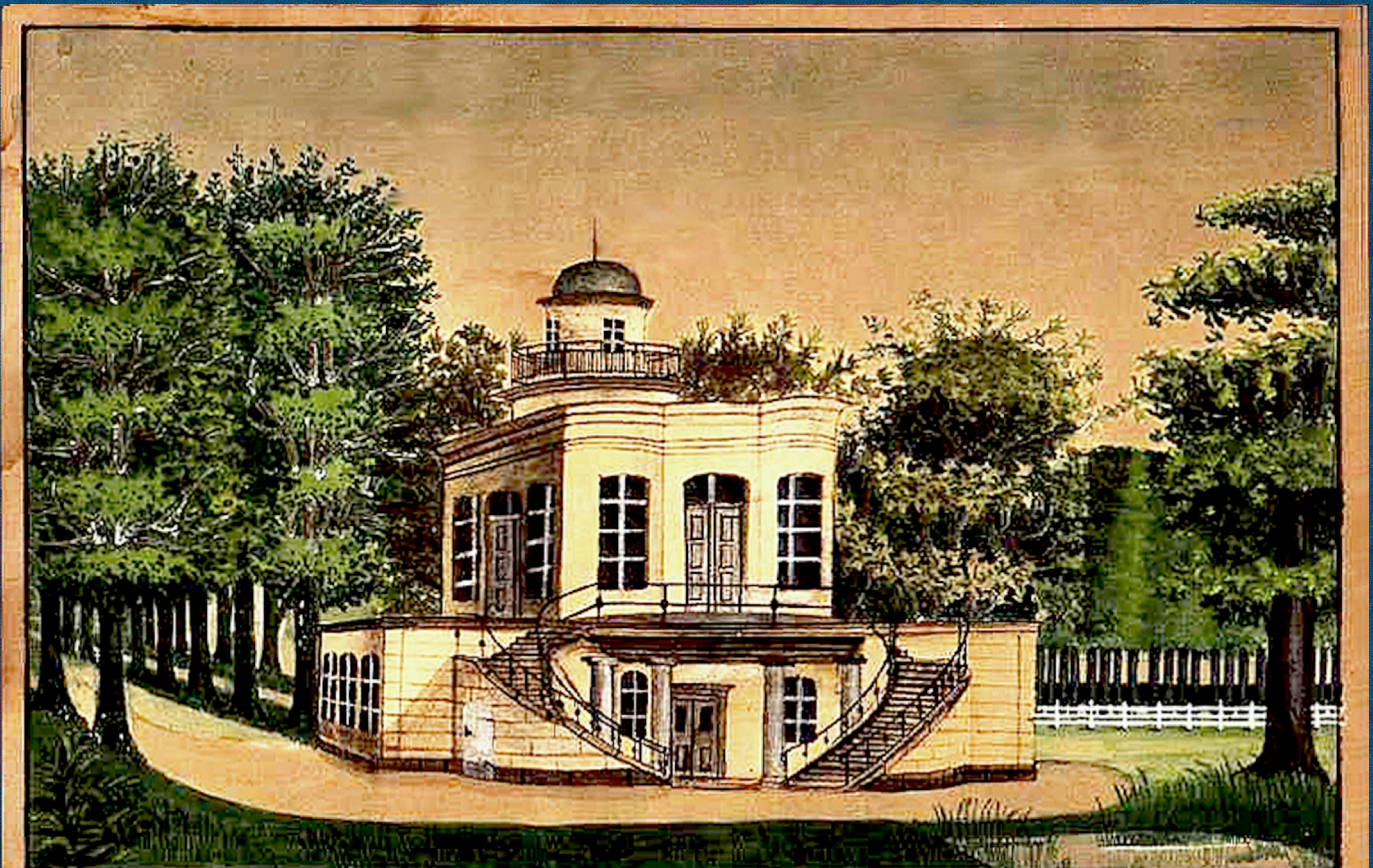
JOURNAL OF ASTRONOMICAL HISTORY AND HERITAGE



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EDITORIAL

With this issue the *Journal of Astronomical History and Heritage* enters a new era, one of the e-journal, as from now on *JAHH* will only be available in electronic form. Issues are scheduled to appear in March/April, July/August and November/December and will be posted on the ADS web site and its mirror sites around the world, so that anyone can download it free of charge. This should greatly increase the international visibility of the journal.

When we first announced the intention to turn *JAHH* into an e-journal we also hoped to produce a limited number of annual print copies at the end of each calendar year for those without easy access to the web, and the late Hilmar Duerbeck, one of the two Associate Editors of the journal, was going to oversee this operation, manage the subscriptions, and arrange the printing and mail out of copies. With Hilmar's sudden demise this will no longer be possible, at least in 2012, but we may be able to implement this scheme in 2013 if current plans come to fruition.

These plans involve a new home for the journal in a new country, forced on us by the decision of James Cook University to close down its entire astronomy program at the end of this year. Thus, I have spent much of the past six months overseas, not only carrying out a range of history of astronomy research projects, but also looking for a new job.

It is partly because of this extensive international travel, and partly because of the unexpected death of my trusty old laptop which I have used since 2005 to produce this journal on that the current March/April issue is so late. When I went to Thailand in February the issue was almost ready to post on ADS, and then the laptop died while I was in Japan. When I transferred the March/April issue from a memory stick to a PC kindly loaned me by the National Astronomical Observatory of Japan I found that all of the papers had reformatted so I spend considerable time revising them and everything was finalised by the time I returned to the National Astronomical Research Institute of Thailand (NARIT) in Chiang Mai, but when I then transferred the journal from my memory stick to a PC kindly loaned me by NARIT I was appalled to find the whole issue again needed reformatting. So for the third time in as many months I was forced to reassemble the journal, only to discover when I returned to James Cook University two weeks ago and transferred it to the laptop I am currently using that the entire issue once again needed reformatting. This has probably been the most frustrating and demanding time of my life, and I have only been able to see the task through thanks to the fine support provided by our two Associate Editors, Professor Joe Tenn and Professor Richard Strom (who kindly agreed to accept the post following Hilmar's unexpected death). However, I must take full responsibility for the delay in 'publishing' this issue, and for this I can only apologise.

I also feel that it is only fair to warn everyone that production of the journal could remain problematic during the remainder of this year as I wind down my James Cook University operations and spend increasing time overseas—in China, Japan, Korea and Thailand, and possibly France and India—attending conferences and conducting research. My hope is that I will be able to move permanently to a new position in one of these countries in January 2013, by which time the future of the journal will be assured and stability will then return. But until that time, life may be difficult for me, and for the journal.

As soon as there is a firm commitment by another institution to take over responsibility for the journal we will announce this by way of a new editorial. Meanwhile, I apologise again for the delay in producing this issue of *JAHH*, and I can only hope that you all find much of interest in the papers that are included here.

Associate Professor Wayne Orchiston
Editor, *JAHH*

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LOMONOSOV, THE DISCOVERY OF VENUS'S ATMOSPHERE, AND EIGHTEENTH CENTURY TRANSITS OF VENUS

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Abstract: The discovery of Venus's atmosphere has been widely attributed to the Russian academician M.V. Lomonosov from his observations of the 1761 transit of Venus from St. Petersburg. Other observers at the time also made observations that have been ascribed to the effects of the atmosphere of Venus. Though Venus does have an atmosphere one hundred times denser than the Earth's and refracts sunlight so as to produce an 'aureole' around the planet's disk when it is ingressing and egressing the solar limb, many eighteenth century observers also upheld the doctrine of cosmic pluralism: believing that the planets were inhabited, they had a preconceived bias for believing that the other planets must have atmospheres. A careful re-examination of several of the most important accounts of eighteenth century observers and comparisons with the observations of the nineteenth century and 2004 transits shows that Lomonosov inferred the existence of Venus's atmosphere from observations related to the 'black drop', which has nothing to do with the atmosphere of Venus. Several observers of the eighteenth-century transits, including Chappe d'Auteroche, Bergman, and Wargentin in 1761 and Wales, Dymond, and Rittenhouse in 1769, may have made *bona fide* observations of the aureole produced by the atmosphere of Venus. Therefore, it appears that several observers—but not Lomonosov—should receive credit for first detecting the aureole due to refraction of sunlight by the atmosphere of Venus during a transit. This crucial observation occurred almost three decades before Johann Schroeter independently demonstrated the existence of the atmosphere of Venus from his analysis of extensions of the semicircle of light of the planet near inferior conjunction, which are produced by back-scattering of light by aerosol-sized particles.

Key words: 1761 and 1769 transits of Venus, atmosphere of Venus, 'black drop', Lomonosov, Chappe d'Auteroche, Bergman, Wargentin, Wales, Dymond, Rittenhouse, Schroeter

1 INTRODUCTION

The surface of Venus is hidden from our visual view by the planet's extensive atmosphere, almost one hundred times denser than Earth's. Though the atmosphere was eventually penetrated during the twentieth century by Earth-based radars and subsequently by Soviet spacecraft that landed on the surface itself, how was this atmosphere first discovered?

The discovery has been almost universally attributed to the Russian polymath Mikhail Vasil'evich Lomonosov (Menshutkin, 1952), who observed the 1761 transit of Venus from St. Petersburg, and extensively reported his results at the time, including his conclusion that Venus had an atmosphere "… similar to, or possibly even greater, than the Earth's." (Lomonosov, 1761a; our English translation).

2 THE ATMOSPHERE OF VENUS AND THE BLACK-DROP EFFECT

Our own interest in optical and solar effects in relation to observations of transits of Venus and Mercury (Pasachoff, Schneider, and Golub, 2005) dates to work by Schaefer (2000; 2001), who reported that most published reports of an effect known as the 'black drop', even current ones, incorrectly attribute it to Venus's atmosphere. The Cytherean atmosphere, in fact, though very dense, is not deep enough to cause this effect, which was drastic enough to interfere with the accurate timing of the second and third contacts. Schneider, Pasachoff and Golub (2004) provided definitive evidence, as had long been suspected (Sheehan and Westfall, 2004), that the black drop effect is caused by a combination of the point-spread function of the telescope smearing any image, in combination with the solar limb darkening, which is especially marked in the arcsecond or so nearest the limb that shows the black drop.

From a historical context, the black drop is important because of its role in spoiling the precise timings of contact points on which Edmond Halley's grand project to estimate the Earth-to-Sun distance (or 'astronomical unit') using the transits of Venus critically depended (see Halley, 1716). Halley's method called for precise determinations of the duration of the transits of Venus. This was to be achieved by measuring precisely—to approximately one second of time—the second-contact and third-contact times from locations separated widely in latitude on the Earth's surface. Because transits of Venus are rare,[1] the opportunities to apply this method were extremely limited. This, needless to say, greatly increased their poignancy and significance.

Halley himself died in 1742, well before the transits of 1761 and 1769, which were to be the last until 1874 and 1882. Other astronomers, however, followed up his lead, and in the eighteenth century transits came to be regarded as the most important astronomical events of the era, the energizing core of years of planning, calculations, and heroic travel to remote locations by most of the important astronomers of that time. Indeed, these transits became "… the first example of big-science, extensive international cooperation, and government/science liaisons; all of which are now the hallmarks of modern research." (Schaefer, 2001: 325).

Figure 1: Lomonosov, from the frontispiece of his republished book of selected writings (after Lomonosov, 1961a).

The French astronomer the abbé Chappe d'Auteroche, who had observed the 1761 transit from Tobol'sk, Siberia, remarked prophetically to a friend over dinner in Paris before his departure for Baja California to observe the 1769 transit that "… certainty of death on the day after the observation would not be sufficient motive to keep him from setting out." (Chappe, 1982: 87). Indeed, though many other observers of the transits no doubt shared his obsession, Chappe was, as far as we are aware, the only one willing to endure martyrdom for the cause of science. Unwilling to give up his choice of a site for his observations merely because of a raging epidemic (probably of typhus), he (and most of his party) died in Baja within weeks of the transit.

In the result, the observations of the contacts were frustrated by several unexpected optical effects. There was an indistinctness, blurring, or ligament of darkness formed between Venus and the edge of the Sun when the two were in near-contact, i.e., at just the most critical times, thus rendering timings discrepant by a minute or more even for observers standing side by side (Hughes, 2001; Sheehan and Westfall, 2004). These optical effects severely compromised attempts to apply the Halley method for determining the solar parallax. Some observers (like many modern authors) attributed this 'black drop' to the interposition of a substantial atmosphere surrounding Venus. In addition, more rarely, observers reported a luminous ring around Venus when it was still partly off the disk of the Sun. Here we consider the phenomena observed during the contacts at the eighteenth-century transits of Venus and their significance—beginning with the celebrated observations of the Russian Academician Mikhail Vasil'evich Lomonosov (Figures 1 and 2) at St. Petersburg.

Figure 2: Lomonosov's statue in front of the Old Library of Moscow State University (photograph by Jay M. Pasachoff).

The stories are told in more detail in such books as those by Anderson (2012), Lomb (2011), Westfall and Sheehan (2013) and Wulf (2012).

3 LOMONOSOV'S OBSERVATIONS OF THE 1761 TRANSIT

Lomonosov (1711–1765) is one of the best remembered of the many observers of the 1761 transit. Born on an island in the Dvina River, near Arkhangelsk in the northern part of European Russia, he was initially destined for the life of a fisherman. However, possessed of native intelligence and insatiable curiosity, at the age of 19 he left his native village (on foot) for Moscow, and eventually taught himself enough to become a student at the St. Petersburg Academy. After a stint in Germany, where he studied at the University of Marburg, he returned to Russia, and won an appointment to the Academy in 1741, though without receiving any specific assignment. Much of his career was spent battling with incompetent and narrow-minded colleagues, who had him arrested and imprisoned for a time, but he eventually succeeded in establishing himself. His work was championed by Empress Elizabeth—who was won over by his poetry—and by the Swiss mathematician Leonhard Euler. Lomonosov became a professor at the Academy and was put in charge of a laboratory, where he did prodigious amounts of work in physical chemistry. Embracing many of the ideas of the Enlightenment sweeping Europe at the time, he was a stalwart enemy of superstition and critic of the Orthodox Church, and a reformer of popular education in Russia, activities that, needless to say, continued to make him suspect in the eyes of the clergy (Menshutkin, 1952; Shiltsev, 2012).

Lomonosov's scientific interests were broad, and not surprisingly, he attentively followed the plans being devised throughout Europe to observe the transit of Venus on 6 June 1761 (N.S.) or 26 May 1761 (O.S). In Russia, the lead in calculating Venus's path across the Sun had been taken by F.U.T. Epinus (1724–1802), a German natural philosopher and the Director of the St. Petersburg Observatory. However, Lomonosov discovered errors in Epinus' calculations, and proceeded to correct them. This did not endear him to Epinus. Eventually, Lomonosov decided to carry out observations of the transit from his own observatory at his home while his colleagues Andrey D. Krasilnikov (a one-time student of the French astronomer J.N. Delisle) and Nikolay G. Kurganov based themselves at the St. Petersburg Observatory (on the top of the Academy building). These seasoned astronomers were assigned to the primary project of carefully observing the contact times in order to apply Halley's method in determining the length of the astronomical unit, while Lomonosov focussed on the physical phenomena that occurred during the transit. For these observations he used a non-achromatic refractor with a focal length of 4.5 feet that consisted of little more than two lenses (objective and eyepiece) capped with a smoky glass that Marov (2005: 213) somewhat unkindly referred to as "… a sort of spyglass ...." This tended to produce distorted images of objects that were not perfectly centered. The poor quality of this instrument must be borne in mind when interpreting the significance of Lomonosov's observations of the transit, while yet another factor affecting the observations would have been the seeing. The transit began shortly after sunrise at St. Petersburg, and the seeing was initially good; however, it deteriorated as the transit progressed.

Lomonosov (1761a; 1761b) was among the first observers of the transit to publish his results. An account in Russian was published by the St. Petersburg Academy of Sciences within a month of the transit (see Lomonosov, 1961a). Another account was written at the same time in German, undoubtedly by Lomonosov himself, who had learned German at Marburg (see Lomonosov, 1961b).[2] However, neither of these publications appears to have had much influence at the time, and few astronomical historians have consulted them since. Among the exceptions are Meadows (1966)[3] and Marov (2005).[4]

Thus, for instance, in his magisterial work on the transits of Venus, Harry Woolf (1959) doubted that Lomonosov's paper was even published during his lifetime, and could not find a copy. The usually reliable Willy Ley (1963: 207) similarly claimed that "… this paper, like many others by Lomonosov was not printed during his lifetime …" and suggested that it did not appear even in Russia until the end of the nineteenth century. Ley (ibid.) further maintains that only in 1910 did it become known outside Russia, when Boris N. Menshutkin, later Lomonosov's biographer, published excerpts in German. It is likely that Ley has been relied on by many later authors, who followed him in believing that Lomonosov had seen a 'luminous ring' around the planet, which he thought indicated the presence of an atmosphere that was possibly greater than that of the Earth. Another influential source has been the Russian astronomer Sharanov (1960).

Unfortunately, eighteenth-century accounts of transit observations are often vague and unreliable, which is certainly excusable, since none of these observers had ever seen a transit of Venus before. Many of the phenomena observed during the transit were unexpected, and collectively raised havoc with the precise timings of the contacts. Descriptions by eighteenth-century transit observers commonly talk of an 'atmosphere' around the planet that was seen during ingress and egress but also, in some cases, remained visible as the planet crossed the Sun. They mention a "feeble light," a "reddish hue," "a luminous band," and even, most vividly, a "narrow waterish penumbra" around the planet (see Meadows, 1966). More often than not the term 'atmosphere' was used to describe these phenomena, by observers who were predisposed on religious or philosophical grounds (see below) to believe that all the planets were inhabited and therefore must, like Earth, possess atmospheres needed to support life. In addition, these various effects shade imperceptibly into those involving the black ligament or black drop, which was by far the most striking and ruinous phenomenon observed at the transits. It has only recently become clear that these effects are produced by the smearing of the isophotic contours of the planet's disk by a combination of solar, instrumental and terrestrial-atmospheric effects. Not only was this faint light or dusky 'atmosphere' seen around Venus, but the black ligament and black drop also were ascribed by many eighteenth-century observers to an actual atmosphere around Venus—something for which, again, they can be excused, particularly as Schaefer noted that even many twentieth-century authors fell into the same error (Schaefer, 2001). Significantly, similar effects were seen during transits of Mercury (which of course is known to be airless) by observers using similar instruments under the same conditions, while a small black drop was noted even by well-equipped observers of the 1999 transit of Mercury (see Pasachoff, Schneider and Golub, 2005).

It would be tedious, and achieve no useful purpose, to consider case by case all of the reports by eighteenth century observers of the various luminous effects, penumbrae, feeble lights or other phenomena seen during the transits and attempt to account for each one. Instead, we consider in detail the case of Lomonosov as representative of all of these. We have consulted both of Lomonosov's original publications, which were written in Russian (1761a) and German (for which we use the 1961 version: Lomonosov, 1961b). The German account (which will be discussed further below) is an excerpt from the Russian, and omits the discussion of the transit observations altogether.[5] The Russian text is therefore of fundamental importance, and the original German almost as much so. We here present the entire account pertaining to Lomonosov's observations and his scientific discussion in a fresh translation from the Russian, based on that made at our request by Olga Tsapina, Norris Foundation Curator of American Historical Manuscripts at the Huntington Library. We have made a few slight changes to make the text more accessible; for instance, where Lomonosov refers to himself in the third person, as "the observer," we have modified the text to first person, and clarified a few ambiguous terms by introducing those that conform to current astronomical idiom. Note that our Figure 1 shows the frontispiece of his book while our Figure 3 encompasses the various figures as given and numbered by Lomonosov himself and referenced in the text below:

> Having waited for Venus to enter the Sun for some forty minutes beyond the time listed in the ephemerides, I finally saw that the edge of the sun at the place of the expected entry became indistinct as if blurred, although before it had been clear and evenly colored [he refers to B in Figure 3.1]. Seeing no darkness and thinking that it was my tired eyes that caused this blurring, I stood back briefly from the telescope. After a few seconds I took up my place again and saw that, where the solar limb had previously been only somewhat disturbed, there was a definite spot or segment; it was very slight, but there could be no doubt that it belonged to the encroaching Venus. Afterwards I watched with keen attention for the ingress of the trailing limb of Venus, which, it seemed, had not yet taken place, for there seemed to be a small segment not yet entered upon the

Sun. However, there suddenly appeared between the trailing limb of Venus and the following [solar] limb a hair-thin luminous sliver. The time that separated the two appearances was not more than a second.[6]

During Venus's egress from the Sun, when its preceding limb was beginning to encroach upon the solar limb, and was (as far as my eye could judge) about a tenth of the diameter of Venus away, then a small blister [see A in Figure 3.1] appeared on the edge of the Sun, which became more and more evident as Venus approached the moment of its complete egress [see Figure 3.3]. LS designates the solar limb, mm, the bulging outline of the Sun in front of Venus [see Figure 3.4]. The blister suddenly broke, and Venus appeared without its limb [see Figure 3.5], nn shows the small, but very clear, sector which was clearly defined.

The complete egress of Venus, or its last contact with the limb of the Sun, occurred with a certain amount of uncertainty, and was accompanied as before with a blurring of the solar edge.

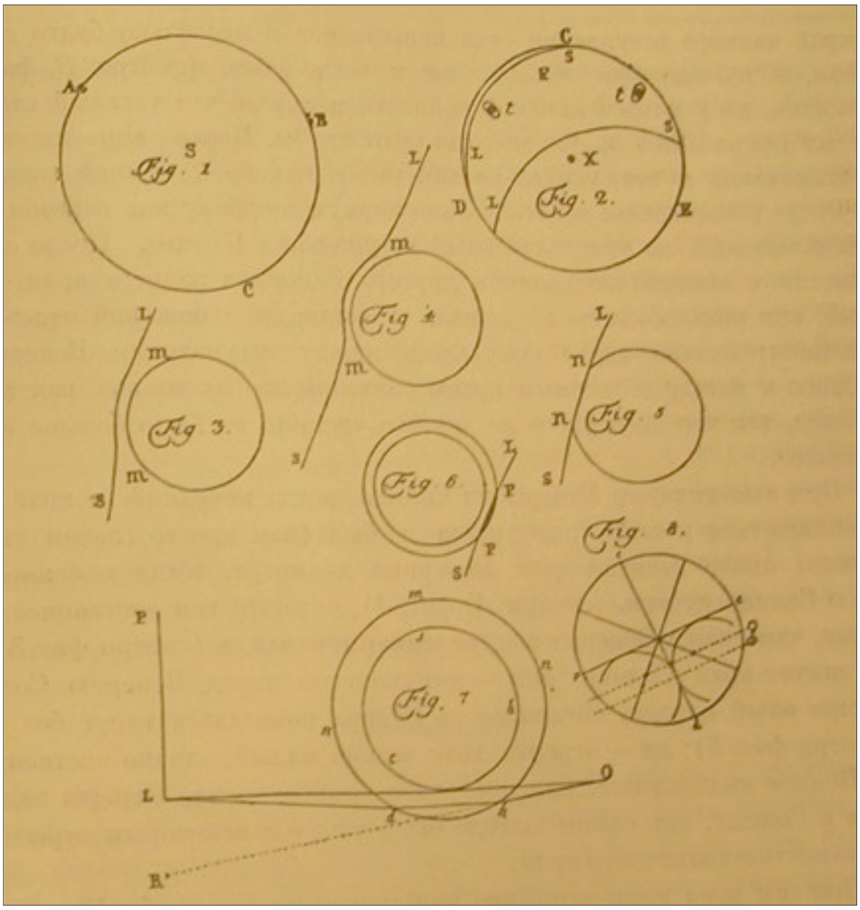


Figure 3: Lomonosov's figures, described in the text.

While this was happening, it was clearly noticed that as soon as Venus moved away from the centre of the telescope and approached the edge of the field of view, a fringe of colours would appear due to refraction of the light rays, and the limb of Venus appeared smeared the further it was from the centre of the telescope tube [Figure 3.2]. Because of this, throughout the transit the telescope was positioned in such a way that Venus was always in the center of the field, where its limb appeared crisp and clear without any colour.

From these observations I concluded that the planet Venus is surrounded by an extensive atmosphere of air, similar to (if not even greater than) that which surrounds our own globe. The reasons for this conclusion are, in the first place, the blurring of the previously well-defined solar limb B, just before the actual ingress of Venus, which was caused, so it would seem, by the encroachment of Venus's atmosphere upon the solar limb. This effect is made evident [see Figure 3.6], where LS is the edge of the Sun and PP the portion of the atmosphere of Venus. At the egress of Venus, contact of the preceding limb produced a blister. This effect, it would seem, can only be due to refraction of solar rays by the atmosphere surrounding Venus. Thus LP is the end of a chord of the visible surface of the Sun [see Figure 3.7]; sch is the main body of Venus, mnn is its atmosphere; LO is the ray from the surface of the Sun that would extend to the eye of the observer in the case where Venus had no atmosphere. However, in the presence of an atmosphere, the ray Ld from the limb of the Sun is refracted toward the perpendicular at d and reaches h, thus arriving at the observer's eye in point O. Now the optics of the situation tells us that the latter is the ray along which the eye actually looks: thus the limb of the Sun, L, after refraction, appears to lie at R, along the straight line OR, or beyond the actual position of the limb L. The excess distance LR represents the blister at the solar limb which bulges out ahead of the pre-ceding limb of Venus at egress.

Thus ends the excerpt taken from Lomonosov's text.

A superficial reading of this—and, in particular, the reference in the first paragraph to what is here translated as "a hair-thin luminous sliver", but which others have referred to as a "luminous ring" (Ley, 1963), or even a "very narrow aureole" (Meadows, 1966)—conjures up visions of the delicate feathery line of light seen along the trailing limb of Venus when the planet had not yet completely entered the limb of the Sun (or the preceding limb of Venus when it had not completely exited) seen by observers of the nineteenth-century transits and by ourselves in 2004. The latter is indeed, properly speaking, an aureole, produced by the refraction of sunlight in the Venusian atmosphere, but since the total apparent angular height of Venus's air is only about 0.02 arc seconds, it is, despite its brilliance, a delicate feature, and would presumably have been beyond the range of most eighteenth century observers with the small instruments available to them.

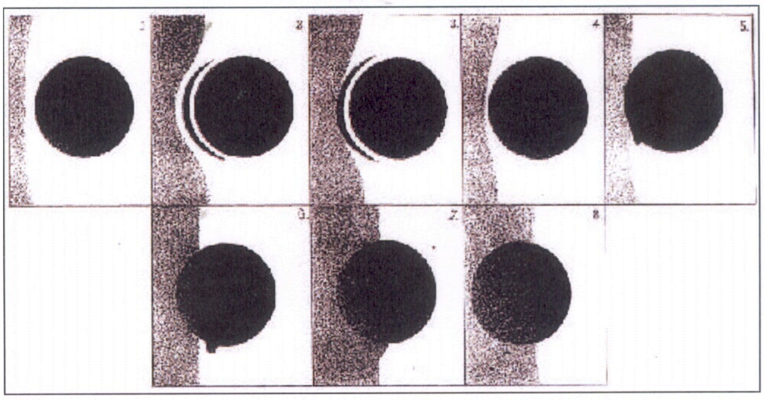
Though some observers used early Dollond achromatic refractors (though Dollond himself used a non-achromat! (Meadows, 1966)) and others used small reflectors, even the best of these instruments were primitive by modern standards, and suffered from varying degrees of achromatic and other aberrations. Lomonosov, in particular, makes clear that his own instrument was of marginal quality. It clearly suffered from chromatic aberration—and possibly other optical distortions—since, as noted above, the image deteriorated markedly whenever Venus neared the edge of the field of view. Though many of the other observers of the eighteenth-century transits described luminous rings and reddish or purplish haloes around the disk of Venus, including some that remained visible throughout the duration of the transit across the Sun, these suggest the effects of eye fatigue or chromatic aberration or both. So some of these 'luminous rings' were edge effects on the dark disk of Venus. If there were an 'arc' off the limb, between first and second contacts or between second and third contacts, then the atmosphere may indeed have been sighted. But at no time did Lomonosov report any phenomena that resembled the phenomena seen during the transits of 2004 and 2012, with an arc above Venus's external limb. We know now that such an arc may be visible for 20 minutes, far from what Lonomosov described.

In any case, a careful reading of Lomonosov's text reveals that the "hair-thin luminous sliver" refers to nothing more than the flash of sunlight between the trailing limb of Venus and the limb of the Sun marking the end of second contact. It corresponds to the breathtaking appearance of the 'diamond ring' at a total solar eclipse. Without going into all the details here, we maintain that multiple other observers' reports of luminous hairs or threads—which have also been uncritically accepted as sightings of the aureole—prove to have been of this same phenomenon. One must remember that observers were especially on the *qui vive* for this moment. After all, the main purpose of observers of the eighteenth-century transits was to determine the precise moments of the second or third contact. When the bright flash or thread appeared at ingress, it meant that second contact had passed; it corresponded with the moment the black ligament broke or the black drop dissolved. The problem they encountered was, of course, that the black ligament or drop spoiled the whole methodology by rendering determination of this critical moment imprecise.

Regarding Lomonosov's discussion of the blister at second contact: it is clear in light of recent work that his arcs mm and nn are artifacts, presumably related to the double cause of the black drop as described by Schneider, Pasachoff, and Golub (2004) and Pasachoff, Schneider, and Golub (2005). Nineteenth century observations of suggestively similar effects, made with much better telescopes, were made in 1874 by the British astronomer Bigg-Wither (1875; 1879; 1883) and many others who reported on their observations in the *Monthly Notices of the Royal Astronomical Society*, where they were indexed under "Sun, Parallax of, from observations of ...," and in 1882 by the skillful Belgian observer E. Stuyvaert (1884). See our Figure 4.

Bigg-Wither (1883: 98) describes, from his observations in India, "At the Egress most unexpected phenomena presented themselves ... As *Venus* approached the edge of the Sun's disk, she appeared to push before her a ring of light concentric with her disk ..." It was seen for almost a half hour, and generally matches the satellite observations of Venus's atmosphere that we made in 2004. He wrote "I am unable to form an idea of the cause of the formation of this crescent: it certainly did not appear at the Ingress, nor was there anything of the sort at the Transit of *Mercury* in 1868, the Egress of which I observed in England with the same telescope." (Bigg-Wither, 1883: 99).

Since Lomonosov's observational data were flawed, his detailed geometrical treatment also proves to have been spurious. Schaefer, though noting that the idea that the black drop results from the refraction of sunlight in the Venusian atmosphere is false—and indicating that it may have been proposed by Lomonosov—goes on to say that Lomonosov "… saw other effects during the 1761 transit which he correctly used to deduce the existence of air around our sister planet." (Schaefer, 2001: 327). We have now shown definitively that this is not the case. Lomonosov arrived at the correct conclusion but on the basis of a fallacious argument. Perhaps it will help to introduce an additional factor that explains the readiness of intelligent and cautious observers to make what seems, in retrospect, to have been such a speculative leap. This factor is the general acceptance of plurality-of-worlds beliefs by many eighteenth-century observers, a topic explored in depth by such historians of astronomy as Steven Dick (1982), Michael Crowe (1986), Helge Kragh (2008) and Møller Pedersen and Kragh (2008). Many astronomers and writers of the Enlightenment—including such well-known figures as Christiaan Huygens and Bernard de Fontenelle, both of whom wrote books on the subject, and afterwards William Herschel and Johann Schroeter—were convinced that the purpose of the planets was to support inhabitants, and thus took the presence of atmospheres for granted.



The black drop effect during egress, observed by E. Stuyvaert at San Antonio. (Picture courtesy o
John G. Wolbach Library, Harvard-Smithsonian Center for Astrophysics)

Figure 4: This observation was by E. Stuyvaert,[7] member of a Belgian team led by Jean Charles Houzeau to San Antonio, Texas, in 1882 (after Stuyvaert, 1884: Plate 1).

