. Their respective and contrasting observations were the subject of a treatise by a teacher at the Collegium Carolinum in Brunswick, August Heinrich Christian Gelpke (1801; 2nd edition 1806). Gelpke (1769–1842; Fig. 4) became Professor of Natural History and Mathematics at the Carolinum in 1821, and authored an important early work in catastrophe theory (Gelpke 1835; cf. John 2004).

In the 1806 edition of his 294-page book (Fig. 5), Gelpke surveyed current astronomical knowledge on many topics including the Solar System and the asteroids, the fixed stars and nebula. Not surprisingly these were the very areas of research that most occupied Schroeter and Herschel. For example, Gelpke duly reported Schroeter's discovery of the rotation period of Venus, and the presence of an atmosphere on the Moon. He also gave other interesting observational results, such as the solar parallax derived from observations of the 1769 transit of Venus.

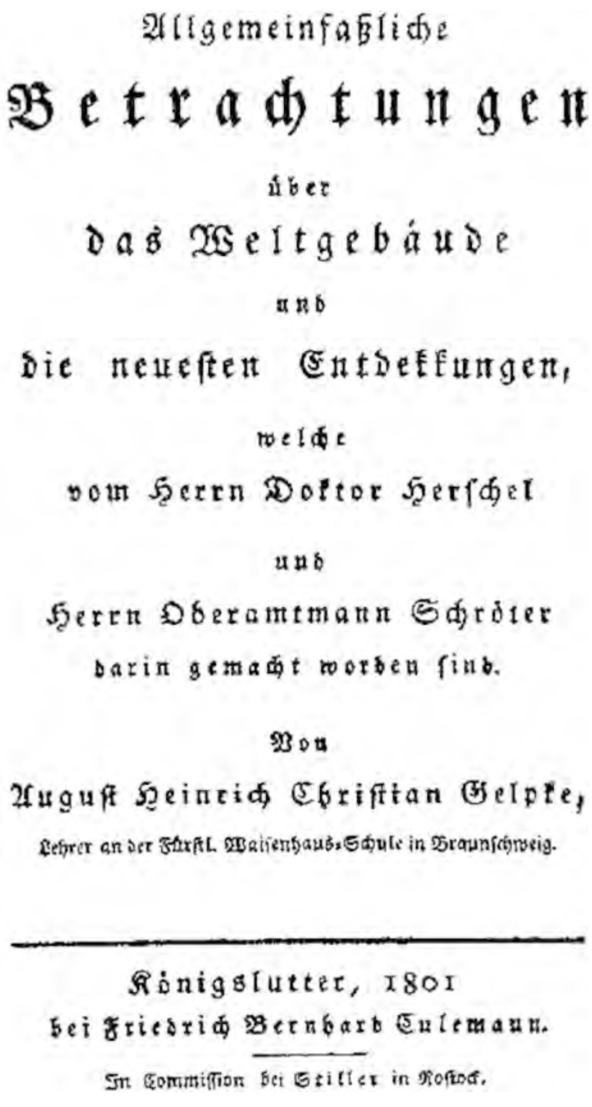
While the book offered no surprises, it was the best contemporary account available for the wider German-reading public about the cutting-edge research being undertaken by Herschel and Schroeter, whose 1805 book on Ceres and Pallas is available in English translation in Cunningham (2001, 2006).

5 Planetary Disagreements

5.1 Mars

As a matter of comparison, it is worthwhile looking at the diameter measurements of Mars made by both men. At the opposition of 1783, Herschel made micrometer observations on three nights and found an equatorial diameter of 9.13″ and a polar diameter of 8.57″. These figures were the first ever proving the oblateness of Mars, the ratio derived being 1:16.3 (Herschel 1784).

Fig. 4 August Gelpke (Braunschweigisches Landesmuseum)


Allgemeinfaßliche
Betrachtungen
über
das Weltgebäude
und
die neuesten Entdekkungen,
welche
vom Herrn Doktor Herschel
und
Herrn Oberamtmann Schröter
darin gemacht worden sind.
Von
August Heinrich Christian Gelpke,
Lehrer an der Fürstl. Waisenhaus-Schule in Braunschweig.

Königslutter, 1801
bei Friedrich Bernhard Culemann.

In Commission bei Stiller in Rostock.