That Lomonosov—whose support of Enlightenment thought frequently brought him into conflict with his contemporaries—was of the same school is demonstrated by what he writes after his discussion of the observations of the transit of Venus and geometrical treatment demonstrating the supposed refraction by the planet's atmosphere. In fact, as Joseph Gangestad, who translated the work for us, has pointed out, Lomonosov's article in German (which, as Duerbeck points out, includes "Aus" = "Taken from" in its title)

> … is only an excerpt of Lomonosov’s report, and discusses none of his scientific findings. It appears that this excerpt comes somewhere near the end of the whole thing, after the scientific description of his observations has already been made. In these pages, he talks exclusively about the religious implications of other planets having atmospheres, the possibility of extraterrestrial life, quoting the Bible and saints, and giving a history lesson on astronomy and the heliocentric vs. geocentric views of the Solar System. This excerpt is almost an exegesis, explaining how atmosphere-bearing bodies with other living creatures and a heliocentric universe can be reconciled by properly-educated Christians (as he has some rather nasty things to say about uneducated ‘common people’).

Duerbeck (pers. comm., 2011) points out that this is the only passage lacking in the more academically-oriented German edition of 1761, and proves that the 1961 editors worked from the basis of the Russian

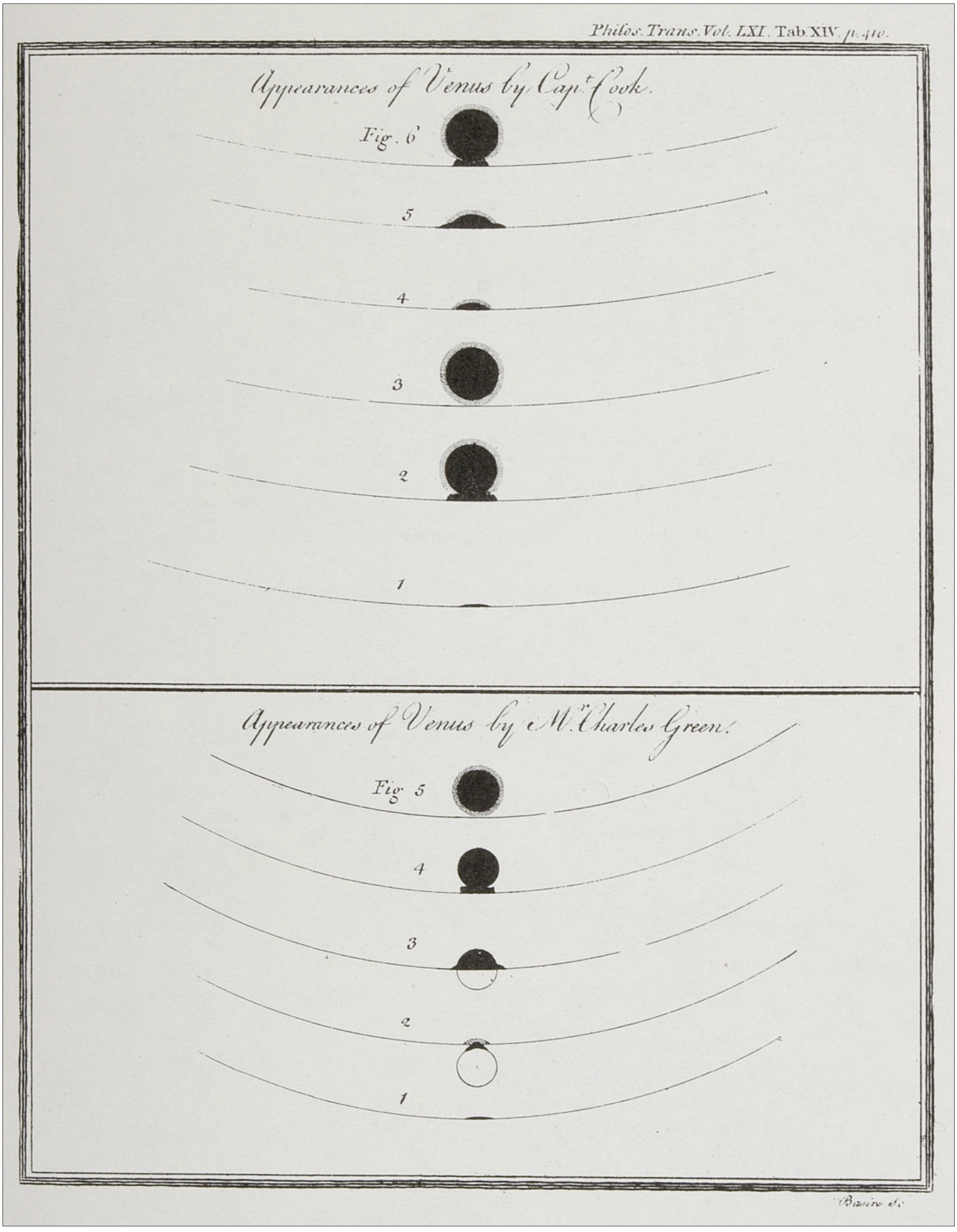


Figure 5: Drawings published in *Philosophical Transactions of the Royal Society* by Green and Cook (1771) of the 1769 transit of Venus that they observed in Tahiti (courtesy: Royal Society of London).

edition. The point is that Lomonosov observed the transit of Venus with a strong predisposition bordering on certainty that the planet was surrounded by an extensive atmosphere. So—when he saw blurring of the Sun's limb and other curious effects—he naturally deduced from these phenomena what he had already been predisposed to believe. In that respect, his supposed discovery of the atmosphere of Venus was not unlike, say, the well-known case of Percival Lowell's discovery of a system of artificial canals on the planet Mars.

4 VENUS'S ATMOSPHERE ACTUALLY OBSERVED

Among other observers of the eighteenth century transits, the best known were Lieutenant James Cook and the astronomer Charles Green, who observed the 1769 transit from Tahiti (Orchiston, 2005); the abbé Chappe d'Auteroche, who observed the 1761 transit from Tobol'sk, Siberia, and the 1769 transit from Baja California; and David Rittenhouse, who observed the 1769 transit from Norriton, near Philadelphia.

Because Cook's Royal Society-sponsored expedition to Tahiti marked the first phase of what would eventually turn into three dramatic voyages of geographical exploration and discovery, he is by far the most celebrated observer of the eighteenth century transits. Cook and Green successfully observed the transit in a cloudless sky in intolerable heat. Cook refers to an "atmosphere" of Venus, a term which may mislead the incautious. The drawings of these observers (Green and Cook, 1771) show a greyish penumbra around the black disk of Venus silhouetted against the Sun, which is clearly an optical effect (Figure 5). Cook's journal entry for transit day, 3 June 1769, reads:

> This day prov'd as favourable to our purpose as we could wish, not a Clowd was to be seen the whole day and the Air was perfectly clear, so that we had every advantage we could desire in Observing the whole of the passage of the Planet Venus over the Suns disk: we very distinctly saw an Atmosphere or dusky shade round the body of the planet which very much disturbed the times of the Contacts particularly the two internal ones. (Beaglehole, 1968: 97-98).

This description is clearly of instrumental effects and the black drop effect, not of a true atmosphere of Venus.

Among the other observers of the 1761 transit, several have been credited (by Link, 1949; 1959; 1969) with having seen the aureole produced by refraction of sunlight in the Venusian atmosphere. The strongest candidates are: P.-G. Wargentin (1761) in Stockholm, Thorbern Bergman (1761) in Upsala and Chappe (1761) in Siberia. In addition Maraldi at the Paris Observatory and Grandjean de Fouchy in La Muette at the Cabinet du Physique may have done so (see Link, 1969). The observations are not entirely satisfactory, for though the phenomena recorded bear some likeness to the aureole, it is also possible that what was observed was merely an optical halo (e.g., see Bergman's drawings in Figure 6).

Chappe's (1762) observations at Tobol'sk merit detailed discussion. On the morning of the transit, Chappe awoke from a sleepless night (he had gone to bed with the skies hopelessly overcast), and found the Sun heartbreakingly hidden by clouds. Fortunately, as soon as the Sun rose at Tobol'sk, the clouds began to dissipate; his first glimpse of the planet on the Sun showed that first contact had already occurred—the disk of Venus was entered halfway onto the Sun's limb. Then Chappe noted a "… singular phenomenon … [a] luminous ring …" (*anneau lumineux*), crescenttic in form and reaching about two-thirds of the way around the semi-circle of the opaque planetary disk. The ring remained visible as Venus glided farther over onto the Sun. Chappe surmised that the ring must be due to refraction of sunlight in an actual atmosphere around the planet, and he worked out by subtracting the diameter of the Sun as seen at Venus from the measured diameter of the planet, a corrected value for the planet's diameter of 58½ seconds of arc (the modern value for the time of the 1761 transit is 58″ .18; note that his calculation did not depend on whether the ring was real or not).

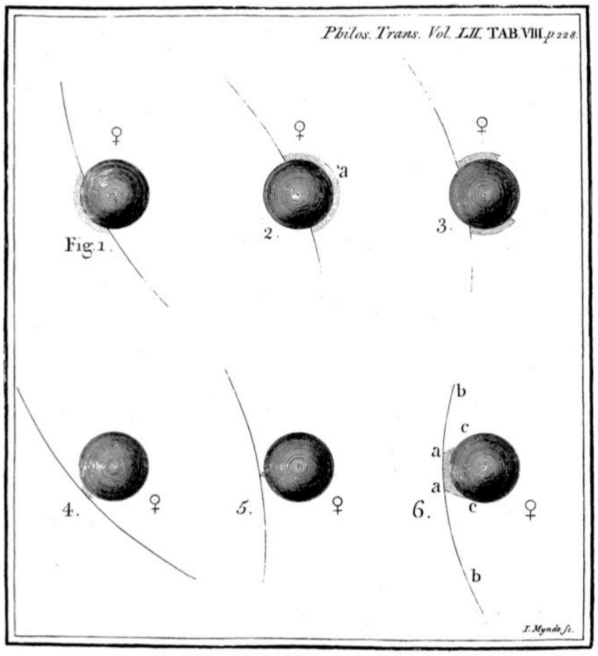


Figure 6: Drawings by Bergman (1761) from the *Philosophical Transactions of the Royal Society* of the entrance and egress of Venus into the solar disk at the 1761 transit. The upper drawings are somewhat ambiguous, and may indicate the aureole, though more likely they record an optical halo. The lower series are unambiguous: they definitely exhibit nothing more than an artifact (courtesy: Royal Society of London).

During the 1769 transit, Chappe, now in Baja California, looked for but failed to see the aureole (see Cassinin de Thury, 1772). Neither did anyone else, as far as we can tell, with the possible exceptions of the pioneering American astronomer David Rittenhouse at Norriton, near Philadelphia, and Joseph Dymond and William Wales at Prince of Wales Fort (now Churchill) on Hudson Bay.

Rittenhouse, a clockmaker and orrery-maker by profession (Hindle, 1964), as a member of the American Philosophical Society's Committee to observe "… that rare Phaenomenon, the transit of Venus over the Sun's disc …", made careful preparations in advance of the great event, including a series of timings of the eclipses of Jupiter's satellites, to determine the longitude of his observatory at Norriton (Rittenhouse, 1769).

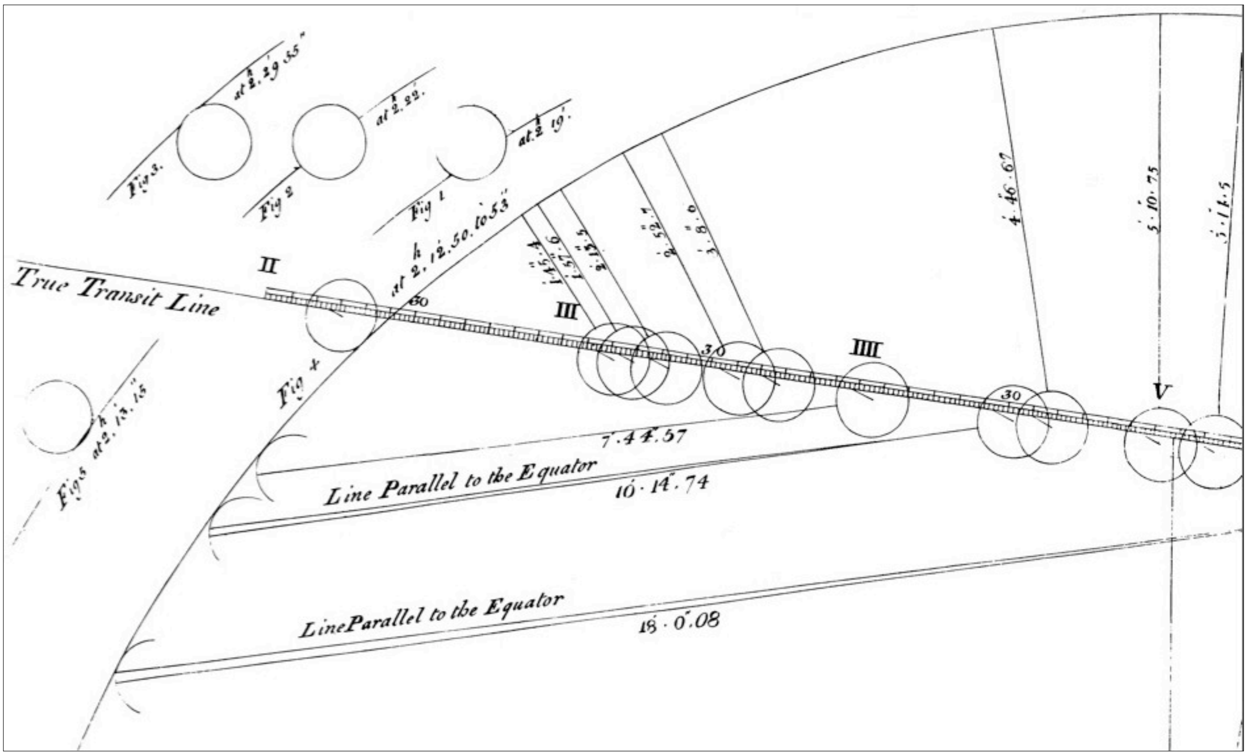


Figure 7: David Rittenhouse's multiple-image drawing of the 1769 transit of Venus (after Rittenhouse, 1769: Plate III).

On the day of the transit, he and his colleagues—William Smith, John Lukens, and John Sellers—were favored with a beautifully clear sky. Their instruments included a Gregorian reflector of two-foot focal length shipped from London, of which Charles Mason and Jeremiah Dixon, who had observed the 1761 transit from Cape Town and were later to become famous for surveying the Mason-Dixon Line, declared "… they never used a better …", also a 42-foot refractor whose lenses had been shipped from London to Harvard College but did not arrive in time for the transit. These instruments were employed by Smith and Lukens, respectively. Rittenhouse observed with his own refractor, with an object-glass of 3-inch aperture and 36-foot focal length, magnifying 144×, to the eyepiece of which he fitted "… with a little bees-wax …" a piece of deeply smoked glass. After describing his earliest intimation of first contact, Rittenhouse's account (1769) proceeds as follows (see Figure 7):

> When the Planet had advanced about one third of its diameter on the Sun, as I was steadily viewing its progress, my sight was suddenly attracted by a beam of light, which broke through on that side of Venus yet off the Sun. Its figure was that of a broad-based pyramid; situated at about 40 or 45 degrees on the limb of Venus, from a line passing through her center and the Sun's, and to the left hand of that line as seen through my Telescope, which inverted. About the same time, the Sun's light began to spread round Venus on each side from the points where their limbs intersected each other.

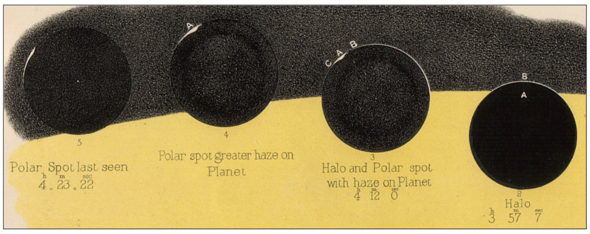


Figure 8: Observations from Sydney, Australia, of the transit of 1874, by New South Wales Government Astronomer Henry Chamberlain Russell, showing the arc of Venus's atmosphere visible outside the limb (after Russell, 1892: Plate XXV).

> As Venus advanced, the point of the Pyramid still grew lower, and its circular Base wider, until it met the light which crept round from the points of intersection of the two limbs; so that when half the planet appeared on the Sun, the other half yet off the Sun was entirely surrounded by a semicircular light, best defined on the side next to the body of Venus, which constantly grew brighter, till the time of the internal contact.
>
> Imagination cannot form any thing more beautifully serene and quiet, than was the air during the whole time; nor did I ever see the Sun's limb more perfectly defined, or more free from any tremulous motion; to which his great altitude undoubtedly contributed much.

Of all the eighteenth-century observers, Rittenhouse has perhaps the strongest claim of having made out Venus's atmosphere appearing as an actual arc, owing to refraction of sunlight. Similar effects to those he describes are in the drawings by the Australian astronomer Henry Chamberlain Russell made at Sydney Observatory during the 1874 transit (Russell, 1892; Orchiston, 2004; cf. Pasachoff, Schneider and Widemann, 2011). Some of Russell's drawings are shown in Figure 8. Rittenhouse's descriptions also bear comparison with the best images ever made of the transit, the ones from NASA's TRACE spacecraft during the 2004 transit (Pasachoff, Schneider and Widemann, 2011; see Figures 9 and 10).[8]

5 CONCLUSIONS

So, if we cannot accord credit for discovering the atmosphere of Venus to Lomonosov, who does deserve the credit? Possibly Chappe. He reported an arc of sunlight produced by refraction in the atmosphere of Venus, and concluded that it was an effect of the atmosphere of Venus on the Sun's limb. He may or may not have been correct. He did not attempt to explain, by geometrical analysis of the kind that Lomonosov presented, how the aureole might be produced by refraction of sunlight in the atmosphere of Venus. Also, Bergman and Wargentin may deserve some credit, though their observations are not quite convincing to us. Wales and Dymond may have seen the aureole and recognized its significance. However, the strongest claim of any of the eighteenth century transit observers to have seen the aureole and recognized its significance was Rittenhouse, whose descriptions are detailed enough to be compared with modern observations, including those made from spacecraft.

The first comprehensive demonstration of Venus's atmosphere to draw on observations other than those at a transit was provided a generation later by Johann Schroeter, who skillfully analyzed the extension of the semicircle of light around the dark side of Venus near inferior conjunction, noted in a crucial series of observations made in 1790 (Baum, 2007; 2010). Earlier references, provided by Duerbeck, include Schroeter (1796), American astrophysicist Henry Norris Russell (1899),[9] and Link (1949, 1959), with more quotations in Meadows (1966: 126). Schroeter methodically eliminated other possible explanations for the phenomenon he observed, in contrast to eighteenth-century transit observers. As Schroeter himself continued to believe that airless Mercury had an atmosphere from a bright halo it exhibited at the transit of 1799, it would seem that transit phenomena were too complex, multifarious, and variable in causation to be entirely reliable grounds for deduction.

The discovery of the atmosphere of Venus was one of the great achievements in planetary astronomy. In our view, at least several observers of the transit deserve credit for having intimations of its existence based on reasoning from the various phenomena they recorded; however, in our opinion, Schroeter deserves the most credit, as the first to offer a definitive demonstration.

6 NOTES

1. Only six transits of Venus have been observed since the invention of the telescope, beginning with that of 1639, which was observed by only two people: Jeremiah Horrocks and William Crabtree (see Chapman, 2005).
2. Duerbeck (pers. comm., 2011) notes that this reference says

> Taken from [= Aus] Erscheinung ..., i.e., it is only an extract of the 1761 paper. It is obviously not based on the German original, it seems that it was translated back from Russian, so it is quite worthless. The 1761[?] paper, with an old-fashioned flavor, but of course much more precise, is very rare; I could trace a single copy in the library of the Martin-Luther-Universität Halle-Wittenberg, which provided a copy. The title page reads: 'Erscheinung der Venus vor der Sonne, beobachtet bey der Kayserlichen Academie der Wissenschafften in St. Petersburg den 26. May 1761. Aus dem Rußischen übersezt.' It describes the observations by Krassilnikow [sic] and Kurganow, and continues '... hat auch der Collegien = Rath und Professor Lomonossow in seinem Hause hauptsächlich Physicalischer Bemerkungen wegen diese Himmels = Begebenheit observiret ... Indem derselbe auf den Eintritt der Venus in die Sonne bey vierzig Minuten länger, als er nach den Ephemeriden hätte erfolgen sollen ...' [i.e., the beginning of our text]. After Lomonosov's observations (which include the set of eight figures bound at the end), follows a 'Zugabe', which is a variant of the text printed in the German Lomonosov edition of 1961(b).

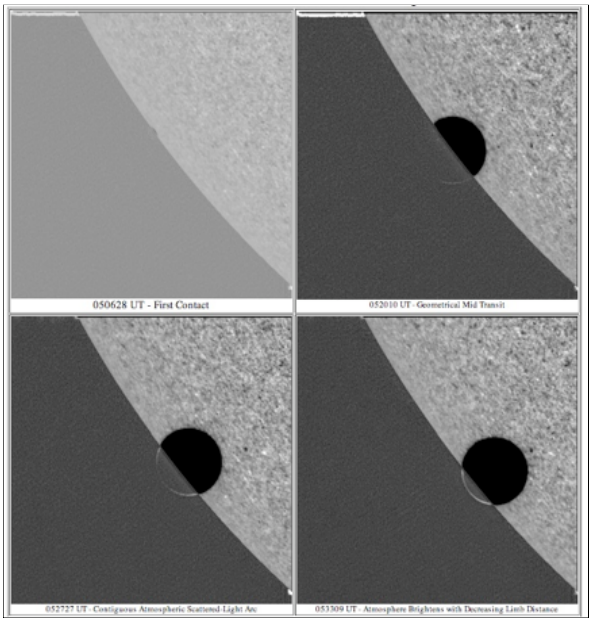


Figure 9: The arc outside the solar limb before second contact, seen in a series of images from NASA's Transition Region and Coronal Explorer (TRACE), reveals Venus's atmosphere seen in refracted sunlight. (The part of the image outside the solar limb, the diagonal, slightly curving line from upper left to lower right, has been artificially enhanced.) (After Pasachoff, Schneider, and Widemann, 2011; courtesy: Lockheed Martin Solar and Astrophysics Laboratory and NASA).

3. H. Duerbeck (pers. comm., 2011) informs us that Meadows correctly quotes F.U.T. Eginus, though he does not quote the 1761 Russian and German papers with their titles, only the (Russian) collected works, making it unclear whether he has seen the German edition; however, he quotes printing runs and publication dates—which must have been taken from other sources.
4. Duerbeck (pers. comm., 2011) also informs us that Marov uses F.U.T. Eginus working from Russian sources, but he also quotes the German title of Lomonosov's 1761 paper exactly as it is written on the title page—so he must have seen it; only the year of publication is guessed since the original has no date.
5. Duerbeck informs us (pers. comm., 2011) that the 1761 text is almost complete, especially concerning

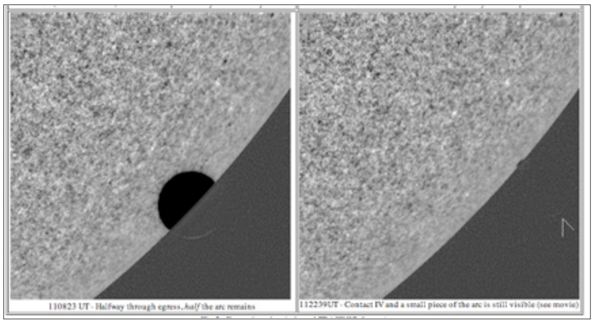


Figure 10: The atmosphere of Venus, at egress from TRACE (left), and (right) the last bit of Venus's silhouette on the solar disk (after Pasachoff, Schneider, and Widemann, 2011; courtesy: Lockheed Martin Solar and Astrophysics Laboratory and NASA).

the observations; only some trivia on Copernicanism in the second half are not translated. In the German 1961 text, on page 428/20, there is a poem with an introductory sentence: "Schade ... kroch?!" This sentence is missing in the 1761 German text.

6. Since so much of our argument depends on this paragraph, we provide the original German text and comments from Duerbeck (pers. comm., 2011):

   > Auf einmahl aber entstund zwischen dem hintern Rand der Venus und dem Sonnen = Rande ein ganz helles Licht, wie ein Haar breit, welches die Venus vom Rande der Sonnen absonderte, so daß beydes in Zeit von nicht mehr als einer Secunde geschahe. So the 'solar' is also here; 'sliver' is expressed as 'Licht' = light. The verb 'absondern' is not totally clear; in modern usage, I would translate it as 'to emit' or 'to discharge', but it can also mean 'to segregate, to detach'.

   Duerbeck (ibid.) took the text from Lomonosov (1960) where passages from Lomonosov's original paper are quoted. The relevant sentence in Duerbeck's transliteration, with the word for 'solar' italicized by us, is:

   > Posle s prileshaniem smotrel vstupleniye drugogo Venerina zadnego kraya, kotoryi, kak kazalos', eshtche ne doshel, i ostavalaya malen'kiy otrezok za Solnzen; odnako vlrug pokazalos' mezhdu vstupayushtchim Venernym zadnim i mezhdu *solnetchnym* krayem razdelyayushtcheye ikh tonkoye, kak volos, siyanie, tak tachto ot pervogo do drugogo wremeni ne bylo bol'she odnoy sekundy.

7. Stuyvaert was a good observer, who had recorded radial streaks in the B ring of Saturn, thus anticipating the 'spokes' we now know to exist. The image shown here is reproduced in Sterken and Duerbeck, 2004 (Figure 13).
8. See, also, the animations available online through a link in the Pasachoff, Schneider, and Widemann (2011) *Astronomical Journal* paper. The publisher has guaranteed that this animation will be available for 100 years (not quite long enough for the next pair of transits, in 2117 and 2125). This animation is also available through the website of Pasachoff at http://www.transitofvenus.info. Inspections of these animations show that the Cytherean atmosphere was visible for at least 10 minutes at ingress and a similar time at egress, which agrees with Rittenhouse's observations.
9. H.N. Russell (1899) concludes:

   > (1) The observed prolongation of her cusps shows that the sunlit and visible areas on Venus extend about 1°10′ farther than they would on an opaque sphere without atmosphere. (2) This has usually been explained as the result of the refraction of a clear atmosphere, more than twice as extensive as our own; but a consequence of this theory is that, when Venus appears as a luminous ring, a very conspicuous refracted image of the Sun ought to appear on that part of the ring farthest from the Sun; and this image has never been seen, even when a refraction of only 12′ would have produced it ... while a much smaller amount of refraction will explain the transit phenomena satisfactorily.

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ROMANIAN ASTRONOMY AND THE 1874 TRANSIT OF VENUS

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Abstract: The 1874 transit was an event that attracted world-wide attention, and many nations arranged observing stations within their own territories or organized international expeditions in order to try and contribute to one of the most challenging problems in astronomy at the time: the value of the solar parallax (and hence the 'astronomical unit'). Romania was also involved in these exploits when two Austrian astronomers, Edmund Weiss and Theodor von Oppolzer, came to Jassy to observe the transit, with assistance from two Romanian astronomers, Stefan Micle and Neculai Culianu. In this paper I describe the state of Romanian astronomy at this time before providing an account of the transit observations.

Keywords: 1874 transit of Venus, Romania, Neculai Culianu, Stefan Micle, Theodor von Oppolzer, Edmund Weiss

1 INTRODUCTION

On 5/6 June 2012 a celestial event will take place which none of our contemporaries will ever have the chance to see again: there will be a transit of Venus. This is an opportunity to recall those famous observations that aimed to measure the distance between the Earth and the Sun, namely the astronomical unit.

Impressed by the large number of observations registered around the world during the eighteenth and nineteenth century transits (see Sheehan and Westfall, 2004; Woolf, 1959), I naturally wondered what impact these events had on Romanian astronomy. There are occasional records that seem to refer to phenomena of this kind, but the first truly professional observations were made during the 1874 transit in Jassy, an important university center in the north-east of present day Romania, by a team including the Austrians, Theodor von Oppolzer and Edmund Weiss, and two Romanian astronomers, Stefan Micle and Neculai Culianu. This transit was a challenge for Romanian scientific astronomy, which was still in its formative stage (see Botez, 2008; Stavinschi, 2010; Stavinschi and Mioc, 2008).

The 1874 transit took place at a time when important technical innovations had occurred in astronomy, especially in the field of astronomical photography, which was to play a key role in many transit expeditions (Lankford, 1987). This transit was visible from China, Japan and elsewhere in Asia, through to Australia, New Zealand and Oceania (Orchiston 2004; Orchiston and Buchanan, 1993; Orchiston et al., 2000). The Astronomer Royal, Sir George Airy (1881), co-ordinated eight British expeditions (see Ratcliff, 2008), including one to Hawai'i (Chauvin, 2004) and another to New Zealand (Orchiston, 2004). In Russia the event was observed from twenty-four stations, spread out from the Sea of Japan in the east to the Black Sea in the west (Werrett, 2006). The French organized three expeditions (Dumont, 2004; Lauga, 2004), to China, Japan (Débarbat and Launay, 2006) and Indochina, under the leadership of G.-E. Fleuriais, J. Janssen, F. Tisserand and A. Heraud, and three others to the southern hemisphere, under the leadership of A. Bouquet de La Grye, E. Mouchez and C. André . On that occasion, Jules Janssen invented a type of 'photographic revolver' that allowed him to take 48 successive images of the transit (Launay and Hingley, 2005).

The number of expeditions organized for the 1882 transit was even higher (Sheehan and Westfall, 2004): we mention here only those to North and South America, Haiti, Mexico, Martinique, Florida, Patagonia, Chile and South Africa (Duerbeck, 2004a; 2004b; Koorts, 2003; 2004; Sterken and Duerbeck, 2004).

On the basis of the observations made during these two transits and the two eighteenth century ones, Newcomb (1895) calculated a value for the solar parallax of 8.794 ± 0.018″,[1] that compares very favourably with the currently-accepted value of 8.794148 ± 0.000007″ which is based on radar measurements and was adopted by the IAU in 1976 (see Dick et al., 1998: Table 1, page 223).

2 ROMANIAN ASTRONOMY DURING THE NINETEENTH CENTURY

On 24 January 1859 the Principalities of Moldavia and Wallachia merged together as 'the United Principalities' under the leadership of Alexandru Ioan Cuza, but it was only in 1866 that the Romanian state was proclaimed and the name 'Romania' was formally adopted.

One of the first measures Cuza took for the prosperity of the new state was to set up universities in the two former capitals: the University of Jassy in 1860 and the University of Bucharest in 1864. They represented a modernization of the traditional education system, which was still far from the typical Western one due to the very complicated political situation in this part of Europe.

Astronomy was among the first scientific disciplines offered at the new University of Jassy, and from the start it was taught by Neculai Culianu (1832–1915), a member of a famous Culianu – Nanu – Zarifopol family of Romanian intellectuals and renowned aristocrats.[2]

Prior to joining the University Culianu was a mathematician at the Mihailean Academy, and since astronomy was primarily celestial mechanics at this time, it was taught mostly by mathematicians. Following his appointment, Culianu occupied all the positions in the Jassy University hierarchy, ending as Rector between 1880 and 1898; he also remained the Dean of the Sciences Faculty until 1906, the year of his retirement.

Culianu was the author of the first textbook on mathematical analysis published in Romanian, the English translation of its title being *Lectures on Differential and*

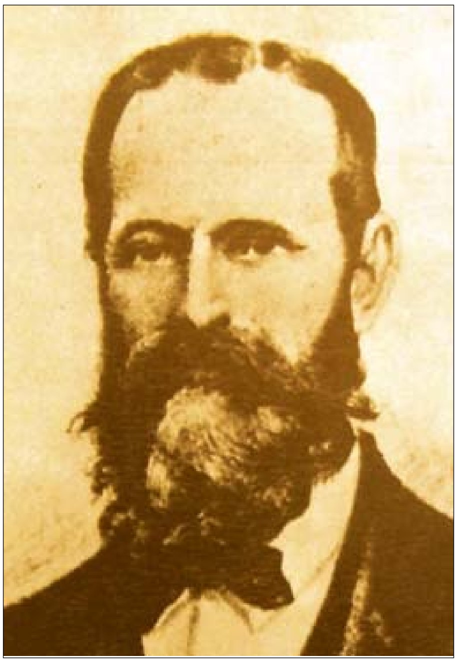

Figure 1: Stefan Micle (courtesy: www. vesperala. com/uploads/1242654943/gallery_1_81_24429. jpg).

Integral Calculus (1870); he also wrote a book, in Romanian, titled *Course in Cosmography* (1873; my English translation). He was a founding member of the journal *Scientific Recreations*; a member of Junimea (an influential literary society); the President of the Jassy Section of the Cultural League; and a member of the Romanian Academy (which was set up in April 1866). He was also the President of the Senate between 1892 and 1896.

Another staff member who taught astronomy at Jassy University was Professor Stefan Micle (1820?–1879), who was one of a series of Romanian professors who came from Transylvania, a province which only joined Romania in 1918. Together with other colleagues from over the Carpathians, Micle (Figure 1) contributed in his own way to the renewal of the traditional links between members of the Romanian academic community.

Figure 2: Theodor Ritter von Oppolzer (courtesy: www.univie.ac.at/EPH/Sofi/ sf1999/englhs.html).

Apparently, these two remarkable astronomy professors from Jassy University were little known in their own country for their scientific contributions, but they were well respected abroad, and this explains their collaboration with the Austrian astronomers Theodor von Oppolzer and Edmund Weiss during the 1874 transit of Venus.

3 THE AUSTRIAN COLLABORATORS

3.1 Theodor Ritter von Oppolzer

Von Oppolzer (Figure 2) was born in Prague on 26 October 1841 and died in Vienna on 26 December 1886 (Obituary …, 1887). From an early age he was interested in astronomy, and had his own private observatory. However, he followed in his famous father’s footsteps and studied medicine at the University of Vienna, but by the time he graduated with a doctoral degree of medicine in 1865 he had already published a number of papers in astronomy. In 1866 he was appointed a Lecturer in Astronomy at the University, and in 1871 he also accepted the Directorship of the Austrian Geodetic Survey. In 1875 he was promoted to Professor of Celestial Mechanics and Geodesy at the University of Vienna. He was elected a member of the Imperial Academy of Sciences of Vienna in 1882 and of the American National Academy of Sciences in 1883, and in 1886 he became the President of the International Geodetic Association (E.W., 1887).

Von Oppolzer was a remarkably productive nineteenth century astronomer, one of his biographers commenting that “We may well be astonished at the vast amount of work which he accomplished in his short life.” (Obituary …, 1887: 309). For instance, he wrote more than 300 research papers, most of which related to the orbits of comets and asteroids.

In 1868 von Oppolzer took part in a solar eclipse expedition, after which he decided to calculate the parameters of as many solar and lunar eclipses as possible. The result of this industrious endeavour was his famous *Catalogue of Eclipses* (*Canon der Finsternisse*) of 1887, in which he brought together information on about 8,000 solar eclipses and 5,200 lunar eclipses that had taken place or would take place between 1207 BC and AD 2161 (solar eclipses) and 1206 BC and AD 2163 (lunar eclipses). At the time, this was “… one of the greatest works of calculation which has ever been accomplished by man.” (Obituary …, 1887: 310), and it has remained a standard reference work through to the present day.

Von Oppolzer’s premature death at the age of 45 did not allow him to finish his other major project, a detailed investigation of the motion of the Moon (E.W., 1887), but his work was continued by his son, Egon Ritter von Oppolzer.

3.2 Edmund Weiss

Another remarkable Austrian astronomer was Edmund Weiss, who was born on 26 August 1837 in Fryvaldov, which was then in Austrian Silesia but is now in the Czech Republic. His father, Josef Weiss, was a surgeon who worked in hydrotherapy, and in 1842 he took the family to England. There Edmund attended primary school, only returning to Austria in 1847 after his father’s death. He then attended secondary school in Troppau. He was mostly interested in the natural sciences, in mathematics, physics and astronomy. In 1855 he graduated from high school with 'excellent' grades and began his studies in the Faculty of Philosophy at Vienna University (Crommelin, 1918).

In 1858 upon completing his degree Weiss was offered the position of Assistant at the Imperial Astronomical Observatory, and in 1860 he completed his studies with a doctorate in philosophy. In 1862 he was promoted to Associate Astronomer at the Observatory, and in 1879 he succeeded Karl von Littrow as Director. He retained this post until his retirement in 1910 (ibid.). Arguably, Weiss' greatest achievement as Director was the acquisition of the celebrated 27-in Grubb refractor, which for a short time was the largest refracting telescope in the world.

Weiss was appointed a Lecturer in Mathematics at Vienna University in 1861, the year after he completed his doctorate, and by 1869 he was an Associate Professor. He was promoted to full Professor in 1875 (ibid.). Among his students was Tomas Masaryk, who would become the first President of the Czech Republic.

As a researcher, Weiss is known mainly for his studies of comets, meteors and minor planets. He

> … perfected new methods for finding the improved orbits of these bodies. Weiss investigated the orbits of meteors and demonstrated an association between the Lyrids and comet C/1861 G1 (Thatcher) and between the Andromedids and comet 3D/Biela. From these associations, he developed the accepted view that meteors are the disintegration products of comets. (Schnell, 2007: 1202).

This work won Weiss international acclaim, and among those who showed their appreciation was Alexander Herschel (the grandson of the famous discoverer of Uranus), who was himself an authority on meteors (Millman, 1980).

Apart from taking part in the 1874 transit of Venus expedition to Jassy, Weiss organized or participated in solar eclipse expeditions in 1861 (Greece), 1867 (Dalmatia), 1868 (Aden) and 1870 (Tunis). This led to a growing interest in solar physics, and he became an active member of the International Union for Solar Research (Crommelin, 1918). He was an honorary member of the Royal Society of London, was awarded an honorary doctorate by Dublin University and received a knighthood (being a counselor at the Emperor's court). Edmund Weiss died in Vienna on 21 June 1917 after a long and productive life (ibid.).

4 ROMANIAN OBSERVATIONS OF THE 1874 TRANSIT OF VENUS

Von Oppolzer and Weiss came to Jassy to observe the 8 December 1874 transit of Venus and to determine the latitude and longitude of the observation site, and their results were recorded in *Astronomische Nachrichten* (see Oppolzer, 1875a).

The choice of an observing site was difficult to make, because the town has hills and valleys, and the Sun would be rather low that winter day. Thus, several days of field observations were necessary, when von Oppolzer and Weiss received help from the Austrian Consul, Professors Culianu and Micle, and from the Romanian authorities. Finally they decided to set up their instruments in the garden on the southern side of the prefect's office, one of the few sites in Jassy where the surrounding hills only masked the horizon by 1-2°. Furthermore, the telegraph had recently been linked to the prefect's office, which was a great help when it came to determining the longitude of the observing site. Weiss mounted a transit instrument of 8 inches aperture on a corner of an interior garden wall, and the distance to the middle of the southern middle pavilion in the prefect's office was found to be 36 meters and its azimuth 156.4°. The prefect's office was already connected by telegraph to St. Haralambie Church, whose geographical co-ordinates had previously been determined by Otto Struve using the telegraphic connections between the Church, Cernauti and Krakow. Meanwhile, they derived the following co-ordinates for the Jassy transit station (Oppolozer, 1875a):

Longitude	$01^h\ 41^m\ 00.41^s$ E of Paris
	$00^h\ 44^m\ 49.70^s$ E of Vienna
Latitude	$47°\ 09'\ 25.2'' \pm 0.2''$ N.

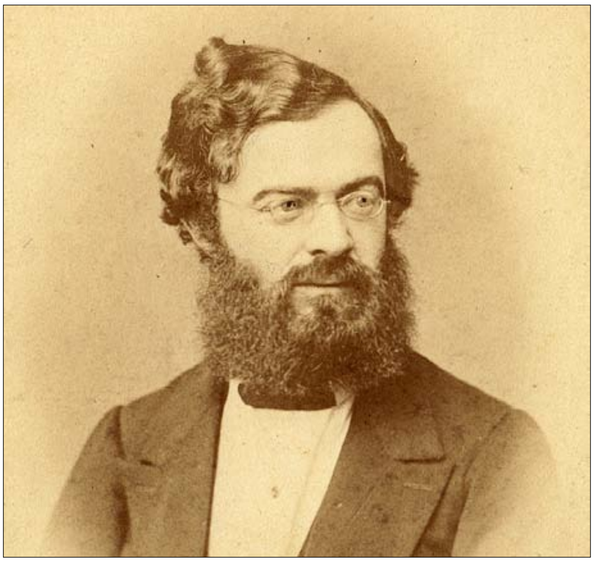

Figure 3: Edmund Weiss (courtesy: en.wikipedia.org/wiki/Edmund_Weiss.jpg).

Several details relating to the observation of the transit by von Oppolzer and Weiss are worth mentioning. In Jassy, on the early morning on 8 December the sky was clear and images of the stars were steady near the horizon. Shortly before sunrise a thick fog rose from the river valley and rapidly covered the entire city. However, as soon as the Sun rose the fog began dissipating, but unfortunately not quickly enough to permit observation of the first contact during the transit. Using a 4-inch Schaffler refractor with a Steinheil objective and a magnification of 60×, Venus could then be seen passing across the solar disk. As the ingress phase approached, the fog dissipated even more, and when the third and fourth contacts occurred it was only a very thin veil; but the solar images continued to be unstable.

In spite of the atmospheric turbulence, the second contact was timed at 13h 36m 50s (local time) using a Molineux chronometer. Knowing the longitude, the correction of the chronometer was calculated, and the moment of the fourth contact was timed at 20h 25m 56.7s. Because of the unsteady seeing, the precise time of the contact was estimated to be several seconds earlier.

5 CONCLUDING REMARKS

Further details of the observations of the 1874 transit of Venus made from Jassy are included in the papers published by von Oppolzer (1875b) and Weiss (1875) in *Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften in Wien*. From a national perspective, however, these scientific observations marked an important—albeit little-known—page in the annals of Romanian astronomy.

6 NOTES

1. Note that the quoted error is a 'probable error', which is 74% of the 'mean error' or 'standard error' that we use today.
2. One of the best-known members of this family is Ioan Petru Culianu (1950–1991), who is the author of more than fifteen books on science and literature and is a unique figure in the history of religion field.

7 ACKNOWLEDGEMENTS

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THE M51 MYSTERY: LORD ROSSE, ROBINSON, SOUTH AND THE DISCOVERY OF SPIRAL STRUCTURE IN 1845

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Abstract: In April 1845 Lord Rosse discovered the spiral structure of M51 with his 72-inch reflector at Birr Castle. Already in March the new telescope had been pointed at the object in Canes Venatici, later nicknamed the 'Whirlpool Nebula'. Two experienced astronomers were present: Sir James South and the Reverend Thomas Romney Robinson. The problem is that there is no record that they noticed the spiral structure, even though it was immediately seen by Lord Rosse the next month. The solution presented here is based on evidentiary facts, highlighting the nineteenth century astronomical praxis. Focal points are bias, fantasy and a sometimes fatal conspiracy of eye and brain.

Keywords: Spiral structure, nebulae, star clusters, Lord Rosse, Birr Castle, Leviathan of Parsonstown, Whirlpool Nebula, nebular hypothesis, visual observation, drawings.

1 DISCOVERY OF M51 AND JOHN HERSCHEL'S 'RING NEBULA'

M51 (NGC 5194) is a nearby Sbc-galaxy with a visual magnitude 8.4 and a size of 11.2′ × 6.9′. It was discovered on 13 October 1773 by Charles Messier (1730–1817) with a 3.5-inch refractor at Paris. The description, published in his famous catalogue of 1781, reads: "… very faint nebula without stars …" (Messier, 1781: 247).[1] The next to observe the object was Johann Elert Bode (1747–1826), using a 3-inch refractor in Berlin. On 5 January 1774 he saw a "… small faint luminous nebula, possibly of an oblong shape …" (Bode, 1782) and made the first sketch (Figure 1) of this object. The peculiar companion, NGC 5195 (9.6 mag, 5.9′ × 4.6′), was found on 31 March 1781 by Pierre Méchain (1744–1804) with a 3-inch refractor. Then William and John Herschel took over at Slough, directing their large metal-mirror telescopes to the famous double nebula.

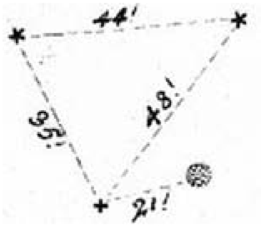

Figure 1: Bode's sketch of M51 (after Bode, 1782: Figure 15).

William Herschel (1738–1822) observed M51 four times with three different reflectors (Bennett, 1976): on 17 September 1783 with a 6.2 inch, on 20 September 1783 with a 12 inch (Herschel, 1785), and on 12 May 1787 and 29 April 1788, on both occasions with an 18.7 inch (see Dreyer, 1912: 657). In 1787 he independently found NGC 5195, listing it as I 186 in his first catalogue of nebulae and star clusters (Herschel, 1786). During his 1787 observation he noted: "Very bright, large; surrounded with a beautiful glory of milky nebulosity with here and there small interruptions that seem to throw the glory at a distance." Alas, he never observed M51 with his 48-inch reflector, completed in 1789—it might have shown the spiral structure.

There are also six observations by William Herschel's son John (1792–1871), on 17 & 20 March 1828, 26 & 27 April 1830, 13 May 1830 and 7 March 1831. schel, 1833). On 26 April 1830 the famous drawing was made (and checked the next night), showing the core, surrounded by a divided ring (Figure 2); it appears as Figure 25 in the Slough catalogue. Herschel

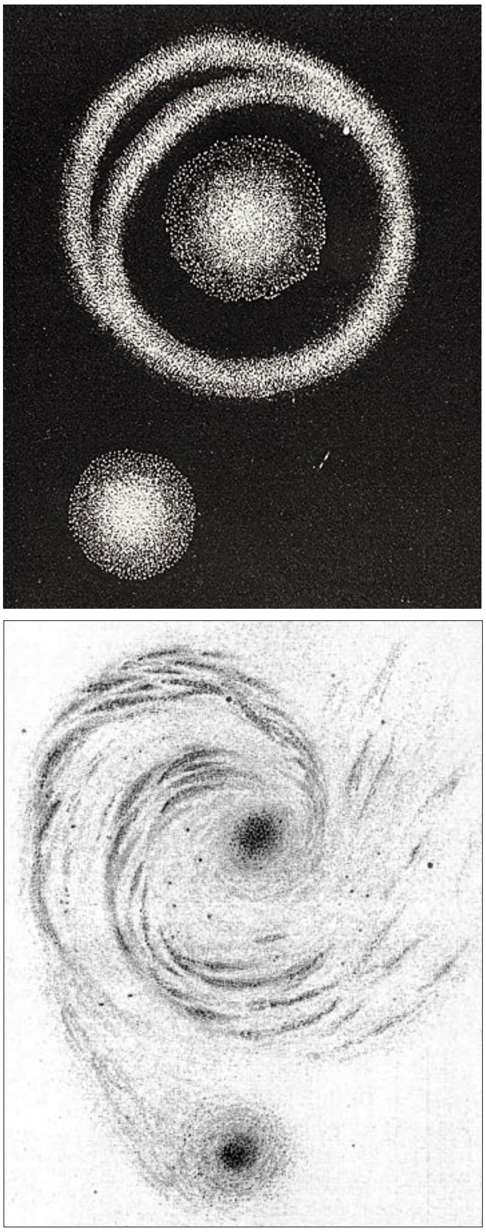

Figure 2: John Herschel's drawing of M51 (top, after Herschel, 1833: Figure 25) compared (bottom) with Lord Rosse's drawing (after Nichol, 1846; rotated, mirror-reversed and inverted).

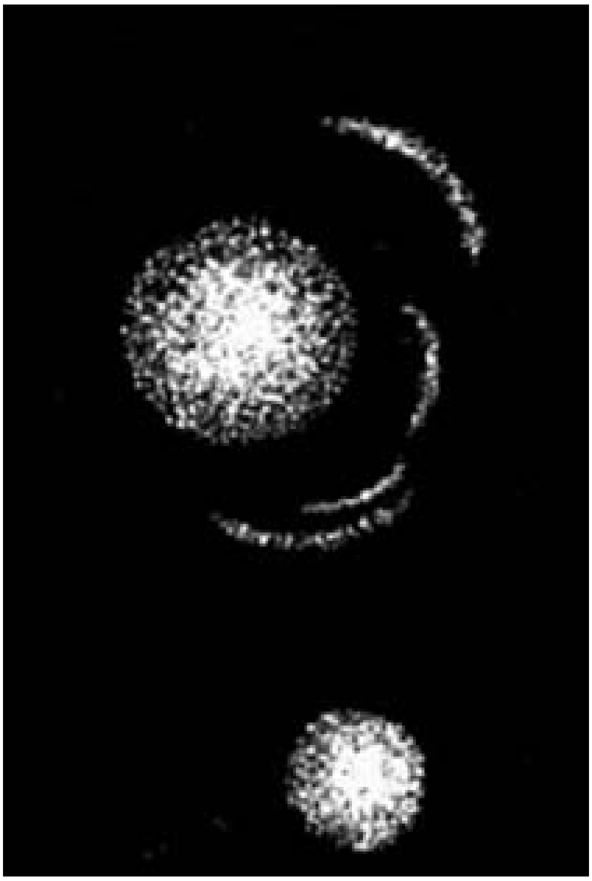

Figure 3: Smyth's sketch of M51 (after Chambers 1891: 74, Figure 55).

noted in his observing journal: "It is a very bright nebula 1′ in diameter of a resolvable kind of light with a double ring or rather 1½ ring like an armillary sphere." (cited by Hoskin, 1987: 12). He further wrote: "Were it not for the subdivision of the ring, the most obvious analogy would be that of the system of Saturn, and the ideas of Laplace respecting the formation of that system would be powerfully re-called for that object." (Herschel, 1833: 497). Here Herschel refers to the 'nebular hypothesis', which will be discussed later. Because the reflector was used as 'front-view' (the eye-piece pointing directly at the main mirror), the image is reversed. A comparison with Lord Rosse's drawing shows that the division correlates with the most prominent spiral arms. In 1836 William Henry Smyth (1788–1865) observed M51 with his 5.9-inch refractor. His sketch (Figure 3) and description ("… bright centre surrounded with luminosity, resembling the ghost of Saturn …") look like a copy of John Herschel's result (Smyth, 1844: 302).

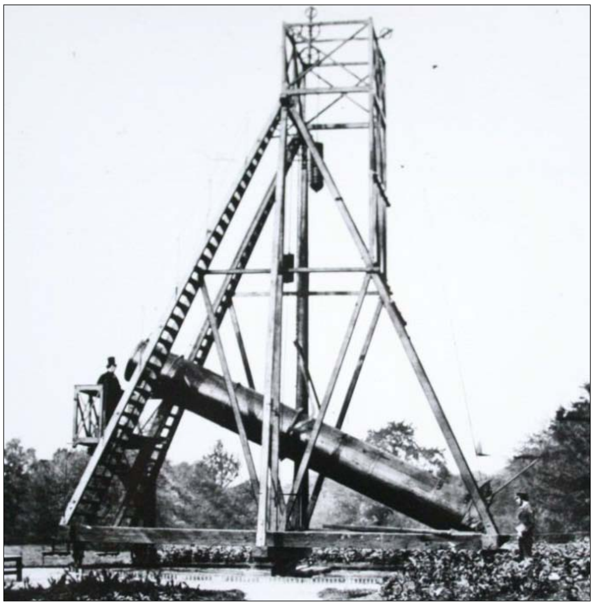

Figure 4: The 36-inch reflector (courtesy: Birr Castle Archive).

2 EARLY OBSERVATIONS OF NEBULAE AT BIRR CASTLE

Birr Castle, located near Birr (formerly Parsonstown) in the centre of Ireland, was actually not a good site for astronomical observation, as too often the weather was bad. But it was the ancestral seat of William Parsons, the 3rd Earl of Rosse, better known as Lord Rosse (1800–1867), and it was there that he had built his giant, metal-mirrored telescopes (Woods, 1844). With the azimuthally mounted 36-inch Newtonian of 1839 (Figure 4) M51 was "… repeatedly observed …" (Parsons, 1850: 510). The first documented observation dates from 18 September 1843. Using a magnification of 320×, Lord Rosse reported: "… a great number of stars clearly visible in it, still Herschel's ring not apparent, at least no such uniformity as he represents in his drawing." (ibid.). About fifty observations of M51 were made until 1878 (Parsons, 1880). On 11 April 1844 Lord Rosse wrote: "… two friends assisting both saw centre clearly resolved." (Parsons, 1850: 510). The two friends were the Director of the Armagh Observatory, the Reverend Thomas Romney Robinson (1792–1867) and the noted English double star observer, Sir James South (1785–1867), both of whom were frequent visitors to Birr Castle. The focus was on 'resolvability', and Robinson in particular was convinced that true nebulosity did not exist and that all nebulae were merely star clusters. However, there were intractable targets, like the Orion Nebula (M42). Thus proof was purely a matter of aperture, and Lord Rosse had built the required instruments.

His largest was the 'Leviathan of Parsonstown' (Figure 5), a 72-inch Newtonian on a meridian mounting (Hoskin, 2002). However, it was not a true transit instrument in that the tube could be shifted horizontally (i.e. in azimuth) around the south direction. The total linear range was about 7.8 feet. By turning a handle near the eye-piece (Newtonian focus) the tube moved along a cross-bar with a cogwheel. So an object could be tracked for a certain time. The azimuthal range—and thereby the maximum observing time—depended on its altitude when crossing the meridian. Objects near the celestial equator were observable for about 45 minutes from the front platform. Towards the zenith, the time increased and reached about 70 minutes at 85°. Now one stood on the highest (fourth) gallery, nearly 60 feet above the ground, as the gallery followed the motion of the telescope tube (see Figure 6).

In September 1844 the great reflector was ready for a test and it showed the globular cluster M2 in Aquarius. However, official 'first light' only was on 11 February 1845, and was witnessed by Robinson and South. On this occasion, Lord Rosse and his guests only saw Sirius and "… some nameless clusters." (Hoskin, 2002: 64) before bad weather terminated all

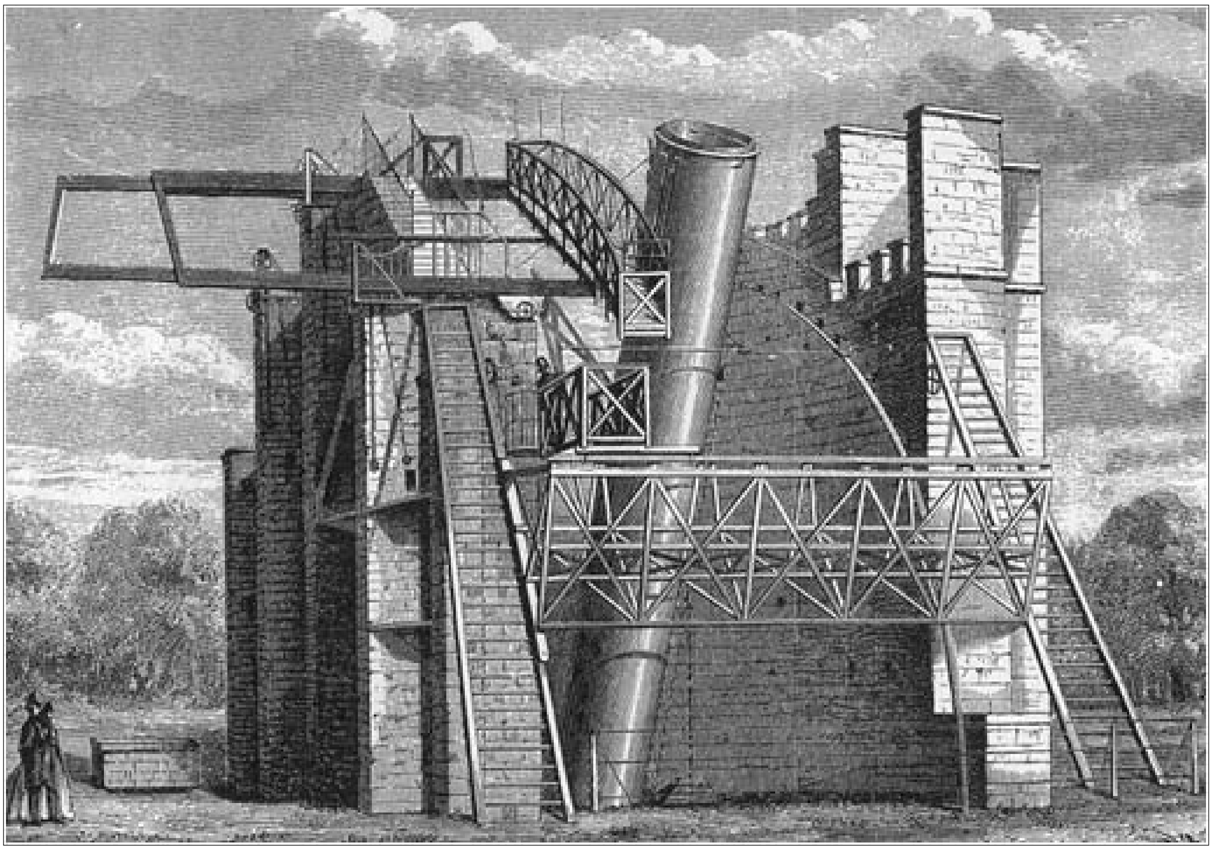

Figure 5: The 'Leviathan of Parsonstown' (courtesy: Birr Castle Archive).

astronomical activity (and did not improve until early March). The three astronomers were disappointed as their key target, the Orion Nebula, was missed and its resolvability was not tested. However, the period from 4 to 13 March 1845 was very clear and stable (New Moon was on the 8th), but at lower than –8° C the nights were unusually cold for Ireland.

There are two independent observational reports by Robinson and South—but there is none by Lord Rosse! On 14 April Robinson gave a talk to the Royal Irish Academy in Dublin, which was printed in their *Proceedings* later that year. There he explained that "… most of the lucid interval from the 4th to the 13th of March was devoted to nebulae." (Robinson, 1845: 125). Moreover, in his observing journal he enthusiastically noted: "… of the 43 nebulae which have been examined *All* have been resolved" (Hoskin, 1990: 339; my italics). South preferred a quicker line of communication: the *London Times*. On 16 April he reported an exceptional event:

> … the night of the 5th [to the 6th] of March was, I think, one of the finest I ever saw in Ireland. Many nebulae were observed by Lord Rosse, Dr. Robinson and myself. Most of them were, for the first time since their creation, seen by us as groups or clusters of stars; whilst some, at least to my eyes, showed no such resolution. (South, 1845).

Concerning the crucial subject of 'resolvability', South sounded more moderate than Robinson. It should also be mentioned that Robinson's statement about "… 43 nebulae …" is a little confusing, because only 39 objects are mentioned in his list (Robinson, 1845: footnote on p. 127). In 1848 he even speaks of "… above fifty nebulae selected from Sir John Herschel's catalogue." (Robinson, 1848: 119).

Figure 6: The 72-inch in a near-zenith position. The cross-bar for the azimuthal motion is at the upper third of the 60-foot (18-m) tube; the highest gallery is on top of the western wall (photograph by the author).

3 M51: DIFFERENT VIEWS IN MARCH AND APRIL 1845

The exceptional night from the 5th to the 6th of March also brought the first observation of Herschel's 'ring nebula', M51, with the new reflector. Could the resolution of the core be confirmed, and would the ring appear now? Robinson's (1845: 128f) record on the observation made about 3 a.m. on 6 March sounds positive:

> … the central nebula is a globe of large stars; as indeed had been previously discovered with the three-feet telescope: but it is also seen with 560 that the exterior stars, instead of being uniformly distributed as in the preceding instances, are condensed into a ring, although many are also spread over its interior. (Robinson, 1845: 128f).

Though there is no lead on the division of the ring, it was now seen as an aggregation of stars. South (1845) gives a similar opinion:

> The most popularly known nebulae observed this night were the ring nebulae in the Canes Venatici, or the 51st of Messier's catalogue, which was resolved into stars with a magnifying power of 548 [560]; and the 94th of Messier, which is in the same constellation, and which was resolved into a large globular cluster of stars, not much unlike the well-known cluster in Hercules, called also 13th Messier.

It is interesting that M94 was seen as a 'ring nebula' too. Actually, the prominent inner spiral arm of the Sa-galaxy is closed. Robinson (1845: 128) described it as "… a vast circular cluster of stars, with ragged filaments, in which, and apparently central, is a globular group of much larger stars." Concerning M51, the essential point is that both observers mention only known features: the resolved centre and the ring. There is absolutely no word about spiral structure!

This discovery was made a month later—by Lord Rosse alone. Unfortunately, the exact date is not recorded. In 1850 Lord Rosse wrote: "The spiral arrangement of Messier 51 was detected in the spring 1845." (Parsons, 1850: 505), and John Louis Emil Dreyer (1852–1926), Robinson's successor at Armagh Observatory and author of the *New General Catalogue* (Steinicke, 2010), is barely more precise. During his appointment at Birr Castle (1874-1878) he edited all of the earlier observing notes for a publication, which appeared in 1880. There one reads:

> 1845, Apr. During this month M. 51 was for the first time examined with the 6 foot and its spiral character immediately noticed, but no record is left of these early observations. (Parsons, 1880: 127).

However, local conditions limit the date (unfortunately, there are no weather reports). From the culmination time of M51 and the phase of the Moon the interval between 1 and 12 April is most likely. On the 1st the nebula crossed the meridian at 1:19 a.m. and the Moon rose at 3:28 a.m. (one day after Last Quarter), while on the 12th the transit was already at 0:35 a.m., and moonset was 2 minutes earlier (two days before First Quarter). Thus the most probable date is 6 April (New Moon), when M51 culminated at 0:58 a.m., 85° above the horizon.

4 THE M51 MYSTERY

The crucial question is: Why was the spiral structure not discovered back in March 1845? In 2005 Mark Bailey, John Butler and John McFarland of Armagh Observatory tried to give an answer (Bailey et al., 2005). However, their conclusion is not really helpful: "It seems likely that Rosse, Robinson and South could have seen the spiral arrangement […] though there is no evidence that they noticed it." The main argument: "With their attention focused on the resolvability of the nebula, it is conceivable that none of the three would have found the spiral arrangement worthy of note."

Another question arises: was Lord Rosse even present when M51 was examined in March? South (1845; my italics) wrote: "Many nebulae were observed by *Lord Rosse*, Dr. Robinson and myself." But this sounds rather vague, and in Robinson's Royal Irish Academy talk he is not even mentioned: "Dr. R[obinson] and his friend Sir James South were invited to enjoy the trial of it [the reflector]." (Robinson, 1845: 119). One further reads that the nebulae "… were examined by Dr. Robinson and also by Sir James South." (Robinson, 1845: 127). Undoubtedly, Lord Rosse wanted to test the power of his new reflector on the clear nights. But he also had many official duties and thus needed his sleep. Robert Ball, Lord Rosse's last assistant, later wrote:

> … it was more the mechanical processes incidental to the making of the telescope which engaged his interest than the actual observations with the telescope when it was completed … [and his] special interest in the great telescope ceased when the last nail had been driven into it. (Ball, 1895: 287).

From Robinson's object list it follows that the earliest observation started about 9:45 p.m. (h 536 = NGC 2695 in Hydra) and the latest ended about 5:30 a.m. (h 1929 = NGC 5964 in Serpens); on the latter nebula Robinson (1845: 127) remarked that it was seen "… during twilight." Probably Lord Rosse had left the telescope to his guests, particularly during the second half of the night, and his sporadic attendance may have been the reason that he did not write a report. Regarding the M51 observation at about 3 a.m., it most likely took place without him. This is further supported by Dreyer's note on Lord Rosse's observation in April (mentioned above): "During this month M. 51 was for the first time examined with the 6 foot." The term "… for the first time …" indicates that he had not observed this object previously.