Fig. 5 The title page of Gelpke's 1801 book *General Observations on the World and the Latest Discoveries made by Dr. Herschel and Counsellor of Justice Schroeter* (Cunningham Collection)

Also employing a micrometer, Schroeter observed Mars on 1 and 3 September 1798 when it was near opposition. His figures were 9.84″ and 9.72″, giving an oblateness of 1:81. Schroeter's Martian observations were published posthumously by H.G. van de Sande Bakhuyzen (1881).

In his study of 22 diameter measurements of Mars, See (1901) gives a mean value of 9.67″. He also notes that the filar micrometer is considered to be the best instrument for such a measurement. So we see that Herschel underestimated the diameter of Mars; in fact, of the 22 measurements given by See, Herschel's is by far the smallest, a figure of 9.47″ being the next closest (by Kaiser in 1862–1864).

While Schroeter's measurement is higher than the mean, several others were larger still, with Lowell's 1896 value of 9.92″ being the largest. Schroeter was also closer to the correct figure of the oblateness, the modern figure being 1:500.

Schroeter's observations of the Martian surface led him to conclude that the dark areas were only atmospheric clouds, with changes occurring on time scales as short as an hour. This was despite the fact they were largely permanent surface features. This wholly incorrect interpretation of what he saw through his telescope was more the norm than the exception.

5.2 *Venus, Jupiter and Saturn*

The year 1792 was an important one in the relationship between Herschel and Schroeter, due to some extent to poor translation from German to English, as noted by Lynn (1892). In referring to recent observations of Venus, Lynn wrote:

> No one can read them without being struck by the fact to how great an extent they confirm the observations made by Schroeter a century ago, the accuracy of which was so strenuously contested by Herschel in the 'Philosophical Transactions' for 1793, and reasserted by Schroeter in 1795. My present purpose, however, in referring to this controversy is to point out the danger of trusting *translations* in matters of this kind and the importance of referring in disputed points to the originals. Amongst the observations of Schroeter to which Herschel alluded, in a tone which he must have afterwards regretted, were what he calls "flat spherical forms conspicuous on Saturn." What Schroeter really wrote was "abgeplattete Kugelgestalt des Jupiter und Saturn," meaning flattened spherical shape of the planets themselves, not of markings on them.

The 10 December 1797 letter (13.S.44), translated into English from Schroeter's original (which is not extant), makes the remarkable claim that he had "… discovered dark spots in each of the four satellites of Jupiter." Schroeter also laid claim to seeing very dark spots on Jupiter itself (Dobbins and Sheehan 1997). While these may very well have been real features, the fact that he saw dark spots on the satellites of Jupiter certainly prompts one to question it. Herschel was skeptical, but he confined his thoughts to a private note:

> Mr. Schroeter says that he has seen dark spots in each of the 4 satellites of Jupiter. He says that these spots are of the atmospheric kind.
>
> That these satellites turn on their axes I have shewn from their variation of light; & from the same phenomena I infer that the satellites have spots; but I have never seen spots. (Note dated 1797; Herschel Archives W.7/6; his underlining).

Herschel and Schroeter were clearly at odds about the supposed mountains of Venus (Baum 2007). Schroeter (1792) believed them to be five or six times as high as those on Earth. Before he read Herschel's rather acidic commentary in the *Philosophical Transactions of the Royal Society* of 1793, Schroeter had written quite jauntily to Herschel: "I have good ground for hoping as well as wishing that my observations on Venus will in due course receive confirmation from you as well as from other authorities." (Herschel Archives, 29 November 1793).

It was not to be, for Herschel (1793) wrote: "As to the mountains on Venus, I may venture to say that no eye which is not considerably better than mine, or assisted by much better instruments, will ever get a sight of them." He then goes on in quite scathing terms, but without once mentioning Schroeter by name:

> Even at this present time I should hesitate to give the following extracts if it did not seem incumbent on me to examine by what accident I came to overlook mountains in this planet of such enormous height as to exceed four, five, or even six times the perpendicular height of Chimboraço, the highest of our mountains … The same paper contains other particulars concerning Venus and Saturn. All of which being things of which I have never taken any notice, it will not be amiss to show, by what follows, that neither want of attention, nor a deficiency of instruments, would occasion my not perceiving these mountains of more than twenty-three miles in height, this jagged border of Venus, and these flat, spherical forms on Saturn. (ibid)

So from this time it was made plain that Herschel believed his telescope was the worlds' finest, and that Schroeter was seeing things that could not in fact be seen.

Schroeter (1795) wrote a rather pained rejoinder to Herschel's 1793 paper, asserting that it "… contains unreserved assertions, which may be easily injurious to the truth, for the very reason that they have truth for their object, and yet rest on no sufficient foundation."

Even though both men accepted the existence of a Venusian atmosphere (Baum 2010), the rotation period of Venus was another bone of contention between them. Schroeter accurately measured the period to be 23 hours, 20 minutes, 59 seconds. He further stated that Venus was inclined 75 degrees. Herschel thought the Venusian atmosphere to be opaque, and thus left the question of the rotation period open. Schroeter's rotation period was quoted as fact for many decades, and was even confirmed by Francescoe de Vico (like Herschel, an astronomer and musical composer) from Rome in 1841 (*The Illustrated London Almanack for 1863*, 51)! The correct value of the rotation period is 243 days, making Schroeter's 'precise' value an object lesson in scientific humility.

In 1900 See published a survey of diameter measurements of Venus, where he lists one by Herschel (1807), based on a single micrometer observation, of 18.790″. Based on a four-day study in 1792, Schroeter (1792) derived a diameter of 16.7″. See (1900) gives a value of 16.8″, based on 32 recent measurements made at the U.S. Naval Observatory, and this is almost identical to Schroeter's result.

The somewhat acrimonious exchange between Herschel and Schroeter was not confined to the pages of the *Philosophical Transactions of the Royal Society*, which had a limited scientific readership. It elicited a detailed commentary in the widely-read *The Critical Review …* (1796). Its articles were not signed, so the author of this particular critique of the Venusian book (Schroeter 1796) is unknown. While acknowledging that Schroeters' instruments are the inferior of the two, the writer says Herschel "… has no right to boast of his superior advantages. Dr. Herschel's instruments do not convey to us a proof of his ability to speak decisively on the subject; because the telescope of Schroeter had sufficient powers for all the observations which either party has made upon the planet Venus."

The reviewer considers whether Herschel's 'industry' in observing Venus may give him an advantage. "The number of observations made upon this planet by Dr.

Herschel, bears a very small proportion to the number of those made by his opponent. Consequently, in point of industry, we must acknowledge Mr. Schroeter to be the superior." The article in *The Critical Review* … even claims Schroeter has "… some grounds for his complaints against our astronomer, and he is evidently hurt at the reflections cast upon his observations." It concludes by enjoining Herschel to make more observations of Venus "… to enable us to account for the difference of opinion between him and his brother astronomer."

5.3 The Moon

Schroeter's (1791) book about the Moon (Fig. 6) was a massive 676 pages, with 43 copper plates engraved by Georg Tischbein, a Bremen artist. The publication of the work was paid for by Schroeter himself, and it was this work that made his European reputation (see Sheehan and Baum 1995), even though it was savaged in the British press. One contemporary review said it did not "… give pleasure to the reader: the *grand* fault is want of method; and of this the obvious consequences are confusion, prolixity, and innumerable repetitions." (*The Monthly Review*, 1792, volume 7, 481–487; their italics and underlining). Another used a sarcastic pun, saying that "… it contains no small portion of fanciful description; we will not say the author has altogether become a *lunatic*, but he pretends to a much more political, geographical, and domestic knowledge of the moon, than many of our politicians, geographers, and economists do with their own mother earth." (*The New Annual Register*, 1809, 416–417; their italics).

The book was carefully scrutinized by Herschel, who wrote a full page of notes about it. Even though the manuscript is undated, it was likely written in the mid-1790s (Herschel Archives, misc. papers 7/14). Most of the entries are critical of Schroeter's lunar work:

Page 8 Einleitung. The author mentions my name as one that has given one or two observations on the moon. Has he seen my measures of its mountains?
Page 60 section 24 I do not approve of the division of the light of the moon in 10. Instead of this I substitute given objects under given illuminations.
72 section 32. His way of naming I do not like.
73 Descriptions better than drawings.

Let us now examine each of these individually.