Assuming that Robinson and South actually discovered the spiral structure of M51 on that night back in March why didn't they report it especially since both were egoists and used every opportunity to increase their fame. Of course, such spectacular news would have been communicated immediately! Thus we have two possible explanations: either the structure was not perceived, or there were reasons for keeping the detection secret. As the latter option seems strange at the moment, we concentrate on the former. Then one must answer the question, Why was the structure "… immediately noticed …" by Lord Rosse in April? What were the differences between the two observations?

First, influencing factors like weather and telescope should be investigated. It seems unlikely that the sky was better in early April than during the "… lucid interval …" in March. Concerning the telescope, the most critical element was the speculum mirror which was made from an alloy of copper and tin. Due to chemical processes the reflectivity of the surface steadily decreased (i.e. the mirror tarnished), but on 3

March the mirror had been freshly polished and according to Lord Rosse it was still in good shape in April:

> In the early observations [1845] with the 6-feet telescope we had the advantage of a very fine speculum … there were also at that time several very good nights and many nebulae were resolved. Very soon after, the spiral arrangement was detected. (Parsons, 1861: 703).

The result: in comparison with March, weather and mirror were (at best) of equal quality in April—which only makes matters worse!

Did the eye-pieces play a role? Because the telescope had no finder, the object-search was effected with a three-lens eye-piece of 46 mm focal length, yielding a magnification of 360× and a 13.7′ field of view. For the very observation one changed to the standard eye-piece of 29 mm (power 560×, field 8′). Finally, to inspect details, often a 13 mm single-lens eye-piece was used. At a power of 1280× the tiny field of 3′ only showed the central region of M51 (see Figure 7). No doubt, the same eye-pieces were used in March and April, but perhaps there was a difference in their application, which will be discussed later. After considering all of these external factors, it remains a mystery as to why the spiral structure of M51 was overlooked in March.

After Bailey, Butler and McFarland (2005), the case was next treated by the American astronomer Trevor Weekes (2010). He presents no definite solution, but does offer five possible explanations: (1) "The unusual structure of the nebula M.51 was not noticed in March 1845, because the attention of the [three] observers was concentrated on the question of its resolvability." This matches the main argument of Bailey, Butler and McFarland. (2) "The observing conditions were inferior in March 1845, in which case the spiral structure of M.51 was not so obvious as it was in April." This seems unlikely as explained above. (3) "There were too many observers in March (including nonprofessional visitors) so that it was difficult for one observer to really concentrate on what he was seeing." However, I am convinced that only Robinson and South were present during the crucial observation. (4) "The three astronomers noticed the spiral structure of M.51 in March 1845 and realized its importance, but Robinson and South left it to their host [Lord Rosse] to verify the following month, so that the discovery would be his alone." This does not agree with the personalities of the three people. For instance, Lord Rosse would have authorized his guests to communicate such a discovery, if he was not able to do so himself. (5) "The spiral structure of M.51 only became convincing when its image was systematically examined and committed to paper." This disagrees with Lord Rosse's statement that the "… 6-feet aperture so strikingly brings out the characteristic features of 51 Messier." (Parsons, 1850: 504).

No doubt, there must be a plausible solution to the mystery. In the following section I will present my own hypothesis. It is based on factors which were not taken into account in the two former papers.

5 A LIKELY SOLUTION

I have come to the conclusion that it was a matter of psychology, and my investigation focused on internal factors: ideology and stress. At Birr Castle an ambitious observing program was executed which aimed to disprove the popular 'nebular hypothesis'. Following Pierre-Simone de Laplace (1729–1827), William Herschel and John Pringle Nichol (1804–1859), Director of the Glasgow Observatory, this hypothesis claimed the existence of true nebulosity in space. By gravity such a 'luminous fluid' rotated, and due to friction it lost speed, gradually contracting to form a central star. First this idea described the formation of the Solar System (and particularly of Saturn), but later it was applied to nebulae, stars, clusters and even our own galaxy. A key object was the bright planetary nebula NGC 1514 in Taurus, William Herschel's (1791) "… star with an atmosphere."

Robinson was an uncompromising opponent of the nebular hypothesis. The Reverend, representative of the Church of Ireland, headed the fight against 'materialists' like the Scot Nichol (Bennett, 1990). In his static system of the world, God had created the stars, and there was no room for nebulous matter and evolution. To prove his view, as many nebulae as possible had to be resolved. Robinson—user of a 15-inch telescope with metal mirror at Armagh—pushed Lord Rosse to build ever larger instruments. After having applied the 36-inch against the hated idea and its secular advocates, the twice as large 'Leviathan' became his ultimate weapon. He had to accomplish a mission, thus instruments, methods or persons must take a subordinate role. Lord Rosse and South gave him his head and forewent independent observations. Influenced by Robinson, they both confirmed the 'resolvability' of many nebulae, including curious cases like M1 or M97, and even the Orion Nebula (M42) was added in the spring of 1846 (Hoskin, 1990: 339). However, their views were more moderate, and both tried to temper the enthusiasm of the Irish 'chief-ideologist'.

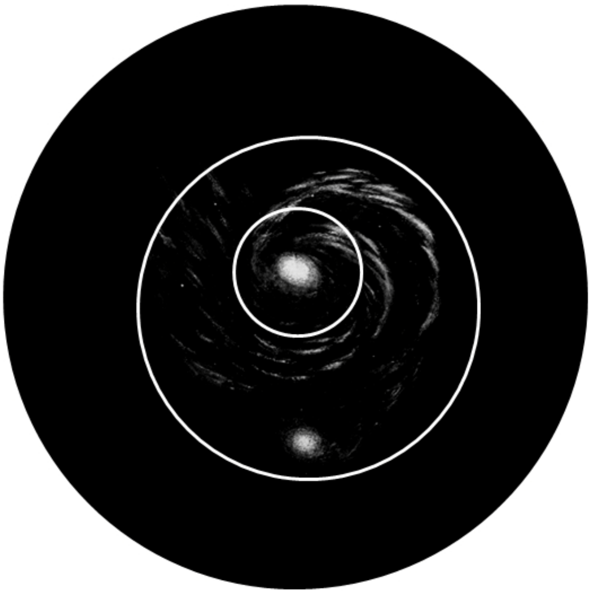

Figure 7: Fields of view of the applied eye-pieces: 13.7′ (finding), 8′ (standard) and 3′ (high-power); (diagram by the author; M51 sketch from Nichol, 1846, rotated).

No doubt, Robinson (1845) controlled the observing sessions. He compiled the target list from John Herschel's Slough catalogue, arranged the nightly observing program, selected the eye-pieces, and was the primary observer. Especially in the early days after the 'Leviathan' became operational, the Armagh astronomer was under great pressure. Being familiar with the inclement Irish weather, the unusually clear skies experienced in March 1845 made him hurry. Fully programmed for success, he wanted to get the desired results as soon as possible. Thus a maximum number of nebulae had to be resolved with the new reflector.

We now focus on the night from 5th to 6th March, three days before New Moon. Near-zenith objects like M51 were on the agenda. Thus, the highest observing gallery had to be used—a small, mobile and declivious construction, high above the ground (see Figure 6). Considering that Robinson and South had so little experience with the new telescope (it was only their second night using the instrument), this was a rather dangerous task. Robinson (1845: 122) even reported that making observations was "… rather startling to a person who finds himself suspended over a chasm sixty feet deep, without more than a speculative acquaintance with the properties of trussed beams."

To waste no time, the positioning of the telescope was exactly planned. According to South (1845), thanks to the aid of the technical helpers it took no more than eight minutes to get an object into the focus of the 72-inch. First, the long tube was lifted to the right elevation. Then it was shifted in azimuth to the eastern wall to catch the target as early as possible (when there was time enough). To read the relevant scales, there was a pretty bright illumination, which influenced the dark adaptation (Robinson, 1845: 122). After this procedure one expected the object to enter the eye-piece. Robinson (1848: 122) later reported: "In searching for known objects, there is, of course, occasional difficulty in finding them, from the small field of view." Once the object was visible, the tube had to follow it smoothly towards the west. This was not an easy task, as near the zenith a field diameter of 13.7′ was crossed in about 80 seconds (and with the high-power eye-piece the time was even less than 20 seconds). At the same time, the gallery also had to be moved. Moreover, any change of eye-pieces, or the replacement of an observer, used up further precious time.

According to South (1845), there was another target in Canes Venatici. This was M94, which at magnitude 8.2 was the brightest object in Robinson's list. It culminated at about 2:15 a.m. at 79°, and probably followed NGC 4025 (1:22 a.m., 75°) and NGC 4062 (1:28 a.m., 69°), both in Ursa Major, and NGC 4618, located only 1.7° west of M94 (2:05 a.m., 79°). Due to overlapping time slots, the maximum observing time of about one hour could never be used. Probably the complex procedure allowed only 15 minutes for the first observation of an object—which no doubt created a certain degree of stress. Therefore, after each successful 'resolution', the 72-inch was immediately set up for the next target. When eventually M51 was next (culminating about 2:54 a.m. at 85°), the observers had been exposed to the darkness and severe cold for many hours. Somewhat overcome by the exertion, their concentration had faded. The following scenario illustrates how the crucial observation could have happened.

Due to previously-discussed aspects (i.e. optimal weather and the fine condition of the mirror in March, and Lord Rosse's easy success in April), Robinson must have immediately perceived the spiral structure of M51 in the finding eye-piece, but he probably attributed the strange appearance to his weak level of concentration. As if this was not enough, his ideological conditioning forced him to dismiss the unwanted structure from his mind. He was unable to accept it, for as a sign of spinning (true) nebulosity it would confirm the nebular hypothesis. True to the motto "It can't be what shouldn't be", Robinson promptly concentrated on his mission: the resolution of this nebula. He changed to the standard eye-piece (power 560×), ignored any sign of spiral pattern, and instantly perceived Herschel's ring. Now his biased mind forced his eye to see flashing starlets all around. When he eventually applied the maximum power, the core appeared—as requested—like a 'globular cluster'. Lord Rosse later made the following illuminating point: "When certain phenomena can only be seen with great difficulty, the eye may imperceptibly be in some degree influenced by the mind." (Parsons, 1850: 503f).

It may sound harsh, but even a willful deception is thinkable. In this case, Robinson may have kept the truth to himself and prevented South from viewing M51 as a whole—otherwise this experienced British observer immediately would have detected the spiral pattern. The true nature of M51 had to be hidden, because Robinson's authority was at stake! With the argument of advancing time, the maximum magnification was retained and the view kept on the central 'globular cluster'. Obviously South accepted Robinson's procedure and, moreover, the 'resolved' centre met his experience—there was no reason for doubt. Then soon after this the observing session ended. Of course, Lord Rosse was informed the next day (for if he had also been involved that night, it might not have been so easy for Robinson to fool him too).

This also explains the lack of publication, mentioned above: obviously South did not notice anything out of the ordinary, and Robinson would report all but this heretical experience! Instead he proudly heralded to the Royal Irish Academy that Lord Rosse's giant reflector had served its purpose and that the intensive observations in March disproved the nebular hypothesis:

> … no REAL nebula seemed to exist among so many of these objects chosen without bias; all appeared to be clusters of stars, and every additional one which shall be resolved will be an additional argument against the existence of such. (Robinson, 1845: 130).

After the stress-filled days in March, Lord Rosse had gained sufficient experience with the 72-inch. In April the skies cleared up again and, at last, he could act freely and unhurriedly. The guests had left Birr Castle and there were no more ideological constraints. Although he always had little free time, he may have been motivated by the successful observations made by Robinson and South. It was probably on 6 April that Lord Rosse observed M51 "… for the first time." The meridian passage was about 0:52 a.m. at 85°. Obviously, the object was the only one observed that night and Lord Rosse was able to use the maximum observing time of 72 minutes. All decisions were in his hands, and his mind was open to new experiences.

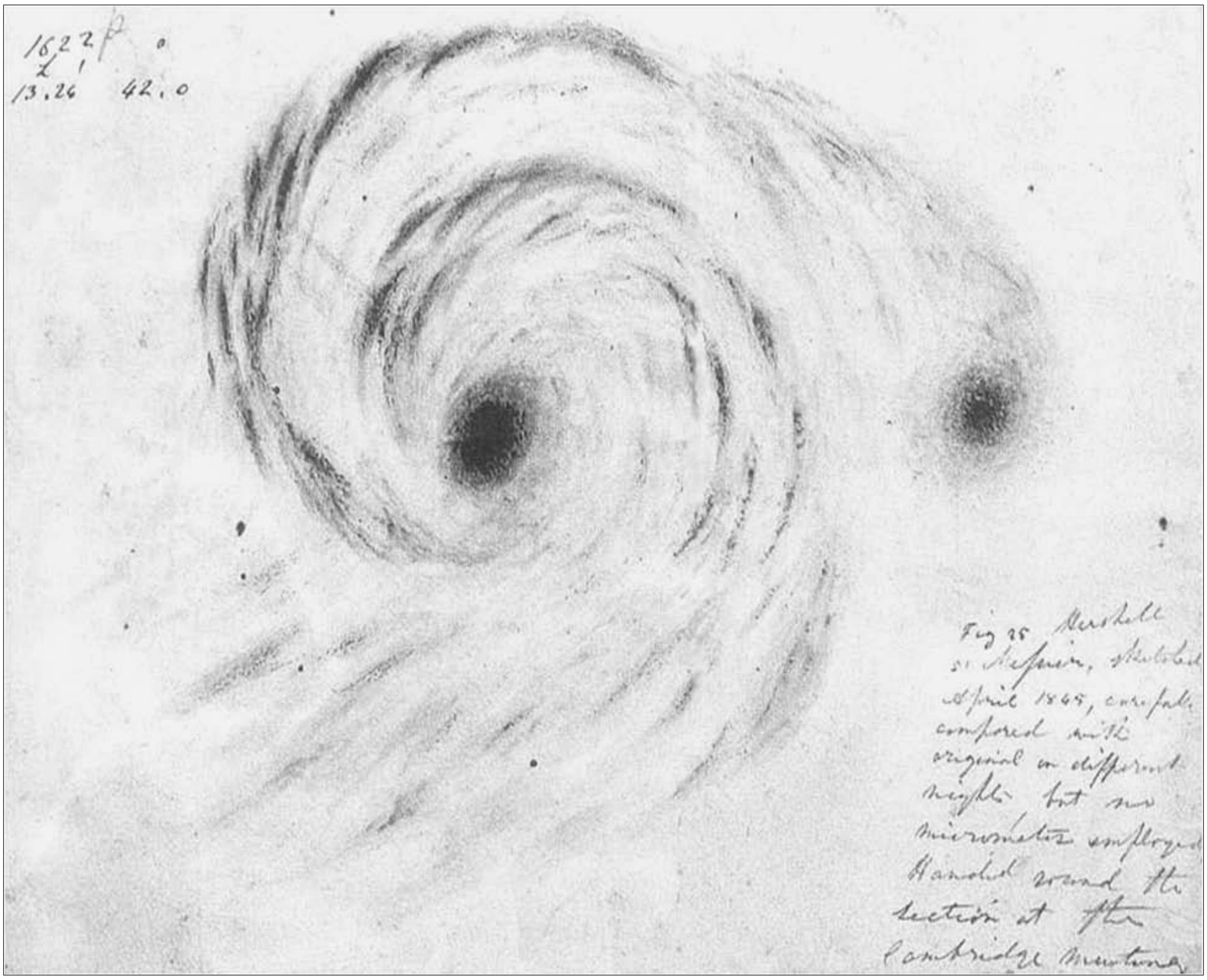

Fig 25 Herschell
51 Messier, sketched
April 1845, carefully
compared with
original on different
nights but no
micrometer employed
Handed round the
section at the
Cambridge meeting

Figure 8: Lord Rosse's first drawing of M51, made in April 1845 (after Hoskin, 1982).

In this context success was inevitable and Lord Rosse immediately saw the spiral structure when he looked through the finding eye-piece! Afterwards he used higher powers to study the new pattern in detail. He also may have been astonished that Robinson, the primary observer in March, had not recognized it. Perhaps here was some doubt about his sincerity. Lord Rosse was a scientist to the core. His moral character did not allow repressing the perceived structure or even hiding it. Ideological blinkers and willful blindness were alien to him. Obviously, South and Robinson were not informed directly (a willful act?), as both filed their reports in the middle of April.

6 LORD ROSSE'S FIRST DRAWING OF M51 AND THE SEARCH FOR SPIRAL NEBULAE

Of course, the important discovery had to be depicted, and so a drawing was developed (Figure 8) in the nights between 6 and 12 April 1845. Lord Rosse presented it on 19 June during his talk "On the nebula 25 Herschel, or 61 of Messier's catalogue", given at the 15th Annual Meeting of the British Association for the Advancement of Science in Cambridge (Hoskin, 1982). The term "25 Herschel" refers to Figure 25 from the Slough catalogue, while "61" is a typo (it should be "51"). The text on the drawing reads:

> Fig 25 Herschell [Herschel] 51 Messier, sketched April 1845, carefully compared with original on different nights, but no micrometer employed. Handed round the section at the Cambridge meeting.

Figure 9: Rambaut's M51 drawing of March 1848 (courtesy: Armagh Observatory; photograph by the author).

At the upper left corner we have "1622" (h 1622) and "13 . 26 42 . 0" (i.e. the right ascension is 13h 26m and the North Pole Distance 42° 0′). Ironically it was Robinson's nemesis, Nichol, who was the first to publish the drawing, in his book *Thoughts on Some Important Points Relating to the System of the World* (1846).

According to Lord Rosse, many visitors to Birr Castle benefited from this illustration: "… this nebula has been seen by a great many visitors, and its general resemblance to the sketch at once recognised even by unpractised eyes." (Parsons, 1850: 504). Moreover, he encouraged other astronomers:

> A 6-feet aperture so strikingly brings out the characteristic features of 51 Messier, that I think considerably less power would suffice, on a very fine night, to bring out the principal convolutions.

Indeed, the spiral pattern was later confirmed with much smaller apertures.

In March 1848 two further drawings of M51 were made at Birr Castle. We owe the earlier one to William Rambaut (1822–1911), Lord Rosse's first scientific assistant (Figure 9). The other one, Lord Rosse's second drawing, was published in 1850 and became the standard image of a spiral nebula (Figure 10; see Parsons, 1850: Fig. 1). Another drawing was finished on 6 May 1864 by Lord Rosse's last assistant, Samuel Hunter (Parsons, 1880: Plate IV, Fig. 1). It is interesting that the companion NGC 5195 is shown here as a 'spiral' (Figure 11). Altogether five drawings of M51 were made at Birr Castle, and these were complemented by many sketches that are in the observing journals.

The discovery of the spiral structure of M51 changed the research at Birr Castle:

> … after the spiral form of arrangement was detected … our attention was then directed to the form of the nebulae, the question of resolvability being a secondary object. (Parsons, 1861: 703).

That is, the focus was no longer on the nebular hypothesis. Gradually, doubts appeared that all nebulae were disguised star clusters. However, Lord Rosse did not generally question his own observations (e.g. the 'resolution' of M42), but he was open to new ideas if they looked physically reasonable.

The systematic search for spiral nebulae started at Birr Castle in 1848, soon after the disastrous Irish potato famine ended (during which the 72-inch was mainly idle). By 1861 no fewer than 76 cases had been documented, 67 of which were true spiral galaxies—an amazingly large fraction (Parsons, 1861). Strangely, among them were eleven objects which had been observed by Robinson and South. Two striking cases were NGC 2903 (h 604; Figure 12) and M65 (h 854) in Leo, and their spiral structures were detected by Lord Rosse on 24 March 1846 and 31 March 1848, respectively (Parsons, 1850: 511f and Figs. 3 and 7). Like M51, these should have been recognized as spiral galaxies in March 1845—raising the likelihood of two further 'Robinson cases'.

The nine non-spiral objects belonged to five (modern) classes: the planetary nebulae NGC 1514, NGC 6781, NGC 6905 and NGC 7662; the elliptical galaxies NGC 205 and NGC 5557; the irregular galaxy NGC 4485; the reflection nebula M78; and the globular cluster M12. For instance, NGC 1514 (h 311) in Taurus—William Herschel's key object—was described by R.J. Mitchell as a "… new spiral of an annular form." (Figure 13; Parsons, 1861: 714 and Plate 25, Figure 7).

Later Wilhelm Tempel (1821–1889), Director of the Arcetri Observatory in Florence, suggested that the Birr Castle observers showed a certain "… spiral addiction". He judged the spiral pattern to be an illusion:

> … one cannot fend off the thought that these forms and shapes are only figments of the imagination, even that their description and drawing can be recognised as an endeavour to assign this form to all nebulae. (Steinicke, 2010: Section 11.3.4).

This statement caused an open conflict with Dreyer in 1878, which Tempel eventually lost. Curiously, his own drawing shows indications of spiral arms (Figure 14).

7 THE EFFECT ON THE NEBULAR HYPOTHESIS AND THE SUBJECTIVITY OF VISUAL OBSERVING

The discovery of spiral nebulae lent credence to the nebular hypothesis. Nichol felt vindicated, as expressed in his books, *Thoughts on Some Important Points Relating to the System of the World* (1846) and *Architecture of the Heavens* (1851). These objects were testimonies of star formation from nebulous matter.

Of course, Robinson could not turn a blind eye to reality. Already on 11 March 1848—at the first M51 observation after Lord Rosse's—he confirmed the spiral structure with the 72-inch (although a check observation with the 36-inch was negative). This may sound odd when we have already suggested that Robinson actually detected spiral structure himself back in March 1845, but we must consider the authority of Lord Rosse which Robinson never questioned. Robinson could hardly question Lord Rosse and ignore (or even deny) the clear evidence of spiral structure yet again. Interestingly, Robinson did not change his ideology, thanks to a rather clever reinterpretation of the observational results. He postulated a rotating ensemble of cosmic "… bodies floating on a whirlpool …" (Robinson, 1848: 128) composed of stars! To him, the reality of nebulous matter was still denied.

From the modern point of view, we must confess that there are true elements in both ideas. The spiral arms host stars as well as 'nebulous matter' (gas and dust). But, according to the present density wave theory, the arms themselves are not truly rotating. Furthermore, matter does not end up gravitating to the centre (like in a whirlpool), where, according to the nebular hypothesis, a star should be born.

Today M51 is often called the 'Whirlpool Nebula'. As Tobin (2008) has shown, the term 'whirlpool' already appeared in the literature in 1833, in connection with the nebular hypothesis. Until 1847 it was only used to characterize a phenomenon rather than a real object. The first to call M51 the 'Whirlpool Nebula' was the American astronomer Ormsby Mitchel (1810?–1862). In 1847 he published a paper titled "Lord Rosse's Whirlpool Nebula" which included a copy of Lord Rosse's drawing that Nichol had published one year earlier (Mitchel, 1847). Nowadays it seems rather curious that gaseous nebulae like M42 or galaxies like M51 should be 'resolvable'.

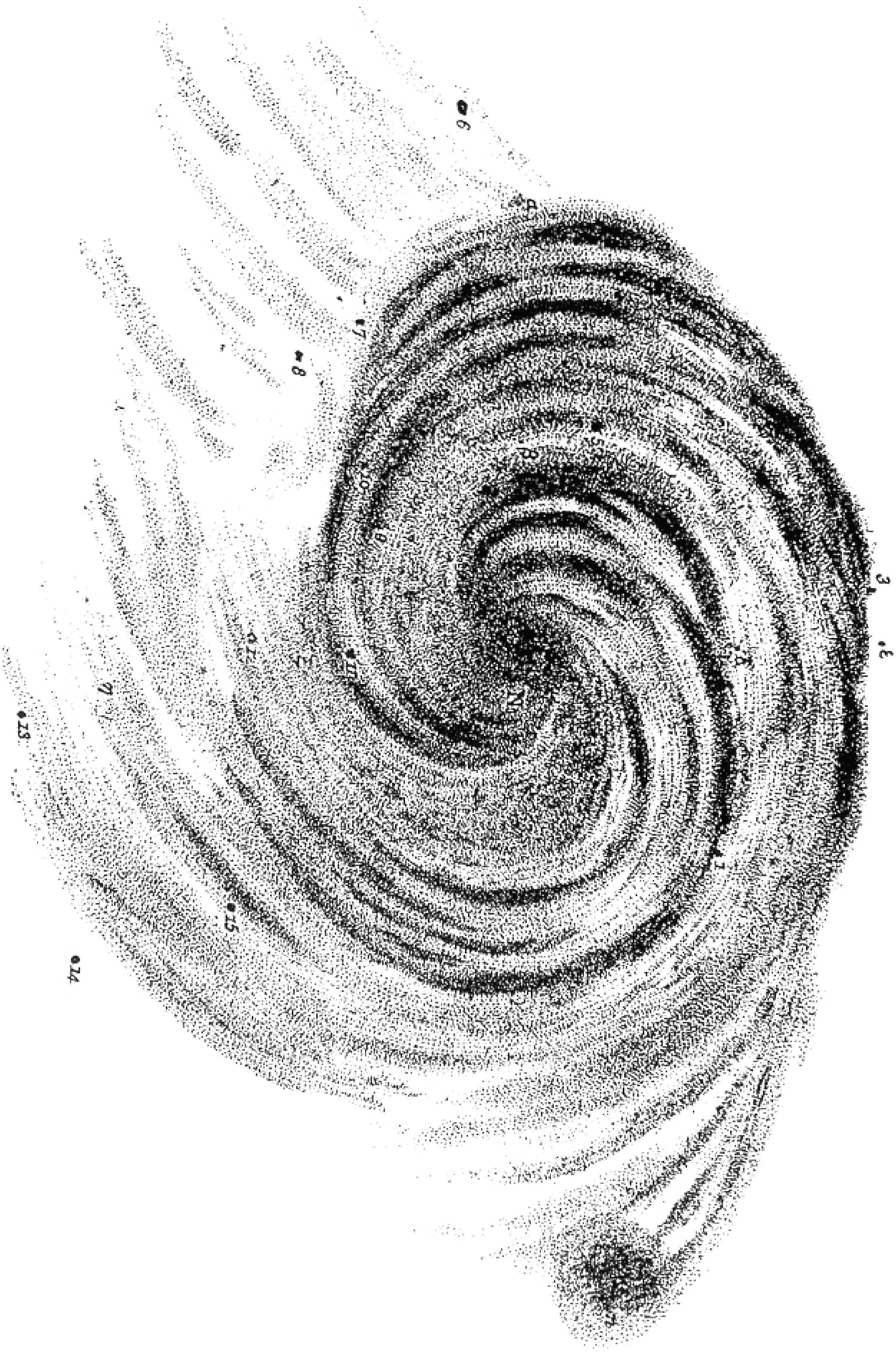

Figure 10: Lord Rosse's second drawing of M51, finished on 31 March 1848 (after Parsons, 1850: Figure 1).

Figure 11: Hunter's drawing of M51, finished on 6 May 1864 (after Parsons, 1880: Plate IV).

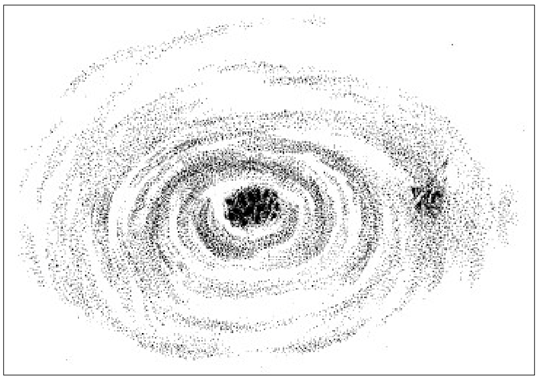

Figure 12: The spiral galaxy NGC 2903 in Leo, drawn by Lord Rosse on 5 March 1848 (after Parsons, 1850: Figure 3). The knot in the spiral arm is the conspicuous HII region NGC 2905, discovered by William Herschel in 1784.

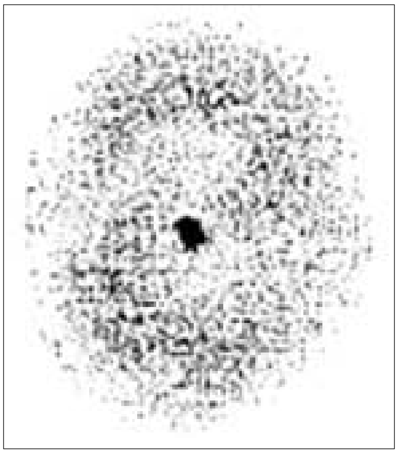

Figure 13: The 'annular spiral nebula' NGC 1514 in Taurus, sketched by R.J. Mitchell on 9 January 1858 (after Parsons, 1861: Plate 25, Figure 7).

No doubt, the nineteenth century observers entertained an illusion. Actually, all objects investigated by Robinson and South were extragalactic, but even the 'Leviathan' was unable to resolve these remote stellar systems into single stars! It is possible that the mirror caused the phenomenon. Its metal surface, polished by a machine and less homogeneous than a modern aluminium-coated glass, pyrex or ceramic mirror, could generate a mottled structure when extended nebulous objects are imaged. Moreover, it is strange that some galactic objects—such as planetary nebula—were seen as 'spirals'.

Any explanation of such illusions should consider the subjectivity of visual observing. In the early nineteenth century there were no objective images and the physical nature of the nebulae was still unknown. When an object was observed unbiased (e.g. for the first time), a description or drawing could strongly deviate from reality. False images easily appeared, especially when the observer was gazing at a faint nebula for a long time with high magnification and a small field of view. On the other hand, known structures were perceived much more easily than unknown ones. But sometimes this led to a curious effect, where one 'saw' the wanted structures, even though they actually were out of reach (i.e. beyond the telescope's power). Facing the often-strange conspiracy of eye and brain, a large portion of self-criticism was needed. Robinson's observation of 1845 should be a warning to others!

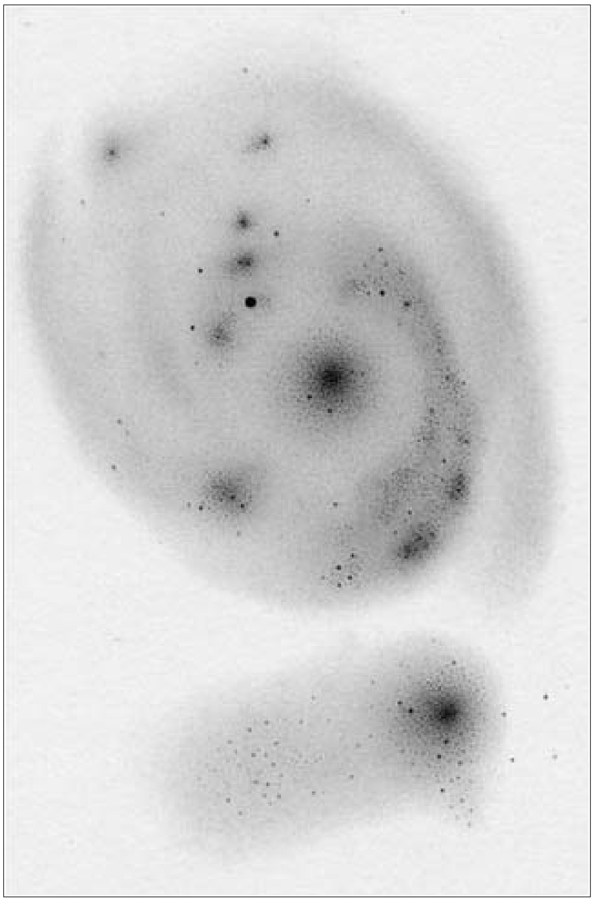

Figure 14: Tempel's drawing of M51, made about 1877 with an 11-inch refractor (courtesy: Arcetri Observatory).