In his first comment, relating to page 8 in Schroeter's book, Herschel wonders if Schroeter had actually read about his lunar observations. This refers to one of his very earliest papers, "Mountains of the Moon," which was read before the Royal Society on 11 May 1780 and subsequently published in its *Philosophical Transactions* (see Herschel 1780).

On page 60 in his lunar book, Schroeter uses a 10-point scale to note the reflectivity of various areas on the surface of the Moon: "The darkest areas = 0; the central grey surfaces = 2; the light grey = 3; usually bright illuminated surface = 4; then far more than usually bright surfaces = 5, 6, 7 and 8; the greatest luminous intensity of

SELENOTOPOGRAPHISCHE

FRAGMENTE

ZUR

GENAUERN KENNTNISS DER MONDFLÄCHE,

IHRER

ERLITTENEN VERÄNDERUNGEN UND ATMOSPHÄRE,

SAMMT DEN

DAZU GEHÖRIGEN SPECIALCHARTEN UND ZEICHNUNGEN,

VON

JOHANN HIERONYMUS SCHROETER

KÖN. GROSBR. UND CHURF. BRAUNSCHW. LÜN. OBERAMTMANNS, DER KÖN. SOC. DER WISSENSCH. ZU GÖTTINGEN CORRESPONDENTEN, DER CHURF. MAYNZ. AKAD. NÜTZL. WISSENSCH. ZU ERFURT, UND DER BERL. GES. NATURF. FREUNDE MITGLIEDS.

Mit 43 Kupfertafeln.

Auf Kosten des Verfassers.
LILIENTHAL bey demselben und in Commission bey CARL GOTTFR. FLECKEISEN,
Universitäts-Buchhändler in Helmstädt.

Gedruckt Göttingen bey JOH. GEORG ROSENBUSCH, Univ. Buchdr. 1791.

Fig. 6 The title page of Schroeter's 1791 book *Lunar Topographical Fragments* (Cunningham Collection)

Proclus = 9; the greatest luminous intensity of Aristarchus = 10.” Herschel takes exception to this, and he also explicitly states that he disagrees with Schroeter’s system of lunar nomenclature, as outlined in section 32. Subsequently, nineteenth century selenologists also found Schroeter’s scheme troublesome:

> In the course of his labours, Schroeter named a very considerable number of different formations, somewhere between seventy and eighty in number, but without any systematic method. In consequence of this he often attached a single name to two or more different formations, usually closely associated, it is true, whilst in other cases he named a region possessing little, if any, natural boundaries, and therefore little suited for the purpose of being named. (Neison 1876: 202)

That the drawings are somewhat lacking also finds confirmation in Neison’s analysis: “Of the minute details of the lunar surface, it may be broadly stated that Schroeter shows nothing.” Was it that Schroeter’s telescopes “… lacked defining power …” as Goodacre (1917) asserted, or did Schroeter simply lack the necessary artistic talent? Nasmyth and Carpenter (1874: 66) comment on this:

> Schroeter was a fine observer, but his delineations show him to have been an indifferent draughtsman. Some of his drawings are but the rudest representations of the objects he intended to depict; many of the bolder features of conspicuous objects are scarcely recognizable in them. A bad artist is as likely to mislead posterity as a bad historian, and it cannot be surprising if observers of this or future generations, accepting Schroeter’s drawings as faithful representations, should infer from them remarkable changes in the lunar details.

As is evident from a letter of 1793, Schroeter was quite frank with Herschel about their disagreements:

> It is to be expected that observers, who have only truth faithfully and eagerly at heart, should publish their observations, even if they give different results, without regard and without reference to persons. Thus will truth prevail, so in my Selenfragmente I have put forward my calculations, which differ greatly from yours, without mentioning yours, though well known to me, or even suggesting the conflict between them. Those who are well acquainted with the subject can then judge for themselves; and truth will not be obscured by partisanship. (29 November 1793; Herschel Archives).

6 The Asteroids

In a contemporary review of Schroeter’s 1805 book about Ceres, Pallas and Juno, the great clash with Herschel was noted at the outset: “The observations themselves, Mr. Schroeter defends against every possible objection, especially against the measurements of Dr. Herschel, which are in strong opposition to them.” (*The Eclectic Review,* 1807, volume 5, part 1, pages 182–183). These “measurements” were contained in a paper read before the Royal Society on 6 May 1802 (Fig. 7), which was the first scientific investigation of Ceres and Pallas (Herschel 1802; Cunningham 1984).

Fig. 7 The meeting room of The Royal Society at Somerset House in London where the papers of Herschel and Schroeter were read and discussed (Cunningham Collection)

6.1 The Diameter Measurements of Ceres and Pallas

Herschel found Ceres to be 161 miles across and showing a disk of just 0.22″. In contrast, Schroeter found Ceres to be 1,624 miles across, showing a disk including an extensive atmosphere fully 6″ across. Herschel found Pallas to be 70 miles across, with a disk somewhere between 0.13″ and 0.17″, while Schroeter found Pallas to be even larger than Ceres, at 2,099 miles in diameter, with a disk of 6.5″, which again included an atmosphere. For comparison, the modern values currently accepted for the diameters of Ceres and Pallas are 590 miles and 326 miles respectively (Hilton 2002).

That Herschel and Schroeter were well aware of each other's methods of measuring the size of celestial objects is apparent in a letter Herschel wrote to Schroeter a decade before the asteroid size controversy erupted. The letter appears to be a rather sarcastic swipe by Herschel, contrasting his 'old' method with Schroeter's 'new' method. Clearly, Herschel was not impressed by Schroeter's claims, either then or a decade later when they used their respective instruments to measure the asteroidal diameters:

> You mention your new Projection's Micrometer; as I suppose that you have undoubtedly taken notice of my camera-eye-piece etc: whereby I project objects on a sheet of paper, upon a wall, upon a measuring scale, upon a set of disks, peripheries, lucid points, draw

images of objects, let the points of a pair of compasses that they will exactly fit into any two holes that a person makes upon a card fixed up at a distance etc. As I suppose you [are] acquainted with all these things I should be glad to know in which respects your new differs from my old Projection-micrometer. (2 May 1792; Herschel Archives; his underlining).

6.2 *Critiques of the Diameter Estimates*

Carl Gauss weighed in on the discrepancy between the Herschel and Schroeter diameter results, as reported by Zach:

> Gauss finds the diameter according to Dr. Herschel's own measurement slightly greater. Dr. Herschel gives on April 22 according to a fairly good observation the diameter = 0″.17; and Dr. Gauss calculated the true diameter 26½ German miles (the distance from earth = 1.562). [A German mile is 25,000 feet, compared to 5,280 feet in an English mile.] In his latest letter he expressed his astonishment about Dr. Herschel's and Dr. Schroeter's different results of the diameters because they were made according to one method. "I am very curious to learn what magnifications Dr. Herschel used. A magnification of 500 times would hardly turn an apparent diameter of 0″.17 into a disc, would it?" I, for my part, could not discern a trace of a disc at 300× magnification of neither Olbers' nor Piazzi's planet [i.e. Pallas and Ceres]. (*Monthly Corres*. August 1802, page 189).

Olbers sided with Herschel, although with reservations:

> The contrast between Schroeter's and Herschel's measurements is most surprising. Just between us, I trust neither of them. I believe Schroeter has included too much spurious light in his measurements, and he would have perhaps found a fixed star to be just as large.- And Herschel? – I mean, the eye could easily be misled in comparing such small dimensions. Even if he enlarged Pallas 500 times it would have appeared to him (according to his stated diameter) only as a 1′ 5″ – diameter disc appears to the naked eye. With such a diameter a disc actually still appears as a point, and whether one of two such small disks appears larger than the other depends only on the brightness of these small disks. The light from Pallas must certainly have become very feeble in the telescope after a 500-times magnification, and hence a probably brighter, though much smaller, disc could still appear as large as Pallas to the naked eye. - Nevertheless, I am convinced that Herschel is much nearer the truth than Schroeter. (Letter from Olbers to Gauss, 14 July 1802; Goettingen Archives; his underlining).

There is a longer section on Schroeter's observations and the critique he received from both Olbers and Gauss in Oestmann and Reich (2001).