8 NOTES

1. All English translations in this paper from French and German sources are by the author.

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THE DEVELOPMENT OF ASTRONOMY IN NAPLES: THE TALE OF TWO LARGE TELESCOPES MADE BY WILLIAM HERSCHEL

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Abstract: Mirrors and telescopes produced by William Herschel were popular in Europe, due to the opportunities they offered for deep sky observations. Leading public and private observatories acquired them to observe new objects in the Solar System, such as planets and asteroids, and strange stellar structures, stellar nebulae and clusters. After the establishment of the Chair of Astronomy at the University of Naples, it took thirty-four years before an observatory was built. Due to the commitment of Lord Acton, Naples became the first Italian city to host a telescope made by William Herschel. A few years later, Count von Hahn also bought a Herschel telescope for his private observatory in Germany, and at the time this was the largest telescope made by Herschel in mainland Europe. In this paper we recount the remarkable story of these telescopes by way of the scientific activities of the two astronomers who were associated with them, and how von Hahn's telescope eventually also ended up in Naples.

Keywords: Naples, Giuseppe Cassella, Friederich von Hahn, William Herschel, speculum mirrors

1 WILLIAM HERSCHEL AND THE PRODUCTION OF TELESCOPES WITH SPECULUM METAL MIRRORS

When he moved to Bath in England, the distinguished German-born astronomer and musician, Sir William Herschel (1738–1822), bought a small Gregorian telescope of 2.5 feet focal length not only to observe the sky with but, especially, to learn something about the construction of telescope mirrors. By October 1773 he had built his first Gregorian telescope (Hoskin, 2011) and on 1 March 1774 he observed the Orion Nebula and Saturn. The following year, he produced a Newtonian telescope, with an aperture of 4.5 inches and giving a magnification of up to 222×, with the aim of observing planets and stars. Soon Herschel turned his home into a workshop in order to construct his own telescopes. In 1778 he was able to manufacture excellent instruments with apertures as large as 10 inches. In comparison, at that time large and small European observatories were using Gregorian and Newtonian telescopes up to 9.4 inches in aperture and 6 feet in focal length made by Short and achromats up to 3.6 inches in aperture and 46 inches in focal length made by the Dollonds (see Holden, 1881). In 1780, Herschel (1780a) communicated his first paper to the Royal Society on observations of the variable star Mira Ceti, and in a second paper to the same Society he referred to one of his telescopes:

> I will now give an account of my own observations relating to the mountains in the Moon; but, perhaps, it may not be amiss to mention the instrument they were made with … that it may appear how far their accuracy may be depended upon. (Herschel, 1780b: 513).

The following year, on 13 March 1781, he wrote: "… in examining small stars in the neighbourhood of H Geminorum, I perceived one that appeared visibly larger than the rest ... I suspected it to be a comet." (Herschel, 1781: 492). In fact, he had discovered Uranus, or *Georgium Sidus* as he wanted to name it, in honour of King George III.

In 1795 Herschel wrote about his telescope-making exploits from 1781 onwards:

> In the year 1781 I began also to construct a 30-feet aërial reflector; and after having invented and executed a stand for it, I cast the mirror, which was moulded up so as to come out 36 inches in diameter. The composition of my metal being a little too brittle, it cracked in the cooling. I cast it a second time, but here the furnace, which I had built in my house for this purpose, gave way, and the metal ran into the fire.
>
> These accidents put a temporary stop to my designs, and as the discovery of the georgian planet soon after introduced me to the patronage of our most gracious King, the great work I had in view was for a while postponed.
>
> In the year 1783 I finished a very good 20-feet reflector with a large aperture, and mounted it upon the plan of my present telescope ... His Majesty was graciously pleased to approve it, with his usual liberality to support it with his royal bounty.
>
> In consequence of this arrangement I began to construct the 40-feet telescope, which is the subject of this paper, about the latter end of the year 1785. (Herschel, 1795:348-349).

Mirrors and telescopes[1] made by Herschel were an immediate success among amateur and professional astronomers in Britain and Europe. João Hyacintho de Magalhaens (1722–1790) was a good friend of Herschel and the High Deputy at the Courts of Spain and Portugal, and he had a mandate to buy several telescopes in London and Paris that would enrich the instrumental collections of some institutes on the Iberian Peninsula. In 1785 he wrote a letter to Johann Elert Bode (1747–1826), Director of the Berlin Observatory and President of Berlin's Science Academy, exalting and pronouncing the absolute integrity and reliability of Herschel's mirrors. In this letter, he invited all European observatories to acquire these extraordinary instruments for their observations of the sky:

> [Herschel] … promised me that he would produce under his supervision (merely to support the work of astronomy and not for his own interest) this sort of telescope of his own invention, which may be ordered for European observatories through me, and also that he will finish the mirrors with his own hands. A telescope of 7 foot focal length with all of the accessories of eyepieces and micrometer costs about 200 Guineas. They are very light and the mounting can be moved by a single person. The 10ft [focal length] telescope, of

> which he's making four for the King now, requires an expenditure of about 600 Guineas, and one of 20 feet, with all the needed movements included, costs 2500 to 3000 Guineas. I ask you to make this news of astronomical science known. (Magalhaens, 1785: 164).[2]

Nevil Maskelyne (1732–1811) for the Royal Observatory at Greenwich, James Archibald Hamilton (ca. 1748–1815) for Armagh Observatory and, on the European mainland, Bode for the Königsberg Observatory and Baron Franz Xaver von Zach (1754–1832) for Seeberg's Observatories, just to cite a few, were able to count on Herschel telescopes for their observations. In Italy, Father Giuseppe Piazzi (1746–1826) and Barnaba Oriani (1752–1832), Directors of the Observatories of Palermo and Milan, respectively, also bought Herschellian mirrors for their observatories (Spaight, 2004).

In collaboration with some laboratories in Bath run by Quakers, which smoothed down mirrors and metallic surfaces, Herschel was able to produce large mirrors with good reflectivity using speculum metal. James Gregory (1638–1675) and Isaac Newton (1642–1727) had not been able to achieve such results. Giovanni Santini (1787–1877), Director of the Padua Observatory, explained in his *Teorica degli Stromenti Ottici*, the construction techniques of the different kinds of telescopes. He wrote: "No doubt the goodness of a telescope depends on the accuracy of the mirror's shape, but the quality of the metal used plays a large and essential part." (Santini, 1828: 241).

The metal cast was speculum, an alloy of copper and tin, usually two parts of the former and one part of the latter, which was quite fragile. The use of speculum, with the same metals and similar proportions or diversifying the alloy composition, dates back to the ancient Chinese and Roman traditions of making sculptures of great value, and luxury mirrors, which were more reflective than those made of bronze.

The complete fusion of the alloy into a sheet of about one inch needed around 12 hours of cooking. Then, the speculum underwent an annealing process which consisted of heating it up to a temperature usually lower than its melting point. Then, the furnace temperature was slowly lowered. This cooling process could last for about 16 weeks. The annealing process allowed for the chemical and mechanical alteration of the material's microstructure by removing the defects in the crystalline structure and making the alloy more homogeneous and ductile for the subsequent stages of sanding and polishing. First, the surface was cleaned of iron rust using sesquioxide of iron, then it was ground to a parabolic shape, and finally the metal mirror was washed and treated with aqua regia, nitro-muriatic acid. In this way, the surface would have a high degree of reflectance, of about 68% (Herschel, 1861).

To avoid a significant loss of light, Herschel thought to remove the secondary mirror from his telescopes. The primary was, therefore, slightly tilted with respect to the optical axis in order to focus the image at the top edge of the telescope tube. Image distortion produced by this tilt was made negligible by the long focal lengths of his mirrors. The exposure of the mirror to the air, however, produced strong oxidation of the surface. At night, the intense humidity amplified the oxidation. Thus, the mirrors required a continuous re-polishing to maintain top performance. They had to be removed and polished without changing their curvature. For these reasons, telescopes often had two or more mirrors, which could be used alternately.

One of the first telescopes produced by Herschel was bought by Johann Hieronymus Schröter (1745–1816). Schröter, who was the Royal Secretary of George III of Hannover and was keen on music, knew Isaac Herschel, William's father. Schroeter's passion for astronomy translated initially into frequent successful observations of the sky: the Sun, the Moon and the planets. He moved to Lilienthal and in his garden he built an observatory, which he called the *Urania Tempel*. In 1791 he published *Selenotopographischen Fragmente*, with 43 plates of the lunar surface; in 1796 *Aphroditographischen Fragmente*, about Venus; in 1800 *Hermographischen Fragmente*, about Mercury; and in 1803 *Aerographischen Beiträge zur genaueren Kenntnis des Planeten Mars*, with detailed drawings of the red planet (Sheehan and Baum, 1995).

In 1783, Schröter bought the optics for a reflector of 4¾ inches diameter and 4 feet focal length for just 5 guineas, and three years later he purchased a mirror of 6.5 inches aperture and 7 feet focal length for 23 guineas.

"Actuated solely by an irresistible impulse to observe ….", Schröter (1785: 156) tried to make his own mirrors for his telescopes. In 1792, he met Johann Gottlieb Friedrich Schrader (1763–1833), Professor of Physics and Chemistry at Kiel University, who was also an amateur astronomer and studied methods of creating reflective metal mirrors. Schrader had experimented with some techniques that would increase their reflectivity, and he found the use of a thin coating of arsenic vapour on the surface of the speculum resulted in a considerable increase in reflectance. Schröter and Schrader then worked together on several mirrors, with focal lengths of 10, 12 and 13 feet.

Schröter placed Herschel's 7-ft telescope and his own 13-ft telescope (which he had manufactured with Schrader) on the ground floor of the octagonal tower of the *Urania Temple*, while upstairs were Herschel's 4-ft telescope and the 7-ft telescope made by Schrader. Schröter involved a gardener named Gefken in the fabrication of these telescopes. Gefken had learnt how to melt and polish metal mirrors which rivalled in size and reflectivity those made by Herschel, but his prices "… were very moderate and lower than those of British telescopes." (Notizie letterarie, 1810).

In 1793, Schrader and Schröter built a telescope with a mirror of 25 feet focal length for the *Urani*a *Temple*, and the following year Schrader went back to Kiel and ground a mirror of 26 feet focal length for his own observatory. But Schröter's appetite for telescopes was insatiable, and he and Gefken then made a telescope with a mirror that had a diameter of 20 inches and a focal length of 27 feet (Schröter, 1796). This instrument is shown in Figure 1, and was the largest telescope in continental Europe, surpassed only by the gigantic 40-ft reflector that Herschel had installed near his home at Slough.

At about the same time in Italy there were also experiments to produce metallic mirrors that could compete with the German and British ones. Carlo Isimbardi (a cousin of the well-known poet and novelist Alessandro Manzoni), who was appointed General Director of the Royal Mint by Napoleon, was a very well-read scholar of optical and mechanical sciences, and he did all he could to melt and work good metal mirrors. Then in 1810 Giovanni Battista Amici (1786–1863) completed a 5-ft Newtonian telescope in Milan.[3] The alloy used by Amici produced a more reflective surface than those obtained by Schrader and Herschel, but, it was much more fragile. Therefore, it was used almost exclusively for small mirrors.

From many experiments, Schrader was able to confirm that coating the surface with arsenic vapours could somehow reduce the continuous oxidation of the metal mirrors, and this technique also increased the mirrors' power. The development of the silvering process by Justus von Liebig (1803–1873) allowed for the use of glass mirrors, which were lighter than the metallic ones, and when the surface was covered by a thin layer of silver they gave far better performance. The last large speculum mirror was cast in 1867 for the 1.22-m Great Melbourne Telescope (Gillespie, 2011).

2 OBSERVATIONS BY GIUSEPPE CASSELLA WITH THE FIRST TELESCOPE MADE BY HERSCHEL THAT WAS BROUGHT TO ITALY

The last decade of the eighteenth century and the first decade of the new century were intense times, characterized by a remarkable sensitivity to astronomical investigations by Neapolitan institutions. Swayed by the great passion of the Royal scientists and notable men, Charles of Bourbon (1716–1788), the first King of Naples after centuries of Spanish Viceroyalty and Austrian rule, introduced the Chair of Astronomy in 1735, following his major reform of the University of Naples. The mathematician, Pietro di Martino (1707–1746) and his successors, having no instruments and rooms to observe from, were confined to a strictly theoretical teaching role:

> There were also men who were disciples of Galilei and Descartes, but unfortunately they also were missing a temple, supported by the King, where they could collect and disseminate the fruits of their knowledge, honouring the King and working for the common good. Charles of Bourbon encouraged the Arts, favouring the scientific gatherings of Celestino Galiani and the Ercolanense Society. (Mininni. 1914: 99).

Nevertheless, some Neapolitan colleges were devoted to the teaching of astronomy and to observation of the sky. A large collection of astronomical instruments was owned by the Royal College of Scuole Pie at San Carlo alle Mortelle and the Jesuit College, where the geocentric theories were taught. The Royal College, founded in 1737 by F. Nicola Severino, was an educational facility for fifty young gentlemen (von Zach, 1819)

> ... noble in lineage or fame, from six to ten years old, provided they have not been educated in another school, even briefly. They leave the college after turning sixteen, or nineteen at most. They are separated, according to age, in different dormitories, each one watched over night and day by one or two religious prefects and one assistant, and all of them are then overseen by the f. Minister. (Ajello, 1845: 42).

In 1751, Nicola Maria Carcani (1716–1764) became Rector of the Royal College. He reorganized the academic courses and assigned a room for an observatory, furnishing it with many good instruments, including telescopes, a quadrant and pendulum clocks. Among the observations made at the observatory, the solar eclipse of 25 October 1753 and the 6 June 1761 transit of Venus (Carcani, 1761) were notable. A report on the eclipse was presented at a meeting of the Royal Society of London and was published in *Memorie per Servire All'istoria Letteraria* (Carcani, 1753).

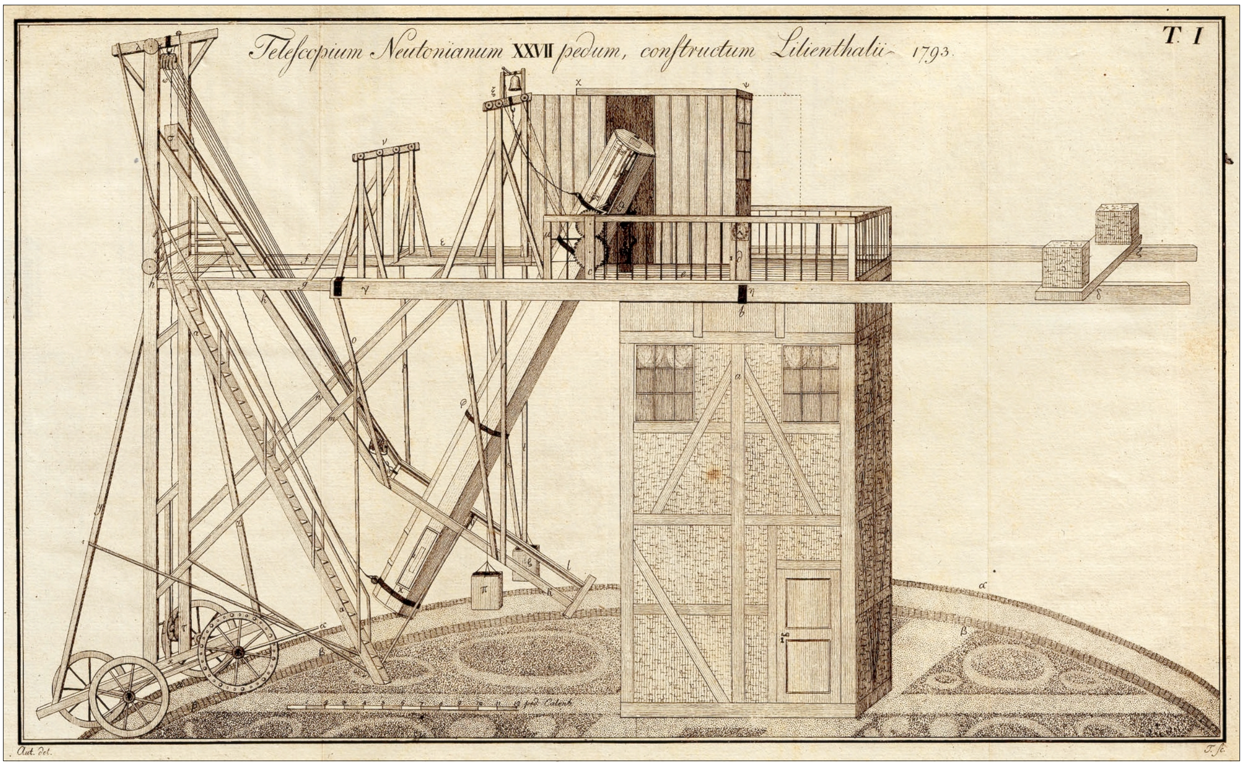


Figure 1: The 20-in aperture telescope manufactured by Schröter and Gefken and installed at the *Urania Tempel* in Lilienthal (courtesy: Library of Astronomical Observatory of Brera).

Other scientific facilities highly regarded by the astronomer Joseph-Jérôme de Lalande (1732–1807) when he visited Naples were the scientific room of the King in the Royal Palace and the observatory of Sir John Francis Edward Acton (1736–1811)—better known as Lord Acton. Equally impressive was the library of Prince Ferdinando Vincenzo Spinelli of Tarsia (1691–1753), which Lalande (1769: 200) described as "… unique for the number of good books, and for the richness and the ornaments of the rooms housing them …", while Troyli (1752: 241) commented: "… the eye has nothing more beautiful to desire." Lord Acton's Palace was near the College of Scolopi, and its "… open and wide horizon [was] a good reason to consider it very suitable to cultivate Astronomy." (Cassella, 1790: 145).

Giuseppe Cassella (1755–1808), a disciple of the mathematician Felice Sabatelli (1710–1786), specialized in astronomy at the Observatory of Padua, which was directed by Abbé Giuseppe Toaldo (1719–1797). Because of his skills he was offered a position to teach astronomy at the Episcopal Seminary of Padua. Cassella observed an occultation of τ Tauri on 5 May 1784 and published a report on this in *Saggi Scientifici e Letterarj dell'Accademia di Padova*. Toaldo referred to Cassella as "The Neapolitan young man highly expert in astronomy." (Occultatio, 1789: 310). In 1786, Cassella returned to Naples to accept the Chair of Nautical Astronomy at the Royal Navy Academy.

Although in Padua Cassella could collaborate with Toaldo and his assistant Vincenzo Chiminello (1741–1815) in observing from the tower of the observatory, he could not make astronomical observations in Naples. The Royal Navy and Science Academies, as well as the University, had not yet assigned any room for an observatory.

In 1791 King Ferdinando IV of Bourbon, on the initiative of Lord Acton and the Prince of Belmonte, Antonio Pignatelli, granted Cassella permission to install an observatory at the Palace of Cavallerizza which housed the University and the Academy of Science. Even before the project was completed Cassella managed to get some astronomical instruments for the education of the students and for his scientific studies. These were obtained from Pietro Napoli-Signorelli (1731–1815), the "… perpetual secretary of Sciences and Fine Letters combined …" (Napoli-Signorelli, 1788: 78). Since the creation of the Chair of Astronomy at the University of Naples, Cassella was the first royal astronomer to have access to telescopes for observing and teaching applied astronomy.

Following his return to Naples, Cassella could also count on using the private observatory of Lord Acton. The collection of instruments it housed was

> … one of the most valuable among others concerning the Navy. What must be mentioned ... among others, is a chronometer by Arnold, the famous craftsman, many good achromatic telescopes by Dollond and Ramsden, an Equatorial by one of the same Craftsman, several Compasses, many azimuth Compasses, Sextants by Ramsden, and Dollond; but, above all, an excellent Newtonian Telescope manufactured by Herschel, famous Craftsman and expert Observer at the same time. Acton purchased it in London not so long ago. *It is a particular and rare instrument, the only one owned in Italy,* and very few are found in Europe; it is surely at the top of this collection. However it should not be thought that these instruments were held for show, or in a cabinet, as they were definitely obtained so that they could be used for observations ... (Cassella, 1790: 145-146; my italics).

Even in *Dei Principali Movimenti e Fenomeni de' Corpi Celesti*, the first ephemeris journal published in Naples in 1788, Cassella described the new astronomical observations, the technological developments introduced by Herschel with his powerful telescopes, and the observations that he made which were published in the *Philosophical Transactions of the Royal Society*. Cassella (1788: 93) also talked about the new powerful telescope purchased by Lord Acton:

> H. E. the Chev. Acton, watchful Minister of War and Navy, ordered up one of the largest Herschellian telescopes of 7 feet focal length with 9 different magnifying eyepieces from London. He takes care mainly of the progress of Navigation, and then of Astronomical Science. He loves, relishes and protects them. He also derives great pleasure from observing all the features of the fixed stars visible at the time in the beautiful clear skies of Naples.

This telescope, according to Cassella (1790: 146), was "… the only one hosted in Italy." It was bought by Lord Acton at William Herschel's house in England in 1787, and cost 110 guineas (Toaldo, 1788). The telescope arrived in Naples on 4 March 1788:

> A new magnificent telescope made by Professor Herschel arrived on the frigate *Cerere* commanded by Kt. Forteguerri. It was manufactured on the basis of the latest developments. Toaldo, the famous astronomer, was leaving this City but he stayed for a few days in order to examine it. Toaldo made some observations with the telescope and he found it better than any other telescope he had used. (Gazzetta, 1788: 168).

Cassella planned to use this telescope to compile a star catalogue, like Herschel's, and list all the stars that could be observed from the latitude of Naples (which included many stars in the southern sky). The first star he observed was β Sagittarii, which was a double. Cassella (1788: 95) noted that

> The ancient astronomers indicated the star β, the northern-most among the three bright stars on the forehead of the Scorpion, was a double star. By observing with our telescope, it appears composed of two quite separate stars, distant from each other by a few seconds.

As soon as Cassella had this excellent instrument at his disposal, thanks to the Minister's munificence, he used it to observe other double stars in Aquarius, Capricornus, Corona Borealis, Sagittarius, Scorpius and Serpens (Amodeo, 1924). He also made many observations of Saturn's satellites, and

> ... thanks to our continual observation of the fifth satellite we have seen and have confirmed the same phenomena which are usually seen in the period of this satellite, and were once observed by the famous Cassini ... (Cassella, 1790: 146).

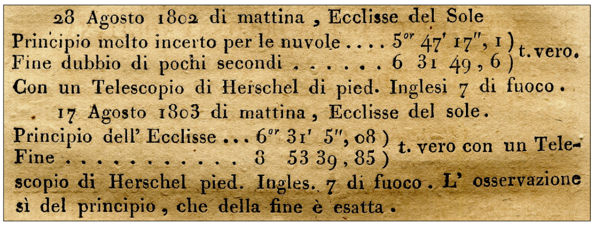
Some observations made by Cassella between 1793[4] and 1797, including an occultation of Jupiter,[5] were published by Bode in the *Astronomical Ephemeris of Berlin* and some by Lalande (1783) in the *Ephemeris of 1788*. Other observations were presented at the Royal Science Academy of Turin, of which Cassella had been a member since 1797. In a memoir presented by Antonio Cagnoli at the Italian Society of Science, Cassella lists a series of "Occultazioni di stelle per la Luna" observed between 21 October 1793 and 21 August 1798, both at the Palace of Studies and at Lord Acton's observatory.

Cassella's enormous passion shone through in these publications, and he was appreciated as a scientist both in Italy and abroad:

> It was known Cassella could make very important observations without an observatory, with very few instruments, and without communication with astronomers in other countries, meriting Bode to talk about them in his Berlin Ephemeris. (Orloff, 1821: 28).

Despite Cassella's undoubted skill and dedication, the University did not have any observatory, let alone a well-equipped one, where he could carry out observational campaigns and educate a new generation of students in astronomy. The impossibility of offering contributions in the main fields of astronomical research at that time, such as observations of the planets, their satellites and new minor planets, or hypotheses about nebulae, made the royal astronomer of Naples a rather ineffective scientist. Maybe Cassella had hoped that Lord Acton might have played the same role that Francesco Maria Venanzio d'Aquino, the Prince of Caramanico, played in Palermo, which had allowed Piazzi to quickly organize a centre for astronomical studies. Instead, Lord Acton offered the use of his private observatory and its first-class instruments, which was the only real opportunity Cassella had to make reliable celestial observations.

Using Lord Acton's telescope (which for a short time was the only Herschelian reflector in Italy),[6] Cassella (1796) enthusiastically observed not only double stars but also Enceladus, a satellite of Saturn discovered by Herschel on 28 August 1789. In January 1793 Cassella observed the comet discovered on 15 December 1792 by Caroline Herschel (ibid.; Bode, 1792). On 21 October 1793 he used an achromatic telescope of 3½ feet focal length to time the lunar occultations of γ and α Tauri, and on 21 January in the following year he used the same telescope to observe an occultation of γ Scorpii. On 5 March 1794 he timed the occultations of μ Ceti and α Tauri using a Gregorian telescope of 1½ feet focal length, while on 21 August 1798 he noted the true times of immersion and emersion of φ Sagittarii, θ and γ Virginis, γ Tauri, γ Librae, μ Ceti and Aldebaran (Cassella, 1795) while using "… a Newt. Telesc. by Herschel of 7 English feet focal length; power of 84." (Cassella, 1799b).



28 Agosto 1802 di mattina, Ecclisse del Sole
Principio molto incerto per le nuvole . . . . 5^{or} 47′ 17″, 1) t. vero.
Fine dubbio di pochi secondi 6 31 49, 6)
Con un Telescopio di Herschel di pied. Inglesi 7 di fuoco.
17 Agosto 1803 di mattina, Ecclisse del sole.
Principio dell' Ecclisse . . . 6^{or} 31′ 5″, 08) t. vero con un Tele-
Fine 8 53 39, 85)
scopio di Herschel pied. Ingles. 7 di fuoco. L' osservazione sì del principio, che della fine è esatta.

Figure 2: Published record of the solar eclipses of 28 August 1802 and 17 August 1803 (courtesy: Library of Science Academy of Turin).

Cassella also observed the solar eclipses of 28 August 1802 and 17 August 1803 from Lord Acton's observatory, using the 7-ft Herschel telescope (Cassella and Cagnoli, 1804), and the published record of these events is shown in Figure 2. But the solar eclipse of 11 February 1804 was a totally different event, for "Her Majesty the Sovereign of Two Sicilies and her Royal Prince D. Leopoldo are also in attendance, specifically for this purpose, besides many Lords of the Court, at the Observatory of H. E. the Captain-General Acton." (Cassella and Cagnoli, 1804: 620). Despite their presence, Cassella had arranged it such that the instruments could obtain precise scientific data. Unfortunately the sky was cloudy at the time of the eclipse, but he did manage to record the following observations towards the end of the event:

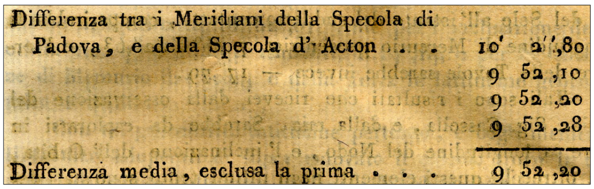
> Latitude 40° 49′ 40″ ... End of the Eclipse 2^h 25^m 10.7^s mean time ... with a Dollond achromatic of 5 feet foc. and a great objective.
>
> The recorded time may differ from the actual time by a few seconds.
>
> A mountain on the Moon was the last one to be observed coming out of the disc; and the irregularities of the Moon are clearly seen on the Sun; these were also seen by others attending the observation, particularly by the frigate captain Mr. Carlo Acton. Just before the eclipse finished, the edges of the Moon and the Sun seemed to be swaying due to the amount of vapour in the atmosphere, with which it was saturated. (Cassella and Cagnoli, 1804: 621).

This eclipse was also observed by Cassella's students at the Palace of Studies: "End of the Eclipse 2^h 24^m 55.0^s Mean time: doubtful … With an achromatic of Nairne, but weak power." (Cassella and Cagnoli, 1804: 621-622). This is the first publication that indicates that some of Cassella's students were carrying out astronomical observations in Naples.

In 1802 Cassella and Chiminello observed a transit of Mercury between 8 and 9 November from Lord Action's and Padua Observatories, respectively. Cassella "… during the egress of Mercury, accurately timed the inner contact with the edge of the Sun at 0^h 54^m 7.6^s t. t. and the external doubtful 0^h 55^m 49.6^s t. t. with a 5 English feet achromatic telescope by Dollond." (Chiminello, 1804: 187-188). By comparing measurements made in Naples and Padua, Chiminello (ibid.) could determine the difference in longitude between Padua Observatory and Lord Acton's observatory (see Figure 3). In his memoir, Chiminello pointed out that the measurements and results from Naples did not come from a public observatory but rather from a private observatory that was kindly made available by its owner for scientific purposes. In this context, Chiminello (1804: 621) referred to Lord Acton as the "… Magnificent Patron."

3 COUNT VON HAHN'S OBSERVATORY AND THE LARGEST HERSCHEL TELESCOPE IN MAINLAND EUROPE

Count Friederich von Hahn was born in 1742 into an ancient family from Mecklenburg, and attended the University of Kiel from 1760 to 1763 where he studied mathematics and astronomy. In 1779, the Count became the sole heir to the Hahn family properties, including the Remplin Estate which had been in the family's possession since 1405. The Count then moved into the residence at Remplin, expanded the house, and built greenhouses in order to grow exotic fruits and flowers. Far from the grandeur of the Imperial Court,



Differenza tra i Meridiani della Specola di Padova, e della Specola d' Acton . .	10′	2″,80
	9	52 ,10
	9	52 ,20
	9	52 ,28
Differenza media, esclusa la prima . . .	9	52 ,20

Figure 3: Published record of the longitude difference between Padua and Naples calculated by Chiminello (courtesy: Library of Science Academy of Turin).

Friederich von Hahn was an Enlightenment follower, and he devoted himself to the education of local children and financed a foundation for the sustenance of poor girls. He also supported the studies and scientific projects of many young people.

The Count built a new castle in Faulenrost, modernized the one in Basedow, restructured the church of Graves, and built the bell tower in Bristow. The German philosopher Moses Mendelssohn (1729–1786), grandfather of the famous musician, considered the Count the most intelligent person he ever met. Von Hahn maintained an on-going correspondence with Count von Bernstorff, the Danish Foreign Minister; the philosopher Johan Gottfried Herder (1744–1803), who celebrated their friendship by dedicating the poem ‘Orion’ to him; and Johann Bode, who dedicated the *Uranografia* to him. Louise of Prussia with her entourage and Johann Friedrich Zöllner (1753–1804), head of the Royal Prussian Consistory and a member of the Berlin Science Academy, were among his welcomed guests. During a stay in Remplin, Zöllner described in his travel diaries von Hahn’s impressive library (which contained about 12,000 volumes), and the observatory, that was built between 1792 and 1793. This was

> ... located all by itself in the beautiful garden. The lower floor is a large hall. The second floor has a little room with 4 doors, each one is paved with stones and leads onto a large balcony. The astronomical equipment is as significant as it is beautiful. (Zöllner, 1797: L.23).

In 1801, the Count also built the 14-m high ‘ox tower’, which was surmounted by an observatory with a rotating dome (see Figure 4). He equipped the observatory with first class instruments, such as a 25-in Cary vertical circle with a telescope of 33 inches focal length and 2-in in aperture. He also bought a 1-ft equatorial and a 4-ft transit telescope by Dollond. A comet finder by Blunt and Nairne, sextants by Dollond and Troughton, a pendulum clock by Klindwort, a chronometer by Arnold[7] and many other smaller instruments and attachments completed the Count’s valuable collection. Besides the astronomical equipment, he also had other instruments that were used for experiments in physics and chemistry (Fürst and Hamel, 1999).

In 1793, von Hahn enriched his observatory with three reflectors made by Herschel, two with mirrors of 20 feet focal length and apertures of 18-in and 12-in and a smaller mirror 8-in in diameter with a focal length of 7 feet.[8] The telescope with the 18-in mirror was the largest reflecting telescope in mainland Europe after the great reflectors of Schröter at the *Urania Tempel* in Lilienthal and Schrader at the Kiel Observatory. Von Hahn’s observatory at Remplin also boasted the largest telescope in mainland Europe made by Herschel. However, by this time Herschel had installed a gigantic 40-ft telescope at his observatory at Slough, which was completed thanks to £2,000 that King George III assigned to him. When the King visited Herschel with the Archbishop of Canterbury he walked inside the enormous tube and said: “Come, my Lord Bishop, I will show you the way to Heaven!”