6.3 *Schroeter's Rejoinder to the Diameter Controversy*

Schroeter examined Herschel's study of Ceres and Pallas, which he specifically says are "… not asteroids." In his letter to an unknown correspondent in England (possibly his friend Baron George Best), Schroeter makes his case quite forcefully, and begins by an absolute rejection of Herschel's designation of 'asteroid' to denote Ceres and Pallas (Cunningham et al 2009):

> After having read Mr. Herschel's paper on the two new planets (not asteroids) I discovered the reasons for his mistakes in measuring their diameters: Dr. Herschel measured the same way I did but

a) He positioned the projection disc at an immense distance from the eye, from 124 to 178 feet without realising that an illuminated body seen with the naked eye, except for a certain distance appears relatively the larger the farther it is removed from the eye. I made several tests with an identical illuminated disc of 1.2 inches by seeing it with one eye and with the other through a sextant's tube without glass. By this it appeared at a distance of 170 feet 5 times smaller than with the other naked eye. The more I was approaching the larger it became proportionate to that one seen with the naked eye and finally both agreed at eight feet. I changed the eyes; but it was and remained the same. Consequently, Dr. Herschel obtained, since he did not use the greater but the true and much smaller diameter for his calculation, a five times smaller diameter as product.

b) He did not measure, as I did, the nebulosity as well but only the brighter disc. And he used magnifications of 400 to 800, much too great for such a pale and comet-like planet. Due to lack of light and acridity he thus did not distinguish the entire disc with nebulosity but only its brighter centre part which he, as he himself says, saw as a cometary nucleus. Thus he saw the nebulosity's diameter sometimes six to seven times greater than this nucleus, which was not the case with my magnifications. A calculation for his errors produced his diameter of Pallas equally great as I found it. As a test I will soon measure the Georgian planet (Uranus) in the same way and Mr. [Karl] Harding, who is working incredibly eagerly, is writing a little work on it to which he will also attach a chart of the smallest stars of that celestial region which Pallas will pass next year to find it wherever possible. [30 October 1802; Herschel Archives; his underlining].

Was Schroeter correct in saying Herschel did not measure the projection disk properly? Herschel's diameter for Pallas was 70 miles. Applying Schroeter's correction factor of 5 gives a diameter of 350 miles. The actual diameter is 326 miles, very close indeed to the 'corrected' figure. His second point, regarding 'nebulosity' will be considered below in Sect. 6.4.

6.4 Irradiation and Spurious Disks

Herschel and Schroeter differed on the crucial question about the existence of atmospheres surrounding the asteroids. The issues involved can be formalised as an application of probability theory to variative induction. In the following quote from John Stuart Mill (1843), his words "animal or plant" have been replaced for the subject under discussion here by the word "planet":

> If we discover, for example, an unknown planet, resembling closely some known one in the greater number of the properties we observe in it, but differing in some few, we may reasonably expect to find in the unobserved remainder of its properties a general agreement with those of the former, but also a difference corresponding proportionately to the amount of the observed diversity.

This expectation to find properties in the "… unobserved remainder …" led Schroeter, Herschel and others to search for two properties in particular that are associated with the known planets—namely, satellites and an atmosphere. We concern ourselves here with the latter:

> Schroeter has, as he informs me, changed much in his work concerning the new planets based on ideas I had pointed out; I thus hope that you will no longer consider the calculation of the masses, densities, and gravitation at the surface of these small heavenly bodies. The

> determination of these details rests upon a totally erroneous application of an unprovable statement of [Daniel] Melanderhjelm. He had adopted the hypothesis that the planet's atmospheric density at the surface varies as the square of the gravitational force at the surface. Schroeter believed he could conclude the reverse, that the atmospheric density at the surface varied as the height of the visible portion of the atmosphere. For our Earth he adopted, along with La Hire, a height of 38,000 Toisen. Since his telescopic observations gave him the heights of Pallas' and Ceres' atmospheres from 100 to 150 miles, he thus decided on a high atmospheric density at the surface of both planets, and this the same for the gravitational force and density. The result is, e.g., that the density of Ceres is 4½ to 5½ times that of gold, etc.- I pointed out to him (1) that Melanderhjelm's so-called theory merely entails the somewhat strangely expressed theory that the ratio of the mass of the atmosphere of every planet to its total mass is always the same, and thus with every planet it would be about 1/800000 of its mass; (2) that this hypothesis, in itself very improbable, is refuted precisely by his observations of such large atmospheres surrounding such small heavenly bodies; and (3) that the heights of the visible atmospheres could by no means vary just like their density at the surface, etc. Just between us, I can't at all believe that Ceres and Pallas have these large atmospheres. Rather, I assume them to be due to irradiation in the telescope. (Letter from Olbers to Gauss, 4 April 1805; Goettingen Archives; his underlining).