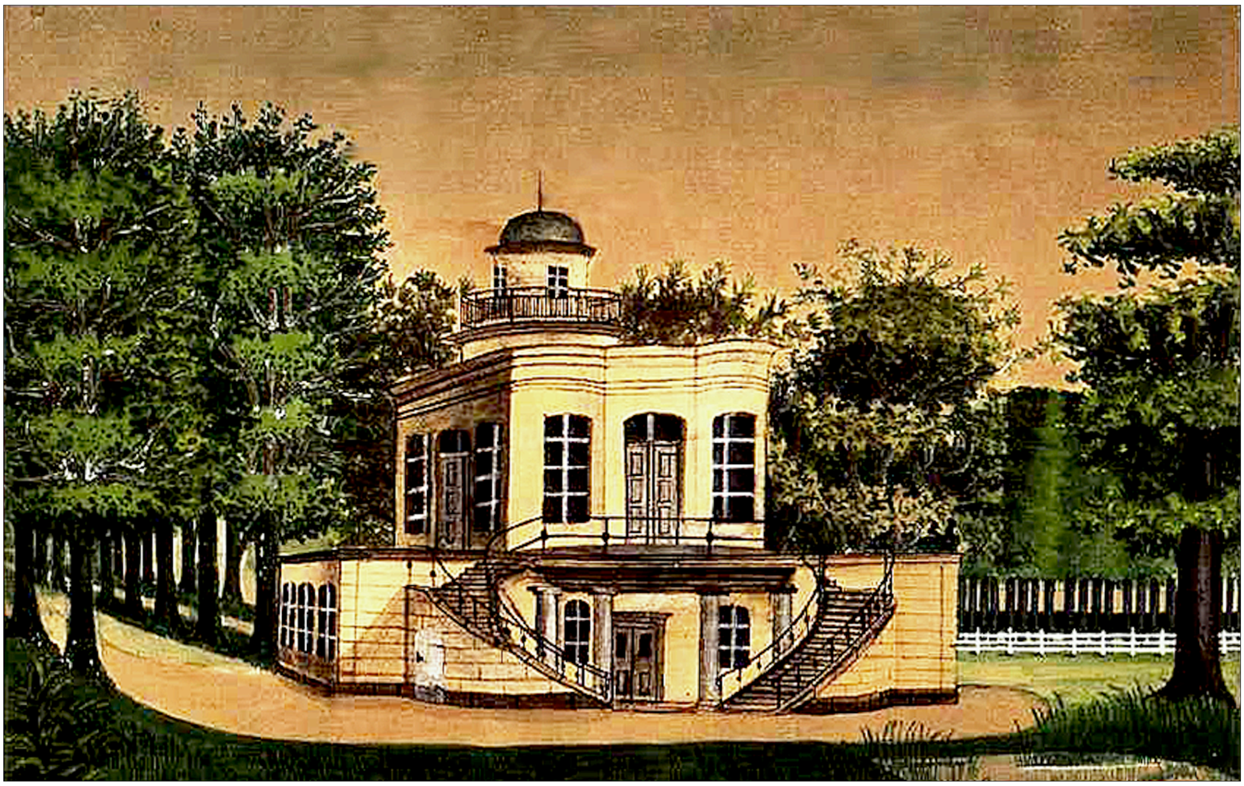


Figure 4: A painting done in 1857 of Count von Hahn’s observatory (courtesy: Rosmarie Schöder).

(Mullaney, 2007: 14).

Zöllner described von Hahn's largest telescope (see Figure 5) in his travel book:

> You will be certainly surprised if I did not write any detail about the great telescope of Herschel ... I don't want to bother you with a description of the mechanism, I tell you just that it is placed under the open sky close to the observatory, and it is cleverly set up in order to orientate the big telescope in any wanted direction and to move the tube of the ocular aperture with a portable staircase ... any movement takes place very easily without any obstacle. They observe to the side through a small tube. And on the bottom, where the mirror is placed, there is a small finderscope. (Zöllner, 1797: L.23).

Von Hahn reported his observations in about twenty papers, which were mainly published in the *Astronomisches Jahrbuch*, where he also was in charge of translating and communicating Herschel's memoirs (see Herschel, 1798). The Count was very interested in the study of the planets and the lunar surface, and he also investigated the Sun (Hahn, 1792) and nebulae in Hydra and in Orion (Hahn, 1799). In 1796 he wrote:

> If we wanted to represent the night sky as an infinite space in which countless suns surrounded by their planets describe their paths ... this concept of the universe would be really great and sublime, but at the same time it would not properly indicate the vastness of nature. The largest telescopes can observe celestial objects that cannot be considered as star clusters. Among these oddities the famous Orion Nebula is especially distinguishable ... I troubled myself to search the left edge (west) of this black cloud with the 20 feet reflector... (Hahn, 1796: 235-236).

In 1800, von Hahn discovered the faint central star in the Ring Nebula M57 in the Messier catalogue, which is a compact white dwarf of magnitude 15. Von Hahn carefully studied this star and found that it varied in magnitude. In the research paper, "Gedanken über die Ursachen der Lichtabwechselungen veränderlicher Sterne" von Hahn (1795) gave a theoretical explanation of the Doppler Effect fifty years before Christian Doppler. He assumed that there was a close relationship between the movement of the light source and the changes occurring in two successive light events: if a star is approaching the Earth at a certain velocity, the light has a shorter path, its particles follow each other quickly and then the object appears brighter to the eyes. He supported the theory of the solar photosphere proposed by Herschel, considering the Sun a cool body like the planets, with a habitable surface under the flames (Crowe, 2011). Like Herschel, he argued that stars evolve.

Count von Hahn died in 1805 and was buried in the church of Graves. The Remplin Estate passed to Carl, his youngest son, who squandered much of his paternal heritage because of his unrestrained passion for the theatre. The precious volumes in the library were used mostly by war refugees to light fires, while the scientific instruments were put up for sale. In 1811 the *Astronomisches Jahrbuch für das Jahr 1811* mentioned that some of the instruments in the collection were for sale:

> The excellent astronomical, physical, and chemical instruments heritage of the late Land Marshal Count von Hahn of Remplin in Mecklenb. Strelitzschen, must now be sold individually, according to the will of the heirs. The astronomical ones will be offered to amateurs at the

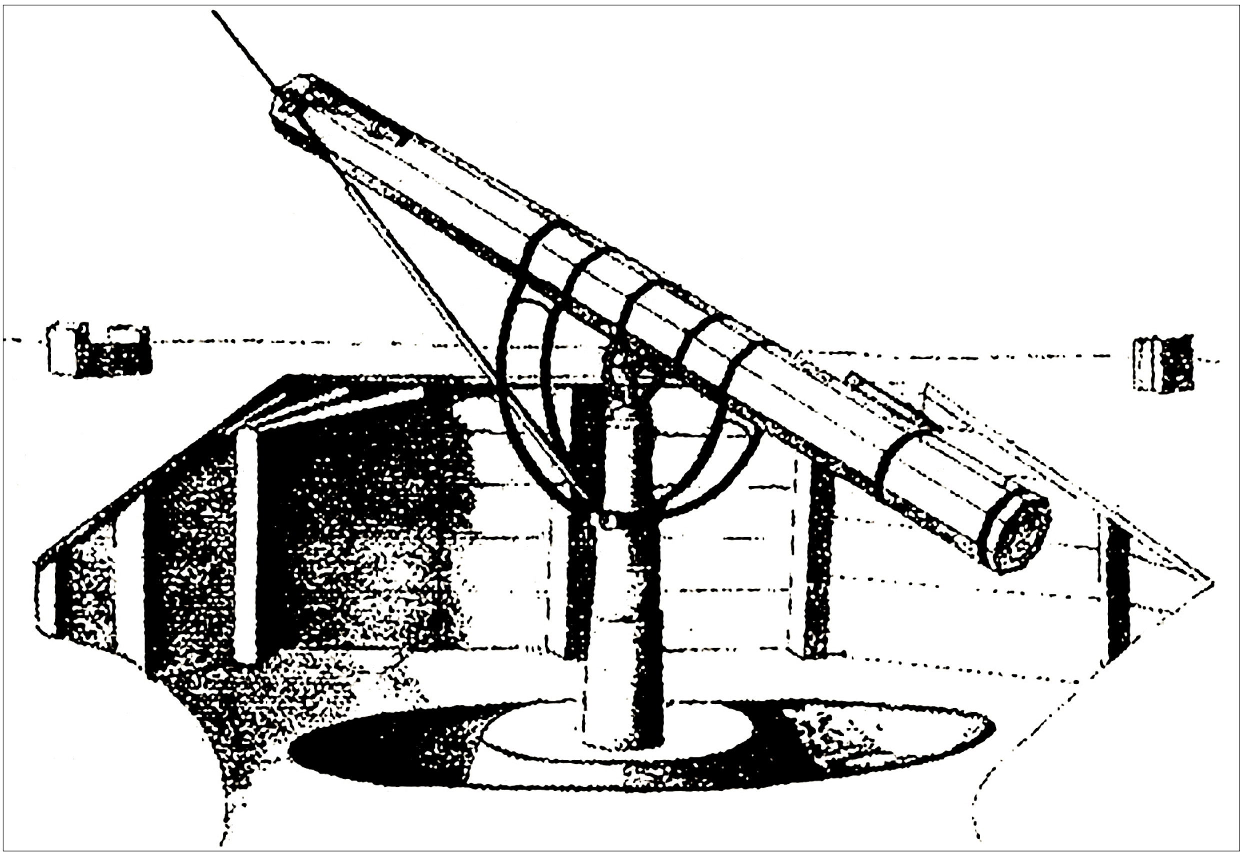


Figure 5: A sketch of the 18-in aperture Herschel telescope mounted on its framework in the garden of the Remplin Estate (courtesy: Wolfgang Steinicke).

> following prices and to this aim I was asked to write a public note for the *Astronomisches Jahrbuch*. The numbers are in accordance with the printed list, the prices are in Crowns of Mecklenburg.
>
> | No. | Rthlr. |
> |---|---|
> | 1. One Herschelian reflector telescope of 20 feet length and 18 inches aperture, 3 oculars, and a mirror cover. The tube is of wood with iron bands and covered with a sail cloth. The frame is very comfortable using method indicated by the late Count. | 1500 |
> | 2. One Herschelian reflector telescope of 20 feet length, 12 inches aperture, 2 oculars. The tube as above | 900 |
> | 3. One Herschelian reflector telescope of 7 feet length, 8 inches of aperture, 7 magnifying glasses, and a comfortable frame | 600 |
>
> [Another 47 objects follow.] …
>
> The instruments were evaluated based on their present value by Prof. Droysen of Greifswalde.
> The amateurs can refer to Secr. Ortmann in Remplin. (Bode, 1808).

Some of the instruments were acquired by the Königsberg Observatory, where Friedrich Wilhelm Bessel (1784–1846) led the main stellar observing campaigns for many years.

4 THE TRANSFER OF ONE OF VON HAHN'S HERSCHEL TELESCOPES TO NAPLES

Cassella died in Naples in 1808, after partly realizing his lifetime dream which was to have a public observatory. This was the Observatory of San Gaudioso:

> H. M. (King Joseph Bonaparte) determined by Royal Decree on the 29th day of the previous month, that the ancient Belvedere of the Nuns of S. Gaudioso, which now belongs to the Friars of S. Girolamo, should be converted into an Astronomical Observatory. (ASNa, 1807b).

More specifically,

> ... the ground-floor room that serves now as a pantry and the little apartments of the 3rd, 4th and 5th Floors will be made available to the Astronomers, after making the necessary renovations to convert this site for use as an Observatory and to house the apparatus there. (ASNa, 1807a).

On 11 August 1811, Joachim Murat, the new French King of Naples, appointed Federigo Zuccari (1784–1817) as the new Director of the Observatory. Zuccari was the Professor of Mathematical Geography at the Royal Academy of Nunziatella. In 1809, he moved to Milan in order to specialize in astronomy under the guidance of Barnaba Oriani. Returning to Naples in 1812, Zuccari brought with him an impressive set of instruments which Oriani had made available to him,[9] after re-equipping the Brera Observatory. The instruments were expected to arrive in Naples "… just in time to observe Polaris … during December and January, and the Iemale (winter) solstice." (Zuccari, 1812d). A skilled engineer named Augusto Aenhelt (b. 1785) arrived in Naples together with Zuccari, and assisted him in installing the instruments in the Observatory at San Gaudioso.

On 8 March 1812 Murat approved the erection of a new observatory for Naples on the Miradois hill, close to the Royal Palace of Capodimonte. Zuccari suggested this site "… because it has an open meridian, and the rest of the horizon is free with respect to other

Figure 6: A print by Cerasoli (1819) of the new Astronomical Observatory at Capodimonte (courtesy: Astronomical Observatory of Capodimonte).

hills: moreover among all the suburban hills, Miradois is near both the University and the Naples' city centre." (Zuccari, 1812a). The impressive-looking observatory building was designed by Zuccari and the architect Stefano Gasse (1778–1840). Although the foundation stone was laid on 4 November 1812, work was only completed in late 1819 (see Figure 6).

Once construction of the new building was approved, Murat also agreed to equip the upcoming Osservatorio Giovachino (see Figure 7) with some new instruments, such as a meridian circle and a pendulum clock from Reichenbach, a chronometer from Breguet and an 8-ft telescope from Amici. Furthermore, the Minister of the Interior, Count Giuseppe Zurlo (1759–1828), proposed the purchase of a Herschel telescope like the one owned by Lord Acton. Zuccari (1812a) regarded Zurlo as "… a very suitable and effective Patron of all the finest disciplines, especially astronomy …", and informed him that in Berlin there were two 20-ft Herschel telescopes for sale. Zuccari (1812b) then wrote to Oriani seeking information about the instruments owned by the late Count von Hahn and mentioned by Bode in the *Astronomisches Jahrbuch*. Oriani recommended the powerful Herschel telescope which von Hahn had used to conduct research and some other astronomical instruments that were also on sale in Berlin. Zuccari wanted to complete the Naples collection of instruments with one of the greatest telescopes created by Herschel, so he asked the Government to buy both the 20-ft and the 7-ft Herschel telescopes, remarking that

> The price of the large telescope is 6,000 francs, the smaller is 2,400 francs. They would be great ornaments for any Observatory, the first for its uniqueness and perfection, the second for its ease of use and comfort. (Zuccari, 1812c).

The Minister of Interior approved the expense, but in June 1812 Zuccari pondered his decision and changed his request, suggested to Zurlo instead of the 7-ft telescope

> … to buy in Berlin an excellent 4-ft Short Telescope with a 7-in aperture at a cost of 60 golden Friderics, and an 8-in Dollond reflecting sextant, well executed and preserved, at a cost of 25. golden Frid:^{s}, including the costs of the crate and packing, 1,540- Lire in total … [Zuccari] ensures that when commissioning the Astronomer of Berlin he will urge him to arrange for the prompt and safe means of their transport to Vienna; and to address the crates to Cav: Gargani Secret.^{y} of the Neapolitan Legation at that Court. In the meantime he asks H. E. to pass his authority to the Min:^{y} of Foreign Affairs so that Mr. Gargani takes charge of bringing them to Naples, and to have laissez-passer, so that the objects do not suffer a long customs inspection. (ASNa, 1812).

In December 1812 Zurlo (1813) informed Zuccari that Bode had sent Gargani "… three boxes containing a Telescope and some books." The Duke of Gallo, Marzio Mastrilli, who was Minister of Foreign Affairs, informed Zurlo that on 27 January 1813 the crates were sent to Naples via Bolzano, and Bode (1813) also wrote a letter to Zurlo on 9 February informing him of the purchase. The latter letter arrived in Naples at the beginning of March and was translated by Zuccari. Bode stated that after receiving pledges of payment he asked Mr Hansen, the Legation Secretary in Mecklenburg, to take care of the packing and to send the Herschel telescope to Berlin. He also wrote:

> The Herschel telescope consists of a wood tube 20 feet long and 1½ in diameter. It is mounted on a great framework with wheels and pinions. The transport of the tube to Naples would cost much more than its value. Mr. Zuccari wrote me to not send the tube if the cost of transportation was high. Fortunately the owner had a model of it made, and I purchased it. This may be used for mounting the Telescope on a great framework in Naples. Therefore, two modest sized crates will be sent to Naples. They contain the great mirror, and three eyepieces with their apparatus, and the model of the framework. The price of the Telescope was 300 golden Friderics, as Mr. Zuccari knows from my Ephemeris of 1811. I deducted 20 and consequently the telescope costs just 280. (ibid).

At about the same time, Gargani informed the Minister of Interior that three crates had arrived at the Neapolitan Embassy in Vienna, containing books and astronomical instruments for the Observatory in Naples (Mastrilli, 1813a). In May, Zuccari (1813) was informed that the crates had arrived in Giulianova for the attention of "il Sig:^{ri} Angeli e Simeoni" and he undertook to ask the Minister of the Interior to arrange with the Minister of Finance, Jean-Antoine-Michel Agar, Count of Mosbourg, for the passage of the crates to the Customs of Naples, and subsequent delivery to the receiver. However, besides some books, these crates only contained the telescope made by Short, not the one made by Herschel.

Figure 7: The Murat gold medal minted to mark the laying of the foundation stone of the Osservatorio Giovachino on 4 November 1812.

In June 1813, a new letter from the Duke of Gallo informed the Minister of the Interior that in the previous month Bode received "… two Crates purchased some time ago by the above-mentioned Astronomer. They contain the Great Mirror of Herschel with all the other objects pertaining to it ..." (Mastrilli, 1813b). In August, the crates finally arrived in Vienna, but they had to remain there until the following year because of the war between Napoleon's troops and the armies of the Sixth Coalition, formed by Great Britain, Russia, Spain, Portugal, Prussia, Austria and Sweden. The war finally ended in October 1813 with the Battle of Nations in Leipzig.

Figure 8: The 20 feet focal length Herschel mirror (photograph: E. Cascone, 2010; courtesy: Astronomical Observatory of Capodimonte).

Understandably, Zuccari (1814a) was concerned about the fate of the crates and in March 1814 he wrote to the Minister of Interior "… about the further fate of same objects … now that communication with that Capital is re-established." The crates were deposited by the Minister Gennaro Spinelli, Prince of Cariati, at the office of Geymuller's bankers, who thought that it was not convenient to send them, because of "… the lack of safety on the road." (Mastrilli, 1814b). On 23 May 1814, the boxes finally were sent to Trieste, to the attention of the shipper Gadolla, who would forward them to Naples (Mastrilli, 1814a). On 4 August, the Foreign Office Minister wrote to Zurlo: "Mr. Bankers Meuricoffre, and Comp. of this City inform me that the two boxes, containing Astronomical Instruments purchased by Mr. Bode for this Royal Observatory, have already arrived at the Customs of Manfredonia." (Mastrilli, 1814c). On 12 August the Count of Mosbourg asked the Customs of Manfredonia to send the crates to Naples for the customs formalities.

Figure 9: A hall of the "Museum of the Ancient Instruments" at the Astronomical Observatory of Capodimonte. In the pyramid is the celestial globe of Roll-Reinhold (1589), and in the corner to the right are an equatorial telescope by Reichenbach and Utzscheider (1814) and a Zenith telescope by Wanschaff (1892) (photograph courtesy M. Casciello, 2005).

On 14 September 1814 the Herschel mirror and the books purchased by Garganiof arrived in Naples in three boxes, but the Count of Mosbourg advised the Customs Office of the arrival of just two boxes. This mistake caused further delays and Zuccari eventually wrote to Zurlo asking him to inform the Customs Director, Graziano Ferrier, of the crates' existence so that they could be processed.

At about the same time Baron von Zach came to Naples to deliver and install the Reichenbach instruments (Piazzi, 1821), and he noted that a large Herschel mirror was among the astronomical instruments available at the Observatory of San Gaudioso:

> We found this observatory active when we arrived in Naples ... It was not badly equipped ... There was ... a large Herschel mirror for a telescope of twenty feet, it was not mounted, and it was acquired from the heirs after the death of Count de Hahn of Remplin, in the Duchy of Mecklenburg, etc ... (von Zach, 1819: 535-536).

The delay in finishing the new observatory at Capodimonte and the changed scientific interests of the successors of Zuccari, who were devoted more to positional astronomy, kept the mirror of the largest Herschel telescope ever installed in mainland Europe in its crate, even though it had arrived in Naples by the end of the summer of 1814. In September 1814 Zuccari wrote that

> … three packages [had arrived] at the big Customs House of Naples from Vienna, [and] they contain the mirrors of the big telescope of Herschel bought in Kemplin for the Royal Observatory together with many books. (Zuccari, 1814b).

Ten years later, Brioschi (1824-1826: 81) called the Herschel telescope useless, but "It is desirable if it could be set working, by constructing all the useful frameworks and devices, and [finding] also an appropriate place to store and use it." .

In 1835, there was still hope to install the large telescope "… polished by the famous Herschel and not yet put in place, but it will happen soon due to the generous and provident care of the sovereign." (Taddei, 1835: 63). Yet this did not eventuate, and the large Herschel mirror never was used to observe the night sky from Naples.

Today the Herschel mirror (Figure 8) is one of the most ancient instruments in the historical collection at the *Museo degli Strumenti Astronomici* (see Figure 9) at the Capodimonte Observatory (see Rigutti, 1992), along with the Roll-Reinhold globe (1589), the Chlasner clock (1567) and the equatorial sector of Sisson (first half of the eighteenth century), as well as instruments like the equatorial telescope and the 1814 meridian circle of Reichenbach-Utzschneider that over a 200-year period were used to make observations and discoveries by the astronomers of Naples.

5 NOTES

1. Herschel also had the "… happy idea to dispense with the small plane mirror in the 20-ft. telescope, and this resulted in a significant increase in the penetrating power ... He has not yet shown the magnification he can reach manufacturing his met-

al mirrors." (Notizie letterarie, 1810).

2. With the exception of this quote, which is taken from Spaight (2004), all other translations into English of French, German and Italian sources quoted in this paper are by the author.
3. Notizie letterarie (1810; my English translation) contains the following evaluation of Amici: "He will be able to improve his metallic mirrors, up to a point where he will not leave us envious of those of the most famous foreign opticians."
4. Bode (1798: 109) wrote: "Mr. Cassella, the royal astronomer in Naples, informed me that on 5 September 1793 he observed the beginning of the Solar eclipse at 11^h 7^m 31.7^s t. t. and the end at 2^h 22^m 38.1^s." Data relating to the observations of the beginning and the end of the solar eclipse of 4/5 September 1793 made in Naples by Cassella and Giovanni Vivenzio are given in the table of observations made by Father Piazzi (1795) in determining the latitude difference between the Royal Palace in Naples and the Observatory in Palermo.
5. According to Bode (1808: 244-245),

> The royal astronomer Mr Cassello observed the occultation of Jupiter by the Moon on 23 September 1795 at the Royal Museum in Naples. He observed it using a 3½ feet Dollond telescope. The sky was clear.
>
> The first contact between the edge of □ and the Moon 6^h 49^m 34.9^s true time with 1 or 2^s uncertainty
> Full entrance of □ at 6^h 51^m 49.9^s exact
> Begin of exit of □ at 8^h 3^m 18.4^s
> Total exit of □ at 8^h 5^m 26.4^s

6. In December 1790 Italy acquired its second Herschel telescope when Giuseppe Piazzi received "… a reflector Telescope at least 6 feet focal length …" from Herschel (Foderà-Serio and Chinnici, 1997: 20). Piazzi had met Herschel when he visited France and England between 1787 and 1789. The telescope had an aperture of 16 cm and was acquired for the observatory in the S. Ninfa Tower at the Norman Palace in Palermo. It was made of mahogany and was equipped with a finder scope, seven eyepieces and two micrometers (Foderà-Serio and Chinnici, 1997).
7. According to Koch (1797: 249):

> In mid-July that year … von Hahn was in Berlin. He took his Arnold chronometer, whose motion and daily average deviation were verified and established same days before his departure from Remplin with his 5-ft. Ramsden meridian circle ...

8. Zollner (1797: L.23) wrote (my italics):

> So we saw ... the variable stars in the head of Medusa with the seven feet [telescope] of Herschel. Mister von Hahn has two mirrors for these instruments: one by Herschel and another by Schrader of Kiel. *There is no significant difference between the two*.

9. These were described by Piazzi (1821: 5) as

> ... a transit instrument of three and a half feet focal length, a repeating circle of 3 and a half feet focal length, a repeating circle of twelve inches, a multiplying theodolite of 8 inches and other small instruments ...

6 REFERENCES

The following abbreviations are used:

ASNa = Archives of the State of Naples
HAAOB = Historical Archives of the Astronomical Observatory of Brera
HAAOC = Historical Archives of the Astronomical Observatory of Capodimonte

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'ASTRONOMY' OR 'ASTROLOGY': A BRIEF HISTORY OF AN APPARENT CONFUSION

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Abstract: The modern usage of the words 'astronomy' and 'astrology' is traced back to distinctions that are largely ignored in recent scholarship. Three interpretations of celestial phenomena (in a geometrical, a substantialist and a prognostic form) co-existed during the Hellenistic Period. From Plato to Isidore of Seville, the semiotic contrast is evidenced, and its later developments are sketched. The concept of astronomy is found to be rather constant and distinct from changing views about astrology.

Keywords: astronomy, astrology

1 INTRODUCTION

The contemporary cultural context allows us to easily distinguish between astronomy and astrology. When needed, some discourse on physics is wedged between the two and it contrasts them, bringing support for the first but not for the second. This strategy turned out to be problematic in earlier times as an inverted situation appeared then: physics founded astrology, while astronomy was taken to be purely hypothetical (see Hübner, 1989). Language considerations point to the fact that today's astrology has appropriated the name of its founding knowledge. A statement that before modern times no clear difference was made between astronomy and astrology is perhaps trivial, but its explication is not really straightforward. Three conceptualisations of the celestial realm are found under the two names, which breed complications and confusion.

In ancient texts sometimes one (or the other) word is used for both disciplines, but no evidence appears for any inversion of the two names. This suggests that our word usage is not a convention but rather the outcome of an unstated tradition and the alleged indistinction might only be lexical. For scholars in the early Middle Ages the existence of two words implied the existence of two realia, and for all concerned the 'right' semantic co-ordination was not a problem. The person involved in celestial science was always an 'astrologer', as if the *nomos* was among the stars themselves, while their *logos* was knowledge that needed an agent. Indeed, the figure of the astronomer, with this appellation, was a late comer. In his monumental studies on the history of science, Pierre Duhem (1908) chose to promote two different kinds of practitioners of celestial science, labelling them either 'astronomes' or 'physiciens'. The traditional 'astrologer', meanwhile, was restricted to superstitious astrology. Useful as it was, this tripartite division was merely a methodological one, which relied on contemporary views and on word usage. In order to distinguish the physical from the metaphysical content, or rather positivist phenomenism from metaphysical fancy, he proposed "… saving the phenomena …" as a slogan under which the 'astronomes' were seen to be laboring. However the expression appears to be of a rather late coinage (cf. Goldstein, 1997), just as the 'astronomer' and his whole reconstruction might seem to be somewhat arbitrarily imposed.

Since the nineteenth century, classical studies have indiscriminately asserted equivalence between 'astronomy' and 'astrology' (e.g. see Daremberg and Saglio, 1919; Lewis and Short, 1879; Smith et al., 1890; cf. Bowen, 2007; Pines, 1964), even if lots of cases, read with regard to intention and content, just as Duhem (1908) did, disagree with this affirmation. The two words could be found to denote different disciplines and many ancient writers—at least those concerned with the distinction—used them knowingly. From Plato to Kepler, the co-existence for two millennia of a synonymic pair with similar word form would be a puzzling fact and just one occurrence of contamination seems to have been recorded. This was Marco Polo's (1928:135) use of 'astrolomie'(sic.) to denote a man who made predictions.

At the close of the Middle Ages, for rhetorical or ideological purposes, the confusion between 'astrology' and 'astronomy' might have been willful, betraying indeed a rather clear grasp of the issue. Later, historians and translators often relied on their own judgment and made incorrect substitutions, thereby obscuring further the distinction which was present in the original texts.

Anyone who was able to master the calendar at a time when almost nobody could write and few people could count up to ten was probably deemed a prodigy. Such a talent involved precise foreknowledge of the Sun's observable behaviour and how this related to seasonal happenings in nature. Different extrapolations were bound to appear. For example, Babylonian scribes left a remarkable record in which they linked the day-to-day configuration of the night sky to various earthly happenings, and it is just a small testimony to their obsession with any kind of omen. Recordings of the form, 'when *x*, there was the occurrence of *y*', were accumulated, with their content ranging from the trivial to the impossible. Exhaustion, as the degree zero of method, is not absurd in a world that is supposed to be finite, for the spirit is truly positive even if it is also totally uncritical. For cyclic phenomena, the discovery of their periods amounted to complete knowledge. Lack of causality, however, was a negative fact which practice did not reveal, so the Babylonians were able to predict celestial omens but not their apodoses, which remained as lists of precedents (Rochberg, 1998). In a similar fashion, the Greeks composed their parapegma (i.e. meteorological recordings for each day of the year) but, understandably, they did not achieve any success as weather forecasters. Explaining the failure lead them to accept a difference in essence between the sublunar world and the higher realm. Thus, Aristotle's decision to prescribe separate sciences for them eludes the problem by dividing it—a seemingly Cartesian gesture.

However, as a side effect this splitting produced what came to be known as astrology.

2 PLATO OR ARISTOTLE: ASTRONOMY OR ASTROLOGY

Plato's discussion of the disciplines in the *Republic (527d-530d)* includes the statement that geometry starts with planar figures, and next it proceeds to solids and their movements, which are properly the concern of astronomy (αστρονομία). The beginning of Aristotle's *Physics* neatly confronts Plato's conception: the enumeration *(194a7)* of 'sciences inverse of geometry' runs through optics, harmony and astrology (αστρολογία). There is no doubt about his meaning, as various translations unanimously testify, but using a different word emphasizes the difference. Plato goes on to mention how astronomy could be useful for navigation, but he then points out that we should be concerned with "… genuine astronomy." Symmetrically, Aristotle (1871: *Post. Anal.* I.13, 79a) remarks that astrology is both "… nautical and mathematical …", and here, as elsewhere, he specifically uses the term astrology rather than astronomy. A similar distinction is also found in Xenophon's *Memorabilia* when he remarks that travelling needs a certain "… practical knowledge of astrology …", while knowing the movements of celestial bodies that lie outside the earthly orb is "… knowledge of astronomy." (Xenophon, 1921: *Mem.* IV.7, 4-5). In Plato's works the word astronomy occurs at least twenty times, but his texts never had a role comparable to those produced by Aristotle, and it is only with the Neoplatonists, some time after Ptolemy, that his terminology achieves a wider circulation. Porphyry then wrote an *Introduction to Astronomy*, and following his mentor's usage he mentioned that Pythagoras had learned "… geometry and astronomy." *(Vita Pyth.* 11). This usage was totally eclipsed by Aristotle's teachings: Eudemos' *History of Astrology* had appeared in his lifetime and that term was adopted by all Peripatetics and the later Stoics.