That Schroeter held the belief that the density of Ceres was greater than that of gold is one measure of his credulity. Olbers had written to Gauss about the irradiation matter three years before:

> What kind of small planets are Pallas and Ceres? Herschel found an apparent diameter of Ceres, as Zach writes, of only 1″, and of Pallas, as Bode informs me from LaLande's letter, of only 1½″. In this way, speaking confidentially, irradiation must have interfered with our friend Schroeter's observations. I admit, I have always suspected this; for my very nice 5-foot Dollond, at 240-times magnification, does not even show an appreciable disc for either planet, nor is there a definite difference from a fixed star. (Letter from Olbers to Gauss, 8 May 1802; Goettingen Archives; his underlining).

As Olbers rightly pointed out, the theory upon which Schroeter based his conclusions was faulty. He also rightly identified irradiation as the cause of these unsupportable atmospheres (Oestmann 2002). The subject of spurious disks and irradiation was examined by Cooke (1896):

> Since the spurious disk is brightest at the centre, and really shades off into the dark ring, it is evident that its apparent linear extension will depend very intimately upon the brightness of the star in question, that the spurious disk formed when a bright star is viewed will appear larger than in the case of a dim one, although the maximum size can never amount to as much as the diameter of the first dark ring. To this must be added the effect of irradiation in the case of the brighter stars. As a matter of fact, it is notorious how much smaller the star-disks appear to be in the case of small (ie faint) stars than in the case of bright ones. In all objectives having their focal lengths equal to 15 times the aperture, then the linear diameter of the spurious disk may be said to average 0.0004 inches. With 6 inches aperture this corresponds to an angular diameter of 0.9 seconds, and in a 12-inch aperture to 0.45 seconds.

In his paper on Juno, Herschel (1807) repeatedly observed a disk of around 0.2 seconds of arc, using his 10-foot reflector with a 9-inch aperture [this instrument had a focal length 13.3 times the aperture, close to the 15 times figure used by Cooke]. But he finds a similar disk is apparent when he looks at stars of comparable brightness. He therefore concludes that the disk of Juno is almost certainly spurious, and he assigns no size to the object, merely saying it is also very small.

Herschel draws six corollaries relating to the identification of real or spurious disks, and claims that a real disk as small as a quarter second can be seen and distinguished from a spurious disk by the application of high power in the range of 500–600. If the disk is real, it is seen as a larger disk at high power; if it is spurious, higher power does not reveal a larger disk. This analysis was echoed by Giuseppe Piazzi, the discoverer of Ceres: "I have candidly to confess that I don't see how we could explain the changes in light and magnitude by means of the atmosphere or nebulosity observed by Schroeter. If Ceres can be seen better with less strong telescopes, it is because of the little light it reflects, which diminishes in proportion to magnification." (Piazzi 1802). Thus, Herschel recognized and rejected the very observational result that Schroeter accepted as evidence of extended atmospheres around the asteroids.

7 Concluding Remarks

Herschel's negative critique of Schroeter's work extended beyond the Solar System to the study of nebula. As Forbush (1980) has commented, "Herschel remained unimpressed by Schroeter's originality, and commented in a personal note in 1797 (Herschel MSS, W.7/6): 'Mr. Schroeter says he cannot consider every Nebula a distant Milky Way. I have already proved the same in my paper on Nebulous Stars and mention the Nebula in Orion among others as an instance.'"

Rarely, if ever, have two dedicated observational astronomers with similar instruments, observing contemporaneously, arrived at such disparate results about exactly the same celestial objects. Whether it was Venus (the mountains and the rotation period), the Moon (the best way to denote brightness of surface features, and nomenclature), or Ceres and Pallas (their diameters and atmospheres), the two men 'saw' the bodies of the Solar System in very different ways. Neither was wholly correct, but the judgment of history has given the plaudits to Herschel, and the nod of disapproval to Schroeter (Gerdes 1986).

As Crowe (1986) has correctly discerned, Schroeter was the victim of an insufficiently-developed critical sense: "Like Herschel, he was a pluralist with much imagination; unlike his more famous contemporary, Schroeter never learned that large telescopes and diligent observation are not of themselves sufficient to transform an amateur into a professional astronomer."

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