The first explanation of the Sun's movement as resulting from two rolling circles was apparently proposed within the Pythagorean School, although Plato has been credited as the author of a full-blown programme. According to Simplicius, Plato proposed that the wandering of the planets was only apparent, while their true movements were just a combination of uniform circular rotations. For this step from the phenomenal to the noumenal Plato adduced arguments and restrictions appealing to perfection, divinity and other ideological bias. Eudoxus' system came as a first realisation of the proposal, an event notable enough to provide a watershed between astronomy and astrology. Aristotle took to reinterpret realistically and quasi-physically the construction that was generated theoretically—with the language itself reminding us of its origin.[1] Rather symptomatic, it was not done in the books about the heavens or physics but in the book, *Metaphysics*. Knowledge for Aristotle involved a knowledge of causes, and movement needed one. In order to build a mechanically-causal explanatory model he introduced a few more 'unrolling' spheres which allowed him to avoid unwanted transmission of movements. The centre of the system, which was originally just a geometrical point, gained the status of the most important place in the Universe. However around that time it became known that a combination of epicycles and deferents offered the best explanation which included rotations about different points. Awareness that is equivalent to eccentric orbits may have occurred to Hipparchus or somebody else and thus Aristotle's view clashed openly with the astronomic programme. A compromise was sought by declaring that models which are not strictly geocentric are just hypothetical or fictional. The better fit to observational data was devalued and 'saving the phenomena' became the catch phrase for it. In this unfortunate category went Herakleides' semi-heliocentric model, Aristarchus' system and, much later, Copernicus' model, as presented in the Wittenberg interpretation. The physics invented by Aristotle took enough hold of reality to combat the earlier geometry and claim to be true. Actually it was only Kepler who conceived the *New Astronomy*, *Based upon Causes* as it was announced in the title of his book. Indeed the causes are accounted for in Newton's mechanics which reproduces easily the phenomenology of the Solar System. But even Newton refused to feign some hypothesis about the cause of gravity. The issue was solved later by introducing material fields, the same idea being already upheld by stoic thinkers who boldly asserted that 'causes are bodies'. Peripatetism and stoicism strongly favored substantial-causal explanations and geocentrism remained despite the clash with astronomical data.

The debate about celestial events extends to their consideration in the sub-lunar orb: even if it was heterogeneous, the World was still a whole. Causal interaction, when viewed qualitatively, can be traced indefinitely far, and this is what the fatalistic stoics did. The difference between the effects of the Sun and Moon and those of the other planets is only in degree, not in essence, and is no reason to exclude them from consideration. Another principle was upheld to cut the endless causal interactions—the self-evident freedom of the will. The occasion for this development was the coming into fashion of Babylonian divinatory practice. The signs of the will of the gods, which they read, would be reified into astral influence by Greek thinkers.

3 THE BABYLONIAN CONNECTION

It is mainly a matter of speculation what Plato, Aristotle or Eudoxus knew about Babylonian astronomical or astrological lore, as its appropriation only became obvious after the conquest of Alexander the Great.[2] This is indeed the problem: why did this foreign practice come to prominence so late? Obviously, it is the conjuncture of accumulated knowledge and a flow of new information which provides a solution. This amounts to agreeing with a conclusion which, despite its numerous statements, still comes as a surprise: astrology, as we know it, was invented by the Greeks. Historical investigations lead to this view (see Neugebauer, 1968: 80; Pingree, 1968; Rochberg-Halton, 1988: 51), as does consideration of its own working and valuation (Beck, 2006).

The first attested linking of an individual's birth with astral recordings—that is, a horoscope—is in cuneiform writing, on a tablet dating from 409 BCE (Rochberg,1998:30), when the Greeks were already speculating on astral matters. Keeping to the contemporary usage, we could ask: What kinds of celestial concerns did the Babylonians have at that time? There is an obvious contrast, but it would be totally unjust to assert that these concerns were purely astrological. Rather the reverse, for one may state that they actually discovered astronomy. It is widely accepted that Pythagorism developed into mathematical science, and obviously a similar process would have led to the appearance of astronomy in the Babylonian kingdom.[3] The indebtedness to superstition, religion or myth would not be greater than the one inherited from Plato and Aristotle, who took for granted the divinity of planets. Tabulating astronomical data using ecliptic coordinates—a numerical system based on 60, with a marking for zero—are elements of a discipline which surpasses in rigor and precision most Greek endeavours. Stellar data are the main content of Babylonian horoscopes, while their interpretation is sketchy, relying on annals and tradition (see Rochberg, 1998). A transfer to Greece would mean to carry over this part which is algorithmically irreducible. The general idea, however, is easily transmissible, and the Greeks implemented it with their own means. A similar instance would be the development leading from common law to Roman law, both being practices to achieve a particular aim. Of course this inversion—astronomy being Babylonian while astrology is of Greek origin—really does not matter, except for the perspective which the participants could have had. For historical purposes one may just as well agree with Philo of Alexandria who said that the Chaldeans invented both astronomy and 'genethlialogy' (*De peregrinatione Abrahami* 33(178); and-see 35(194)).

So there were three main interpretations of celestial science in Ptolemy's day: a Pythagorean one, where it was viewed as geometry; a physicalist and substantial one, inspired by peripatetism; and a prognostical one which was attributed to the Chaldeans and still needed a name. It was called descriptively by referring to its alleged originators, the Chaldeans, or known as 'apotelesmatics' and, more particularly, as 'genethlialogy' or 'katarkhe'. For Latin authors, and for anybody not involved in this, the distinction between Pythagorean, peripatetic and Babylonian views would have been rather elusive. What is more, Babylonian tables allowed preparation of horoscopes and celestial prognostication without any grasp of astronomy. Any 'astronomer' could and did the same, so the common denominator of the profession was 'astrology' and correspondingly its practitioners were 'astrologers'. Before the first century CE, Latin authors did not use the term 'astronomy' (the exception perhaps being the *Astronomica* of the Manilius), as the majority of Greeks had adopted the word 'astrology'. The former term was still currently used as witnessed by the texts of Theon of Smyrna or the data collected by Diogenes Laertius. For example, Diogenes Laertius collated various sources where 'astronomy' was used at least four times and 'astrology'or 'astrologer' at least ten times. Sextus Empiricus, in writing against the learned men = doctores of his day, notes that "… Chaldeans call themselves mathematici or astrologi …" and attacks their astrology or "… mathematical art differing from arithmetic and geometry … [and different from] the prognostics of Eudoxus and Hipparchus, which some call astronomy." (*Adv. math.*, V: 1-2).

4 PTOLEMY'S SHUFFLE

Ptolemy has a special place in history, as for a millennium he remained the authority on astronomy, and for even longer on astrology. His achievement appears to be not so much a novelty as a reconfiguration. Instead of the dilemma describing/explaining his work brings to the front knowledge in the form of prediction – it can be only more or less exact. Describing the celestial movements is apodictic while tracing their causes or effects is just probabilistic.

The eclecticism of the zeitgeist is perceptible in Ptolemy's writings which comprise both platonic astronomy and peripatetic-stoic physics. Aristotelian astrology was always something like an astral twin of sublunary valid knowledge, and obviously there was no room for it in this mix. The return to a Pythagorean tradition was obvious, and the avoidance of Aristotelian terminology was marked.[4] The dual hierarchy of Aristotle's cosmos is replaced by a fourfold scheme built on oppositions from the categories 'immaterial' and 'invisible'. Thus, theology is the science of the immaterial and invisible, mathematics is about the immaterial and visible while physics is about the material and visible. The material and invisible, which corresponds to the soul, is subsumed in physics and this imbalance reveals that the really meaningful distinction is between ideal and material.

The four books, or *Tetrabiblos*, devoted to what is today's astrology, were known as Ptolemy's *Apotelesmatics*, which is his own preferred term, explained as prognostication by means of astronomy. In the celestial realm predictions are strictly true, while anywhere else they are only probable—for meteors or individual predictions. But a continuously-distributed probability erases the opposition between sublunar and higher realms and thus invalidates the Aristotelian difference between astrology and physics. Lacking a proper content, 'astrology' can be used for the founding and explaining of astral influences, as was previously done by physics. And this is what really happened, but much later, when Aristotelian science was fully discredited. For the moment, 'astronomical prediction', or some such paraphrasing, was commonly used as it was mostly taken in the same restricted sense as 'astrologer'. An interest in star patterns when they are devoid of divinity and without reference to their effects would have been odd indeed. So the first modern-looking definition of astrology—namely, judging or predicting by the stars—appears to have been given by the more pragmatic Arabic commentators (see Pines, 1964).

5 FAST FORWARD

Since late antiquity the quadrivium has provided a context which unambiguously identifies astronomy independently of the word used. Mathematics, already in a restricted sense, included two proper subdisciplines, arithmetic and geometry and they had as counterparts music and a celestial science. Varro and Martianus Capella still called it 'astrology' but Cassiodorus only used the term 'astronomy'—even when referring to Varro's *De Astrologia*. The existence of two distinct words assured medieval authors that there were two quite different concepts involved, and generally they were able to provide an educated guess—as apparently Alcuin or Hugo of Saint Victor did[5]—and they discussed the geometrical Pythagorean science separately from its more substantial variants. In the early ninth century Martin of Laon (1981) enumerated the disciplines from the quadrivium ending with "… astronomy to which cling astrology and medicine." The same disposition was found much later, when university education had been instituted: Aristotle was taught by the theological faculty, while astronomy and its astrological and medicinal continuation had their place in the faculty of medicine. Galileo still had to teach them there. Aristotle's texts mentioning astrology became known to Western scholars a few centuries after they learnt from the Arabs about 'judging by stars'. *Liber de Astronomice judicandi* by Roger of Hereford is an early example (ca. 1184) of an astrological treatise presented with the words that Ptolemy might have used. Improving the calendar was of prime interest to ecclesiastics, and they were aware that astronomical tables—be they Arabian or Babylonian—only offered valid data for the locations where they were computed, so any prognostication needed astronomy as its precondition.

In compiling his *Etymologies*, Isidore of Sevilla included a comment about the difference between astronomy and astrology which surely would not have been there if it had not appeared in an earlier text. It is worth noting that his definition of astronomy reproduces the words that Cicero used when writing about astrology,[6] so Isidore, or somebody before him, knew enough to transpose this usage. Remarkably, Isidore went on and made a further distinction, dividing the topic into three parts. After separating astronomy from astrology, he added that the later was "… partly natural, partly superstitious …", which corresponded to Aristotelian and Babylonian concepts. The religious qualification here etymologically speaks about 'standing-over' or 'supernatural', which is indeed what Chaldean science was. A 'natural astrology' would have been for a peripatetic something of a contradictio in adjecto, just like 'celestial physics', which much later was used by Kepler (1609) in the title of one of his books.[7] Nevertheless the same text reappears elsewhere,[8] and the *Etymologies* remained influent through the Middle Ages, transmitting an understanding achieved already at the start of Hellenism.

It seems safe to conclude that through the ages people who used the word 'astronomy' knew what they were talking about. Late Medieval and Renaissance writers sometimes stretched the term to cover most of what is astrology, but such a rhetorical strategy would not have been possible without prior knowledge of the difference.

Since the end of the thirteenth century there has been a discussion about how much of astrology is 'licit': the Church and secular powers maintained conflicting opinions, which were further complicated by the humanists' views during the Renaissance. As a defender of astrology Pierre d'Ailly (1414 went so far as to write about "… astronomy falsely known as astrology …" in his *Tractatus de concordantia theologie et astronomie*, while Pico della Mirandola's *Disputationes adversus astrologiam divinatricem* (1496) dealt it a nearly fatal blow.

Acknowledging the history hidden behind the term 'astrology' leads to a clearer grasp of the ambiguities in its usage. Pleonastically-looking qualifications such as 'divinatory' or 'judicial astrology' are witnesses of the distinction from a 'physical' or 'natural astrology', an early attempted science which became sidetracked.

6 NOTES

1. It would be almost a tautology to point that astronomy is the first 'theoria' – a way of seeing. Aristotle's approach was metaphysical, as he proposed to explain what is seen: a separate realm with its own laws. Nature, or 'physis', for him consisted of generations and corruptions explained by the four elements, but above the Moon there was a fifth substance. One is tempted to describe the appropriate science, astrology—which inevitably relies on earthly logic and analogies—as literally supernatural or at least para-physical. The situation was further complicated by viewing the soul also as a substance; interestingly, renaissance alchemy was sometimes called 'astronomia inferior').
2. Plato's *Timaeu*s provides grounds for some acquaintance with Babylonian astronomical lore to be acknowledged, while Aristotle's remarks remain in a naturalistic vein. According to an uncorroborated remark in Cicero (*De Div.*, ii, 42, 87), Eudoxus demanded that "… no credence should be given to the Chaldeans, who predict and mark out the life of every man according to the day of his nativity."
3. Today Babylonian mathematics is understood to be mostly arithmetic but, rather curiously, Josephus wrote in his mythical account of the *Jewish Antiquities* that Chaldeans learned from Abraham 'arithmetic and astronomy' (I.8.2 (166)), the usual pair of 'geometry and astronomy' appearing elsewhere (I.3.9 (106)).
4. For example, in the *Almagest* neither word appears; in the *Tetrabiblos* 'astronomy' is used just six times and, as Feke (2009: 153) notes, its only other appearance is in the *Harmonics* where it is defined as a mathematical science.
5. Alcuin (*Opera Omnia*, col. 947): "Astronomia lex astrorum, qua oriuntur et occidunt astra. Astrologia est astrorum ratio et natura et potestas, coelique conversio." ["Astronomy is the law of the stars, how the stars rise and set. Astrology is about the reason and nature and the power of the stars and sky rotation."] Hugo St Victor (*Opera Omnia*, col. 756): "… astronomia de lege astrorum nomen sumpsit, astrologia autem dicta est quasi sermo de astris disserens. Nomos enim lex et logos sermo interpretatur." ["… astronomy took the name of 'law of stars' but astrology is said to be like a discourse treating of the stars; because 'nomos' is translated as 'law' and 'logos' as 'discourse'."] (cf. Pines, 1964).
6. *Etym 3.27*: Astronomia caeli conversionem, ortus, obitus motusque siderum continet, in the enumeration of disciplines by Cicero: "Astrologia, caeli conversio, ortus, obitus motusque siderum." (*De Oratore*, ii.42). ["Astronomy comprises the rotation of the sky, the rise, setting and movement of stars / Astrology is (about) the rotation of the sky, the rise, setting and movement of stars."]
7. *Astronomia Nova Αἰτίολογητοσ, seu Physica Coelestis*, which was translated into English as: *New Astronomy, Based on Causes, or Celestial Physics*.
8. See in *Dubi*a *e*t *Spuri*a of Bede (908D), where

'astronomy' and 'astrology' are named as two of the six parts pertaining to physics, and then the same text is reproduced.

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LONG-PUBLISHING ASTRONOMERS, OR THE PROBLEM OF CLASSIFICATION

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Abstract: In response to several discussions among astronomers and historians of astronomy, I started out to prepare a paper on long-publishing astronomers—those who published for 70, 75, or even 80 years. However, I soon ran into a number of questions of classification, and that turned out to be at least as interesting. How do we decide on classifications? Every time we choose classes, such as asteroids, planets and stars, we run into objects that seem to be in between. In the present case a number of questions arise: Who is an astronomer? Several of those with the longest publication runs started out as physicists, published for years in that subject only, and later took up astrophysics, eventually publishing a few papers in astronomy journals. What is a publication? Should we count publications in physics, chemistry, or mathematics? What about philosophy of science or history of science? What about the elderly retired astronomer presenting a memoir of his or her own work? Abstracts of oral presentations? Monographs? Textbooks? Book reviews? Obituaries? Then there is the problem of posthumous publications. Probably most would include papers in the pipeline when the astronomer dies, but what about the case where the coauthor finally publishes the paper as much as twenty-two years after the death of the person of interest? I eventually decided to make two lists, one which would include most of the above, and one restricted to papers that make contributions to physical science. Note that I do not say 'refereed', as that presents its own problems, especially when applied to periods before the twentieth century.

I present a list of astronomers who have published for periods of 68 to 80 years and discuss the problems of defining such terms as astronomer and publication.

Keywords: Astronomers, long-publishing.

1 INTRODUCTION

On several occasions historians of astronomy have discussed the question of the longest-publishing astronomers. For example, an obituary (Boeshaar, 2000) claimed that Philip Keenan's 71-year publishing record was "… the longest publishing career in modern astronomy." Helmut Abt (1995) tabulated the longest-publishing astronomers at that time, but his list was confined to publications in the *Astrophysical Journal*, and his longest run, 64 years for Joel Stebbins (1878–1966), does not come close to those described here.

An attempt to compile a list led to a number of interesting questions regarding classification. Whenever we try to classify something and put every member of a population into a bin, Nature confounds us by presenting objects that do not fit. When I took my last biology class (in the 1950s) I was taught that there are two kingdoms, plant and animal, and a few things, e.g., fungi, that don't quite fit. Today American students are taught that there are six kingdoms, while those in some countries are told there are five. And several newer systems have been proposed, some with far more than six kingdoms classified into three domains. Astronomers are more familiar with the question of how to define a planet. There are difficulties at both ends, as shown by the controversies over dwarf planets and brown dwarfs.

The present endeavor leads immediately to two questions: (1) Who is an astronomer? (2) What is a publication? In order to proceed, I had to make a number of quite arbitrary decisions. Readers may well disagree with some of them.

2 CLASSIFICATIONS

Regarding the first question, I decided to include anyone who has contributed to astronomy, interpreted broadly. This includes many physicists and quite a few mathematicians, chemists, geologists, and planetary scientists. Some of them published very few papers in astronomical journals.

The second question proved so difficult that I decided to make two lists, one confined to publications that make original contributions to scientific knowledge, and one of essentially all publications that contribute to astronomy or the community of astronomers. The first list is almost, but not quite, synonymous with "refereed" publications today, but refereeing is a fairly recent development, and journals have changed. Table 1 lists a number of types of publications and whether they are included in the "original contribution" list and the total list.

The two lists have different objectives. The first list ("original") is simple in principle: any publication which makes an original contribution to scientific knowledge. This includes papers in journals and monographs. Posthumous publications are included only if the author actually worked on them. Thus papers published by coauthors long after the death of the person of interest but with his name on them because his data were used are not counted. Also omitted are the cases where an observation or two contributed to a line in a table of observations published by another. If these were counted, the New Zealand amateurs Frank Bateson (see Table 3) and Albert Jones (b. 1920) would rank higher, as they contributed observations to organizations of variable star observers several years before they began publishing in their own names.

The second ('total') list is to show which astronomers were intellectually active, to the point of publishing, for the longest times. Elderly scientists are frequently called upon to write reminiscences of their own work and obituaries of departed colleagues. Many write book reviews and popular articles on science, while a few update their textbooks. Some

Table 1: Decisions on which publications to count.

Type of publication	Count for "original" list?	Count for "total" list?
Journal articles with new science	yes	yes
Monographs	yes	yes
Publications in other physical sciences and mathematics	yes	yes
History of science (not personal)	no	yes
Personal history, reminiscences	no	yes
Abstracts of papers presented at meetings	no	yes
Textbooks	no	yes
Popular books and articles on scientific topics	no	yes
Obituaries	no	yes
Book reviews	no	yes
Ph.D. and master's theses	no	no
Publications on non-scientific topics	no	no

present at conferences. Not a few have turned to history of astronomy. While they may no longer be contributing to the advancement of scientific knowledge, they are still active. We will see that this can extend their publishing records to seven decades or more. The omission of dissertations and theses from the "total" list is a pragmatic choice: it is difficult to find their dates in most cases, and this gives an unfair advantage to those whose theses happen to be readily available. In most cases the thesis work appeared in a published paper within a year or two.

3 METHODOLOGY

Once the above—admittedly arbitrary—decisions had been made, there was still the problem of comparing publications of the distant past with those of today. Publication was quite different a few centuries ago, and much of the world's scientific work is difficult to find. Therefore I made another practical decision: This work is limited to authors born in 1800 or later, and it is based primarily, though not exclusively, on two sources, ADS (http://www.adsabs.harvard.edu/) and Google Scholar (http://scholar.google.com/).

The major omissions are probably those who published in non-European languages, although it is quite possible that some others have been missed. I hope that the list will still be of interest, and I welcome corrections and additions to the list.

4 THE LONGEST PUBLISHING ASTRONOMERS: ORIGINAL CONTRIBUTIONS TO PHYSICAL SCIENCE

Table 2 shows the twenty astronomers who made original contributions to physical science over periods of 68 to 80 years. Some are very prominent scientists—three were awarded Nobel prizes—while others are known only to specialists in their fields. Haas is an amateur astronomer. Cousins made the transition from amateur to professional in mid-career, while Baldwin went in the opposite direction. Let's take a closer look in inverse order.

4.1 Sixty-eight years of Scientific Contributions

Ralph B. Baldwin (Figure 1) was a Ph.D. astrophysicist who helped develop the proximity fuse during World War II, taught at several universities, wrote a number of books, and then spent 37 years running his family's machinery business in Michigan. He is best known for convincingly demonstrating that lunar craters are due to impacts.

Figure 1: Ralph B. Baldwin (courtesy Archives, Grand Rapids Public Library, Grand Rapids, Michigan).

Theodor S. Jacobsen (Figure 2), the lone astronomer at the University of Washington for several decades, made spectroscopic studies of stars. He published a book on the history of planetary systems (with a lot of help from his friends) at age 98.

Charles P. Olivier (Figure 3) taught at the Universities of Virginia and Pennsylvania and founded the American Meteor Society. He measured parallaxes and orbits of binary stars.

Jan Oort (Figure 4), long-time director of the Leiden Observatory in the Netherlands, is justly famed for his theory of the rotation of the Galaxy, the advancement of radio astronomy, the founding of international organizations, and proposing today's accepted model for the source of long-period comets, the "Oort Cloud."

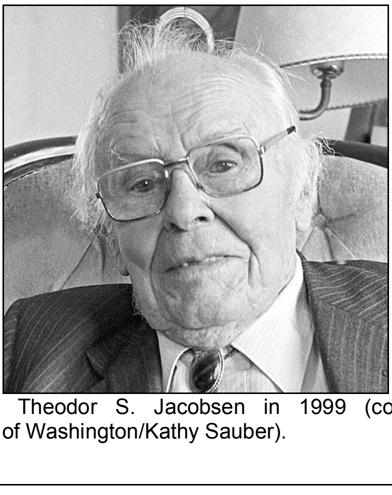

Figure 2: Theodor S. Jacobsen in 1999 (courtesy of University of Washington/Kathy Sauber).

Table 2: Longest-publishing astronomers: original contributions to physical science

Rank	years	Name (lived)	First Orig. Sci. Pub.	Last Orig. Sci. Pub.
1	80	Hans Bethe (1906–2005)	Bethe, 1927	Bethe, et al., 2007
2	77	Alan W.J. Cousins (1903–2001)	Cousins, 1924	Cousins and Caldwell, 2001
		Harold Jeffreys (1891–1989)	Jeffreys, 1910	Jeffreys and Shimshoni, 1987
4	74	Viktor A. Ambartsumian (1908–1996)	Kosirev and Ambarzumian, 1925	Ambartsumian and Gyulbudaghian, 1999
		Fred Whipple (1906–2004)	Berman and Whipple, 1928	Cochran, et al., 2002
6	73	Charles H. Townes (b. 1915)	Townes, 1938	Townes, et al., 2011
7	72	Charles G. Abbot (1872–1973)	Noyes and Abbot, 1897	Abbot and Hill, 1969
		George H. Herbig (b. 1920)	Herbig, 1940	Dahm, et al., 2012
		Dorrit Hoffleit (1907–2007)	Hoffleit, 1930	Webbink, et al., 2002
		George Van Biesbroeck (1880–1974)	Van Biesbroeck, 1904	Van Biesbroeck, et al., 1976
11	71	Philip C. Keenan (1908–2000)	Keenan, 1929	Barnbaum, et al., 2000
		Willem J. Luyten (1899–1994)	Luyten, 1918	Warren, et al., 1989
13	69	Lawrence H. Aller (1913–2003)	Aller, et al., 1935	Mooney, et al., 2004
		Walter H. Haas (b. 1917)	Haas, 1937	Haas, 2006
		Gerhard Herzberg (1904–1999)	Herzberg, 1927	Dabrowski and Herzberg, 1996
		John A. Wheeler (1911–2008)	Wheeler, 1933	Holtz and Wheeler, 2002
17	68	Ralph B. Baldwin (1912–2010)	Baldwin, 1938	Baldwin, 2006
		Theodor S. Jacobsen (1901–2003)	Jacobsen, 1924	Wallerstein, et al., 1992
		Charles Olivier (1884–1975)	Olivier, 1901	Olivier, 1969
		Jan H. Oort (1900–1992)	Oort, 1922	Oort, 1990

Figure 3: Charles P. Olivier in 1914 (Holsinger Studio Collection, Special Collections, University of Virginia Library).

4.2 Sixty-nine Years of Scientific Contributions

Lawrence H. Aller (Figure 5), a theorist and observer at the Universities of Indiana and Michigan and, for most of his career, the University of California, Los Angeles, was a leading authority on planetary nebulae, stellar spectra, and chemical abundances of the Sun, stars, and nebulae.

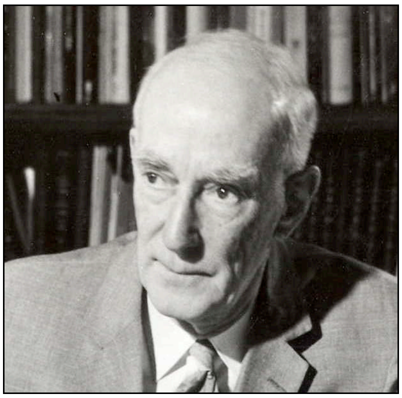

Figure 4: Jan H. Oort (This image is copyright by the Leiden Observatory).

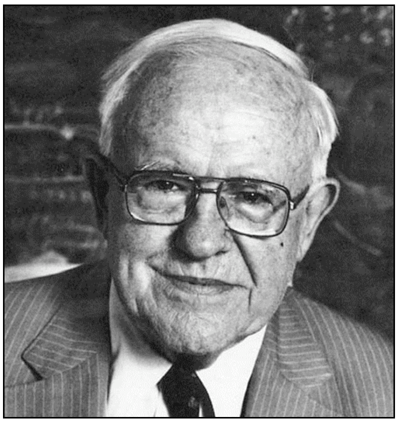

Figure 5: Lawrence H. Aller (courtesy National Academies Press).

Walter H. Haas (Figure 6) is an American mathematics instructor and applied mathematician who founded and for many years led the Association of Lunar and Planetary Observers (ALPO), a large organization of amateur astronomers. Most of his publications have been accounts of observations published in the *Journal of the Royal Astronomical Society of Canada, Popular Astronomy,* and the *Journal of the ALPO* (formerly called the *Strolling Astronomer*), which he founded.

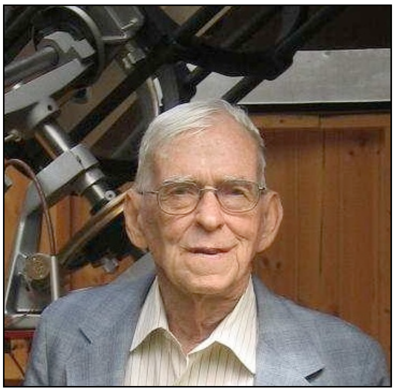

Figure 6: Walter Haas in 2004 (courtesy Richard McKim).

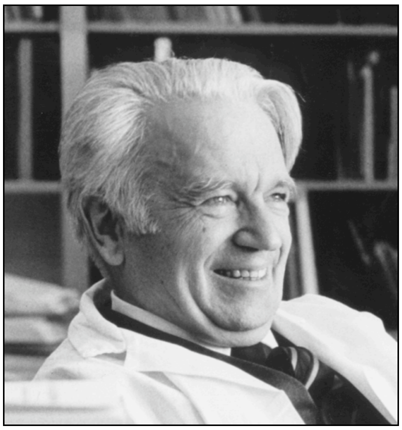

Figure 7: Gerhard Herzberg (courtesy National Research Council Canada).

Gerhard Herzberg (Figure 7) once described himself as “25 percent astronomer, 30 percent chemist, 40 percent physicist.” He is best known for theoretical and experimental work on atomic and molecular spectra and structure. He emigrated from Germany to Canada in 1935 and was awarded the Nobel prize in chemistry in 1971 “for his contributions to the knowledge of electronic structure and geometry of molecules, particularly free radicals.” Most of his research was done at the University of Saskatchewan and the National Research Council of Canada.

John Archibald Wheeler (Figure 8) was a theoretical physicist who worked at Princeton University and the University of Texas at Austin. He led one of the world’s leading research groups in general relativity and contributed to the theory of black holes (coining the term) and cosmology. He also developed the theory of nuclear fission with Niels Bohr. Nearly all of his publications were in physics journals, general science publications, and books.

4.3 Seventy-one Years of Scientific Contributions

Philip Keenan (Figure 9), a spectroscopist who, with W.W. Morgan, developed the two-dimensional classification of stellar spectra, had a long and productive career studying cool stars at Ohio State University. His work included stellar abundances and evolution as well as spectral classification.

Willem J. Luyten (Figure 10) was born in the Dutch East Indies (now Indonesia) and educated in the Netherlands, but worked in the United States, especially the University of Minnesota, where he taught for 36 years, the first 26 as the university’s lone astronomer. He observed, despite losing an eye in his youth, and he blinked and measured plates, using a machine he designed, to find proper motions of more than 500,000 stars and to discover a great many white dwarfs.

Figure 8: John A. Wheeler (Courtesy University of Texas.)

Figure 9: Philip Keenan (courtesy Gerald Newsom).

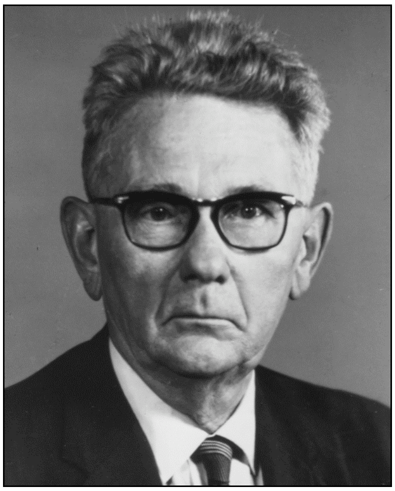

Figure 10: Willem J. Luyten (courtesy James Luyten).

4.4 Seventy-two Years of Scientific Contributions

Charles G. Abbot (Figure 11) directed the Smithsonian Astrophysical Observatory and later the entire Smithsonian Institution, devoting most of his efforts to measuring the solar constant and attempting to show correlations between variations in the Sun’s output and terrestrial weather. He established solar monitoring stations around the world and invented improved bolometers.

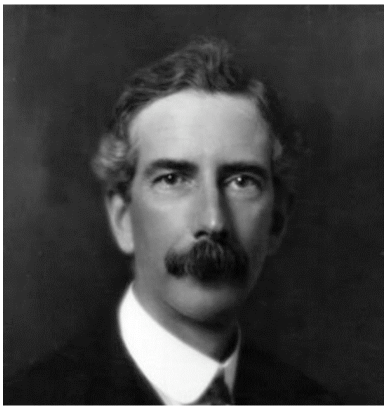

Figure 11: Charles G. Abbot (Photo by Bachrach).

Figure 12: George H. Herbig (courtesy Karen Teramura).

George H. Herbig (Figure 12) is a spectroscopist who had a full and productive career at the Lick Observatory and then moved to the University of Hawaii at age 68. Now, at 92, he is still publishing observations of stars and the interstellar medium. He is best known for his work on early stages of stellar evolution, including his independent discovery of the Herbig-Haro objects, and for studies of diffuse interstellar bands.

Dorrit Hoffleit (Figure 13) worked at Harvard and Yale Universities and directed the Maria Mitchell Observatory on Nantucket Island, where she and her students measured variable stars. Her best-known work consists of spectroscopic parallaxes, several editions of the *Bright Star Catalogue*, and a catalogue of stellar parallaxes, but she also wrote many popular articles, and in her later years she wrote books and articles on the history of astronomy.

George Van Biesbroeck (Figure 14), who was born in Belgium and educated at the University of Ghent, worked at Yerkes Observatory and the University of Arizona, observing until well into his nineties. His specialties included visual binary stars and discoveries and positions of comets, asteroids, and planetary satellites. He also made several eclipse expeditions.

4.5 Seventy-three years of Years of Scientific Contributions

Charles H. Townes (Figure 15) is an experimental physicist who has worked at Bell Labs, Columbia University, the Massachusetts Institute of Technology, and, since 1967, the University of California at Berkeley. He worked on radar in World War II, he shared the Nobel Prize in physics for co-inventing the maser, and he proposed the idea of extending stimulated emission into the visible range to make the laser. Masers led to radio astronomy, and he has spent his later years extending interferometry from the radio region into the infrared and using a three-element interferometer to measure such quantities as stellar diameters and the formation and conditions of molecular material in stellar atmospheres.

Figure 13: Dorrit Hoffleit in 2007 at her 100th birthday party (courtesy Yale University).

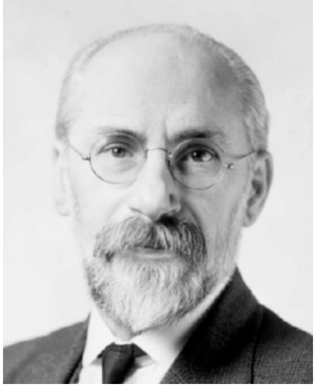

Figure 14: George Van Biesbroeck in 1939 (courtesy Archival Photographic Files, apf6-00174, Special Collections Research Center, University of Chicago Library).

4.6 Seventy-four Years of Scientific Contributions

Viktor A. Ambartsumian (Figure 16) worked at the Pulkovo Observatory, the Byurakan Astrophysical Observatory, which he founded and directed, Erevan University, and the Armenian Academy of Sciences, which he served as president from 1947 to 1993. He

Figure 15: Charles H. Townes in 1968 (courtesy Lawrence Berkeley National Laboratory).

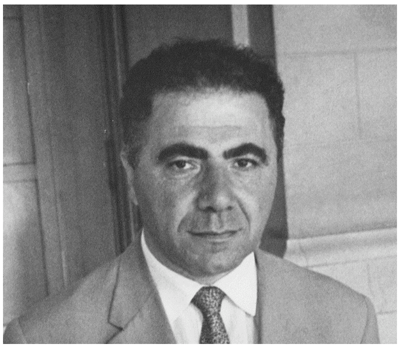

Figure 16: Viktor A. Ambartsumian (courtesy *Sky & Telescope*).

Figure 17: Fred Whipple (courtesy Smithsonian Astrophysical Observatory).

applied invariance principles to the theory of radiative transfer, dealt with inverse problems, and developed theories for the origin and evolution of stars and galaxies. He suggested that T Tauri stars are young, and he proposed that stellar associations are expanding.

Fred L. Whipple (Figure 17) conducted research on meteors and comets at Harvard University and the Smithsonian Astrophysical Observatory and led the merger of their astronomy programs into the Harvard-Smithsonian Center for Astrophysics. He showed that most visible meteors come from cometary material and proposed the "dirty snowball" model for comet nuclei. The inventor of a device for confusing radar and of the "Whipple shield" to protect spacecraft from micrometeorites, he was on the science team for a NASA mission to a comet in his late nineties.

4.7 Seventy-seven Years of Scientific Contributions

Alan W.J. Cousins (Figure 18) made variable star observations as an amateur astronomer while working as an engineer on power stations until the age of 44, when he obtained a professional position at what is now the South African Astronomical Observatory. He is known for his development of photographic and photoelectric photometry and especially for making the UBVRI system the accepted standard.

Harold Jeffreys (Figure 19), primarily a mathematician, was a professor of geophysics and astronomy at the University of Cambridge. He modeled the interior of the earth and outer planets, studied and wrote about earthquakes and worked in pure and applied mathematics as well.

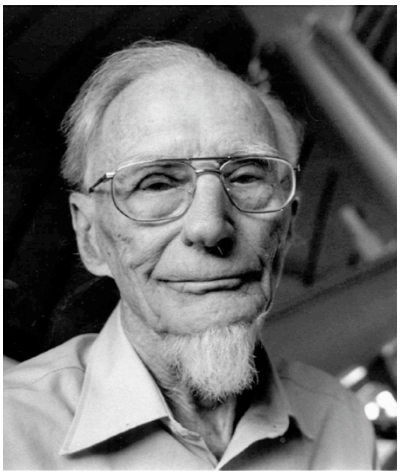

Figure 18: Alan W.J. Cousins (courtesy South African Astronomical Observatory).

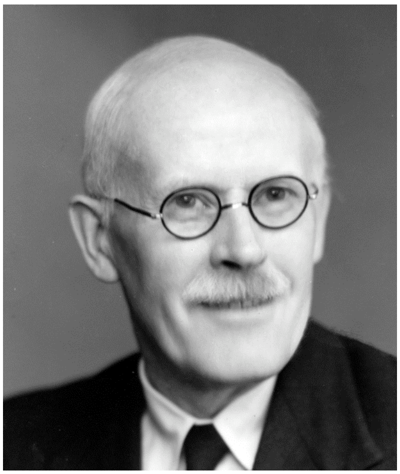

Figure 19: Harold Jeffreys in 1952 (photo by Walter Stoneman, American Geophysical Union, courtesy AIP Emilio Segrè Visual Archives).

4.8 Eighty Years of Scientific Contributions

Hans A. Bethe (Figure 20) made major contributions to solid state physics, nuclear physics, and astrophysics and significant ones to atomic physics and quantum electrodynamics. Alsace-born and German-educated, he taught and conducted research at Cornell University from 1935 to 2005. His detailed models of the two hydrogen-burning reaction chains which power the stars, computed in the late 1930s, led eventually to a share of the 1967 Nobel prize in physics. He was a noted statesman of science and advised governments on arms control and energy policies.

4.9 Honorable Mention

Those who published original scientific results for "only" 67 years, are Paul Baize, who will be discussed in the next section; Subrahmanyan Chandrasekhar, the Indian-born University of Chicago astrophysicist, whose discovery of the limiting mass of white dwarf stars was eventually recognized with a Nobel prize and who made theoretical discoveries in half a dozen branches of astrophysics; and Yngve Öhman, the Swedish solar astronomer.

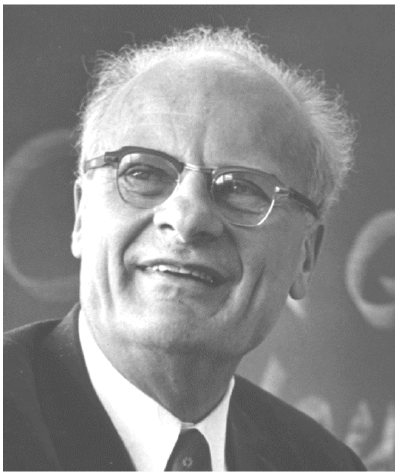

Figure 20: Hans Bethe in 1967 (courtesy Cornell – LEPP Laboratory)

Table 3: Longest-publishing astronomers: All contributions related to physical science

Rank	years	Name (lived)	First Publication	Last Publication
1	80	Hans Bethe (1906–2005)	Bethe, 1927	Bethe, et al., 2007
2	79	Harold Jeffreys (1891–1989)	Jeffreys, 1910	Jeffreys, 1989
3	78	Willem J. Luyten (1899–1994)	Luyten, 1918	Hintzen, et al., 1996
4	77	Alan W.J. Cousins (1903–2001)	Cousins, 1924	Cousins and Caldwell, 2001
5	76	Dorrit Hoffleit (1907–2007)	Hoffleit, 1930	Hoffleit and Gay, 2006
		Theodor S. Jacobsen (1901–2003)	Jacobsen, 1923	Jacobsen, 1999
7	75	Giorgio Abetti (1882–1982)	Abetti, 1905	Abetti, 1980
8	74	Viktor A. Ambartsumian (1908–1996)	Kosirev and Ambarzumian, 1925	Ambartsumian and Gyulbudaghian, 1999
		George H. Herbig (b. 1920)	Herbig, 1938	Dahm, et al., 2012
		Fred Whipple (1906–2004)	Berman and Whipple, 1928	Cochran, et al., 2002
11	73	Ernst J. Öpik (1893–1985)	Öpik, 1912	Öpik, 1985
		Charles H. Townes (b. 1915)	Townes, 1938	Townes, et al., 2011
13	72	Charles G. Abbot (1872–1973)	Noyes and Abbot, 1897	Abbot and Hill, 1969
		Hermann A. Brück (1905–2000)	Brück, 1928	Brück and Brück, 2000.
		George Van Biesbroeck (1880–1974)	Van Biesbroeck, 1904	Van Biesbroeck, et al., 1976
16	71	Paul Baize (1901–1995)	Baize, 1923	Baize, 1994
		Philip C. Keenan (1908–2000)	Keenan, 1929	Barnbaum, et al., 2000
18	70	Frank M. Bateson (1909–2007)	Bateson, 1936	Bateson and Jones, 2006
		Jesse L. Greenstein (1909–2002)	Greenstein, 1930	Freeman, et al., 2000
		Jan H. Oort (1900–1992)	Oort, 1922	Oort, 1992
		John A. Wheeler (1911–2008)	Wheeler, 1933	Wheeler, 2003

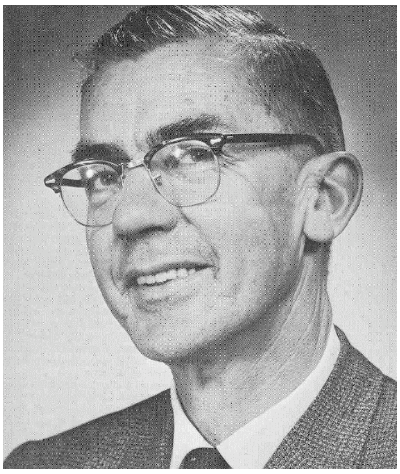

Figure 21: Frank M. Bateson (courtesy F.M. Bateson).

5 THE LONGEST PUBLISHING ASTRONOMERS: ALL CONTRIBUTIONS TO PHYSICAL SCIENCE

Table 3 shows the twenty-one astronomers who produced all kinds of publications relevant to astronomy or astronomers over periods of 70 to 80 years. There are six who were not on the previous list: Abetti, Baize, Bateson, Brück, Greenstein, and Öpik.

5.1 Seventy Years of Publications

Jan H. Oort and **John A. Wheeler** were discussed in Section 4.

Frank M. Bateson (Figure 21), like Cousins, started out as an amateur astronomer and became a professional relatively late in life. The founder of the Variable Star Section of the Royal Astronomical Society of New Zealand observed variable stars and coordinated the observations of others during a career as a businessman in the Cook Islands. He helped found the Mount John University Observatory in New Zealand and became its first director in 1963.

Jesse L. Greenstein (Figure 22) left the University of Chicago's Yerkes Observatory to start the astronomy graduate program at the California Institute of Technology in 1948. A spectroscopist with interests in theory and instrumentation, he explored the interstellar medium, the colors of nebulae, abundances of the elements and isotopes, and peculiar stars. He observed hundreds of white dwarf stars and determined their properties.

5.2 Seventy-one Years of Publications

Philip C. Keenan was discussed in Section 4.

Paul Baize (Figure 23) was a French pediatrician and hospital administrator by day and an amateur astronomer by night. There was nothing amateurish about his observations of double stars, however, and he was granted permission to use the telescopes of the Paris Observatory. Many of his later publications were short notices of orbits he computed, published in the *Information Circulars* of International Astronomical Union Commission 26 (Double Stars).

Figure 22: Jesse Greenstein in 1948 (courtesy Archival Photographic Files, apf6-04368, Special Collections Research Center, University of Chicago Library).

Figure 23: Paul Baize in 1993 (courtesy Jean-Claude Thorel).

5.3 Seventy-two Years of Publications

Charles G. Abbot and **George Van Biesbroeck** were discussed in Section 4.

Hermann A. Brück (Figure 24) was born and educated in Germany, where he changed fields from solid state physics to astronomical spectroscopy. After 1937 he worked at the University of Cambridge, the Dunsink Observatory in Ireland, and from 1957, the Royal Observatory Edinburgh and the University of Edinburgh, where he updated the equipment, designed and constructed scanning machines, and did precision mass spectroscopy of stars, using Schmidt telescopes. After retirement as Astronomer Royal for Scotland, he and his wife, Mary, wrote on the history of astronomy.

5.4 Seventy-three Years of Publications

Charles H. Townes was discussed in Section 4.

Ernst J. Öpik (Figure 25) was born in Estonia and educated in Moscow. He worked in Estonia and, for 33 years, at the Armagh Observatory in Northern Ireland. Often too far ahead of his time for his ideas to be accepted, he made early contributions to stellar structure and evolution theory, explained the structure of giant stars, and showed that spiral nebulae were extragalactic as early as 1922. He made statistical studies of meteors, comets, and asteroids and wrote a great many articles for the *Irish Astronomical Journal*, which he edited from 1950 to 1981.

5.5 Seventy-four Years of Publications

Viktor A. Ambartsumian, George H. Herbig, and **Fred Whipple** were discussed in Section 4.

Figure 24: Hermann A. Brück in 1965 (courtesy Royal Observatory Edinburgh).

Figure 25: Ernst Öpik (courtesy Armagh Observatory).

5.6 Seventy-five Years of Publications

Giorgio Abetti (Figure 26), who had worked in Rome and Florence, succeeded his father as director of the observatory in Arcetri, Italy in 1925. A leading researcher in solar physics, he constructed a solar tower and used it to study motions around sunspots. He wrote textbooks, monographs, and books on the history of astronomy. He held several national and international positions.

5.7 Seventy-six Years of Publications

Dorrit Hoffleit and **Theodor S. Jacobsen** were discussed in Section 4.

5.8 Seventy-seven Years of Publications

Alan W.J. Cousins was discussed in Section 4.

5.9 Seventy-eight Years of Publications

Willem J. Luyten was discussed in Section 4.

5.10 Seventy-nine Years of Publications

Harold Jeffreys was discussed in Section 4.

5.11 Eighty Years of Publications

Hans Bethe was discussed in Section 4.

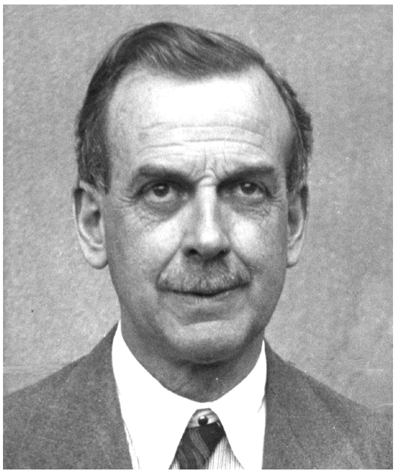

Figure 26: Giorgio Abetti (courtesy Archival Photographic Files, apf6-04366, Special Collections Research Center, University of Chicago Library).

5.12 Honorable Mention

Lawrence Aller, Frank K. Edmondson, Walter Haas, Gerhard Herzberg, William H. McCrea, and Antonie Pannekoek had total publication spans of sixty-nine years. Not mentioned previously are Edmondson, the Indiana University astronomer who discovered and tracked asteroids and was a leader in establishing the Association of Universities for Research in Astronomy; McCrea, the Irish/British mathematician, general relativist and cosmologist; and Pannekoek, the University of Amsterdam theoretical astrophysicist whose abundant writings on Marxist theory are not counted here.

6 CONCLUSIONS

Perhaps it is surprising that although all astronomers born in 1800 or later were investigated, none born before 1872 made the top lists. Of course there were fewer astronomers in the 19th century than the 20th, and life spans were generally shorter. Of those considered who were born before Abbot, the longest publishers (total list only) were John Evershed (1874–1956) with 68 years and William Thomson (Lord Kelvin, 1824–1907) with 66 years.

Those who are desirous of joining this elite group should follow three rules: (1) Start early. (2) Live long. (3) Stay active.

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I am grateful to Helmut Abt, Alan Batten, Steven Dick, Michael Drieschner, and Richard Strom for helpful advice and to Thomas Hockey for a list of astronomers included in the *Biographical Encyclopedia of Astronomers* (Springer, 2007). I am especially grateful to those who helped me acquire images: Judith Dart, University of Chicago Library; Heather Edwards and Karolee Gillman, Grand Rapids Public Library; Louise Good, University of Hawaii; John B. Hearnshaw; François Launay; Mary Levin, University of Washington; John McFarland, Armagh Observatory Library; Karen Moran, Royal Observatory Edinburgh; and Gerald Newsom. This research has made extensive use of the SAO/NASA Astrophysics Data System.

A shorter version of this paper was presented to the Historical Astronomy Division of the American Astronomical Society at its January 2012 meeting in Austin, Texas.

This paper is dedicated to the memory of Hilmar Duerbeck.

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Journal of Astronomical History and Heritage, 15(1), 57-58 (2012).

JAMES FERGUSON REMEMBERED

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Abstract: The year 2010 marked the three hundredth anniversary of the birth of the astronomer, author and lecturer James Ferguson (1710–1776). Subsequently I visited the site of the churchyard where Ferguson is buried. He is mentioned in a plaque on the site and I thought that the details might be of interest.

Keywords: James Ferguson, London, Marylebone High Street, the Old Church Garden

1 THE OLD CHURCH GARDEN IN MARYLEBONE HIGH STREET, LONDON

James Ferguson died in London on 16 November 1776 (Davenhall, 2010). John Millburn, his most recent biographer, notes that he was buried in Old Marylebone churchyard, adjoining the Old Church in Marylebone High Street. Neither the church nor the churchyard survives. The church was demolished in 1949 and most of the churchyard is now a school playground. However, part of the churchyard was converted to a public garden, the 'Old Church Garden', and a plaque there lists several notable people buried in the churchyard, including Ferguson (Millburn and King, 1988: 250).

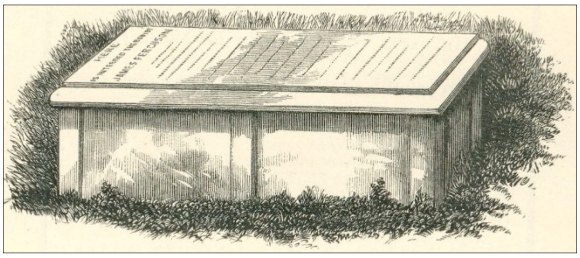
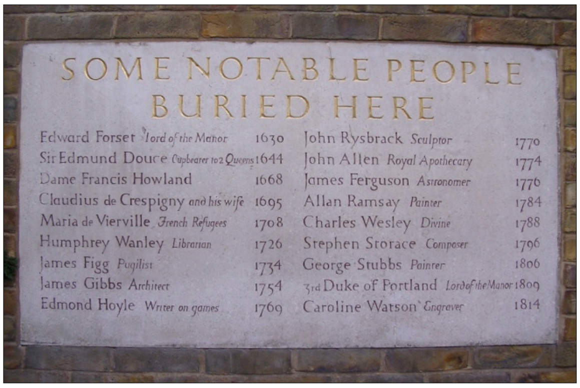


Figure 1: The sketch of James Ferguson's tomb included in Ebenezer Henderson's *Life of James Ferguson* (1867).

Of Ferguson's tomb there is, of course, now no sign. Fortunately Ferguson's first biographer, Ebenezer Henderson, included a sketch in his biography (see Figure 1) and recorded the inscription, which is reproduced in both his own book (Henderson, 1867) and by Millburn and King (1988: 251). Henderson also commissioned a wooden model of the tomb, but this is no longer extant (see Millburn and King, 1988: 316, note 5).

Writing in 1988 Millburn noted that the "… inscription, though not yet 40 years old, is already barely readable." (Millburn and King, 1988: 250). Perhaps it has been re-inscribed because I am pleased to report that the plaque, and the others in the garden, are now perfectly legible.

I visited the Old Church Garden, Marylebone in October 2010 by chance. I was in London on other business and in Marylebone High Street by accident. I saw the sign for the garden, went in, found the plaque and returned the following day to take photographs. The plaque commemorates "… some notable people buried here …", including "James Ferguson Astronomer 1776". Figure 2 shows the plaque and Figure 3 a view of the Garden. Both were taken on Sunday 24 October 2010.



SOME NOTABLE PEOPLE
BURIED HERE

Edward Forset	Lord of the Manor	1630	John Rysbrack	Sculptor	1770
Sir Edmund Douce	Cupbearer to 2 Queens	1644	John Allen	Royal Apothecary	1774
Dame Francis Howland		1668	James Ferguson	Astronomer	1776
Claudius de Crespigny	and his wife	1695	Allan Ramsay	Painter	1784
Maria de Vierville	French Refugees	1708	Charles Wesley	Divine	1788
Humphrey Wanley	Librarian	1726	Stephen Storace	Composer	1796
James Figg	Pugilist	1734	George Stubbs	Painter	1806
James Gibbs	Architect	1754	3rd Duke of Portland	Lord of the Manor	1809
Edmond Hoyle	Writer on games	1769	Caroline Watson	Engraver	1814

Figure 2: The plaque in the Old Church Garden off Marylebone High Street commemorating notable individuals, including Ferguson, buried in the churchyard.

Figure 3: A view of the Old Church Garden off Marylebone High Street.

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SOME NEW INSIGHTS INTO THE HISTORY OF THE GLASGOW TIME BALL AND TIME GUNS

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Abstract: The 1857 time ball machinery at the Glasgow Sailors' Home was supplied by Alexander McKenzie, mechanist, using a design that had much in common with the 1853 Edinburgh apparatus. It was operated using electrical connections to a mean time clock in the Home. This clock required adjustment by hand each day to compensate for its losing rate. Such manual intervention and lack of independent verification of accuracy undermined the authority of the signal.

The relative prestige of the Glasgow and Edinburgh Observatories was an important issue. There was no telegraphic link between Glasgow Observatory and the City until the end of 1863, but it had been demonstrated as early as October 1855 that a time ball could be dropped by telegraph from Edinburgh. Another Edinburgh initiative in September 1863 using time guns fired from Edinburgh caused offence in Glasgow and the trials were terminated in February 1864. Professor Grant, Director of Glasgow Observatory, argued successfully that a system of slave clocks controlled from Glasgow Observatory would be far superior to either a time ball or time guns which only provided a signal once per day. He won the debate in March 1864.

Keywords: Glasgow, time ball, time gun

1 INTRODUCTION

This paper developed from contact between the authors during September 2011. David Clarke was completing a book about the astronomy of Glasgow (Clarke 2012) and found a reference to the paper about Glasgow time signals which Roger Kinns had published in this journal (Kinns, 2010). We were not previously aware of each other's work, but it rapidly became clear that we had been using different principal sources and that we could clarify a complicated story by combining references from material at Glasgow University, the Royal Greenwich Observatory archives, now in Cambridge University Library, and contemporary newspaper articles published in Britain and Australia.

Details of the 1857 Glasgow time ball are described here and the way it was operated. It had much in common with the Edinburgh time ball, both being raised and released using electrical signals from a mean time clock. The difference was that the Glasgow clock was adjusted by hand every day, just prior to the drop, to compensate for its losing rate, with occasional chronometer checks by the company which operated it, but with no independent checks on accuracy. That led to protests from John Nichol and Robert Grant, successively Regius Professors of Astronomy and Directors of Glasgow Observatory during the period of time ball operation. Edinburgh Observatory kept daily records of the time ball drop, which were open for public inspection.

Glasgow trials with time guns, controversially operated by telegraph from Edinburgh, gave rise to strong protests that Glasgow Observatory had an obligation to the Crown to provide a time service for shipping on the Clyde and would not be usurped by Edinburgh. Trials with a single gun in October 1863 led to vigorous complaints about disturbance and damage to property. That almost ended the trials within days, but reduced powder charges and the addition of two more guns in Glasgow and another at Greenock extended their combined existence for a further four months. Robert Grant argued in favour of multiple clocks, controlled from Glasgow Observatory, and visible both to shipping and the citizens of Glasgow. These provided an accurate reference at any time, whereas guns and time balls provided only a single daily signal. Following experiments and demonstrations at the end of 1863, involving telegraphic signals despatched from the Observatory some five km away to the turret clock at the Old College and a slave clock within its courtyard, he won the debate in 1864.

2 DESCRIPTION OF THE GLASGOW TIME BALL

The best available description of the Glasgow time ball and its operation is by James Brown (1862), but there is little information about the mechanical apparatus. Brown stated that it was erected by Alexander McKenzie in 1857 and operated by McGregor & Co. of Clyde Place from the outset. He also noted that this company used a transit instrument at their premises, as reported by Nichol (1859). Their business was on the south side of the Clyde, nearly opposite the time ball on the other side of the river:

> On the Tower of the Sailors' Home, is the Harbour Time-Ball, (which was erected in 1857, by Mr Alexander McKenzie, mechanist, and has been worked, from the commencement, by the firm of McGregor & Co., chronometer makers, who have an observatory at the south-side), the transit instrument in which is mounted on one block of polished marble, cut down centrally, to a certain extent, so to allow the instrument to traverse in the plane of the meridian.

Brown (1862) then gave a comprehensive description of the way in which the astronomical clock, located in the basement of the Sailors' Home, provided signals to the ball operator. It was connected electrically to the time ball apparatus in the tower above. The clock had electrical contacts which provided signals a few seconds prior to 5 minutes before 1 pm, when the operator raised the ball to half-mast high, and just prior to 2 minutes before, when he raised the ball to the top. Presumably, the operator then set triggers which were pulled by electromagnets to release the ball, although this was not stated by Brown. Another signal at 1 pm released the ball automatically. This was the procedure established at Edinburgh in 1854 (Kinns, 2011a).

According to Brown:

> The Time-Ball is dropped daily, exactly at one o'clock, Greenwich mean-time, by an electric current from an astronomical clock, which is attached to the basement of the building; and a brief account of the mode of working it, may prove interesting, as many persons have been led to suppose that the ball is dropped by hand. The dial of the clock is cut through, above the figure 60, on the seconds-dial, and through the opening projects a thin plate of pure gold, which is inclined to the seconds-hand, also of gold, at an angle of about eight degrees. Concentric, and revolving with the minute-wheel, is a wheel, notched out in three places, above which rests a lever, connected with the gold plate or trigger. At a few seconds before five minutes to one o'clock, the lever drops into the first notch, allowing the gold trigger to fall into position for contact with the seconds-hand, which, as it completes the 60th second, touches the gold plate, and a minute bright spark is seen. The signal is conveyed to the attendant, at the top of the Tower, and the ball is wound up half-mast high. The seconds-hand, after making the contact, pushes back the gold plate, which is very flexible, and continues its course; but before it completes another circuit, the trigger is lifted above the point of contact by the mechanism of the clock. At a few seconds before two minutes to one, the trigger again drops, the second contact is made, signalling as before, and the ball is wound up to the top of the staff; and when the seconds-hand completes the last second of the hour, it again touches the trigger, and the ball instantaneously descends; and no one who ascends the Tower to witness the working of it, can fail to remark the unerring precision with which the ball is discharged by the clock below. The hands of this clock are never altered. It has a small losing rate, and a little before one o'clock, every day, the pendulum is accelerated for a few beats, which brings it to the exact time.

The last sentence is significant. The clock itself was adjusted every day, shortly before the time ball drop, by speeding up the pendulum manually to compensate for its losing rate. There was no electrical connection to McGregor's premises, so a chronometer had to be brought across the river from time to time to check the controlling clock. It was these aspects, as well as the lack of independent checks on observations made with the transit instrument, that so disturbed the Director of Glasgow Observatory (Nichol, 1859). They were also of concern to Robert Grant, Nichol's successor, and led to some occasionally heated correspondence in the *Glasgow Herald* during 1863, described later. Unwillingness to allow independent verification helped to precipitate the end of the Glasgow time ball.

Brown then described some features of the ball and mechanism, but there are several errors in his account as are discussed subsequently. He relates that:

> The entire weight to be lifted is fifteen cwt., the ball itself being four cwt., and is five feet diameter, built of mahogany, and covered with zinc, nearly 1-16th in thickness. It rises fourteen feet, near to the model of a ship at the extreme point of the rod. The Tower, with the Time-Ball rod, measures 217 feet from the ground, and at the highest story, the view compensates the labour of the narrow ascent – the river in its windings, in its freights, in its bustle, and in its expanse, is seen and can be studied with advantage. In Edinburgh, where there is a time-ball on the top of Nelson's monument, Calton Hill, the apparatus, designed and erected by Messrs J. Ritchie & Son, is connected by a wire to a gun in the Castle; and at the same moment the sense of seeing is gratified, the hearing also. At one o'clock P.M., the report of the cannon is heard in every quarter; and if Glasgow Time-Ball had such an apparatus ....

2.1 Time Ball Weight and Construction

The time ball's description of having a 5 ft. diameter is likely to be correct, as this was the diameter used for the principal time balls at Greenwich, Deal and Edinburgh. The ball construction is also consistent with other time balls of the period. A zinc spherical surface with 5 ft. diameter and 1/16th inch thickness would itself have weighed about 1.5 cwt (75 kg). The wooden frame would have added significant mass, so a ball weight of 4 cwt is plausible, if higher than usual. It is highly improbable, however, that the total moving weight would have been as much as 15 cwt.

A description of the Strand time ball was published by its supplier and is likely to have been authoritative (Clark, 1852). The Strand ball had a diameter of 6 ft. and also used a zinc skin on a wooden frame, but weighed only 2.5 cwt, including the piston which entered an air cushioning cylinder to stop the ball. It is worth noting that there were two time balls in central London, both operated by telegraph using time signals from Greenwich. One was in the Strand and was operated by the E & I Telegraph Company with official sanction from Astronomer Royal, George Biddell Airy. The other was at Cornhill in the City of London, the location of chronometer makers, and was often described, rather confusingly, as being at the "City Observatory" (Howse, 1997). Both were included in Airy's 1861 list (see Kinns, 2010, Page 203, but note that the author had not then appreciated the equivalence of Cornhill and the City Observatory). Neither time ball appears to have survived beyond the 1860s.

There was a tendency to exaggerate time ball weights, perhaps to impress the reader. Smyth (1853), writing about the new Edinburgh time ball, said "… the ball is made very heavy, say 15 cwt." The ball must have weighed much less than that, judging simply from the dimensions of the air cylinder that was designed to cushion its descent (Kinns, 2011a). More plausibly, Airy (1857) stated that 5 ft. diameter time balls weighed about 200 lbs, in correspondence concerning possible developments at Portsmouth Dockyard (Wood, 1856) and with the

Astronomer at Copenhagen. Another description of the time ball apparatus had been published in 1858 (Glasgow Harbour Time Ball). The description of the electrical apparatus is similar, but more detail is given about the mechanical design. The ball was hoisted using a rack and pinion arrangement, and an air-cushioning cylinder was used to control its descent. The rack was fixed to a 36 ft. long mahogany shaft which linked the ball and piston. The drop height was stated to be 8 ft., much smaller than the 14 ft. stated by Brown, while the ball diameter was given as 4 ft. 9 in. The total moving weight was given as 15 cwt.

2.2 Time Ball Drop Height

The drop height of 14 ft. and the raising of the ball "… near to the model of a ship at the extreme point of the rod …" (Brown, 1862) are not consistent with later photographs, but there may have been alterations to the mast after the time ball ceased to operate in 1864. The views in Figures 1 and 2 are from photographs taken in 1876 and 1897. Both show compass cardinal point arms between the ball and the ship model and suggest that the distance between the ball and the compass arms was two ball diameters. The print in Figure 3 shows the ball and mast at its left hand edge above the Broomielaw and is consistent with the photographs. The ball would have been raised to the compass arms, not the ship model. If this arrangement existed in 1862, the drop height would have been 10 ft. as at Edinburgh, not 14 ft. The same print shows the first Caledonian Railway Bridge, apparently in an incomplete state during its construction between 1876 and 1878, so it too post-dates time ball operation.

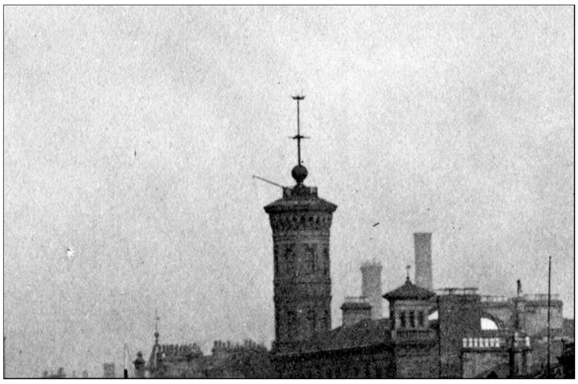

Figure 1: The Glasgow Time Ball in 1876 (courtesy: The Graham Lappin Collection).

The photographs and print all show the pole that was used to display Fitzroy's storm signals. This pole was erected on 27 February 1862 (Clarke, 2012).

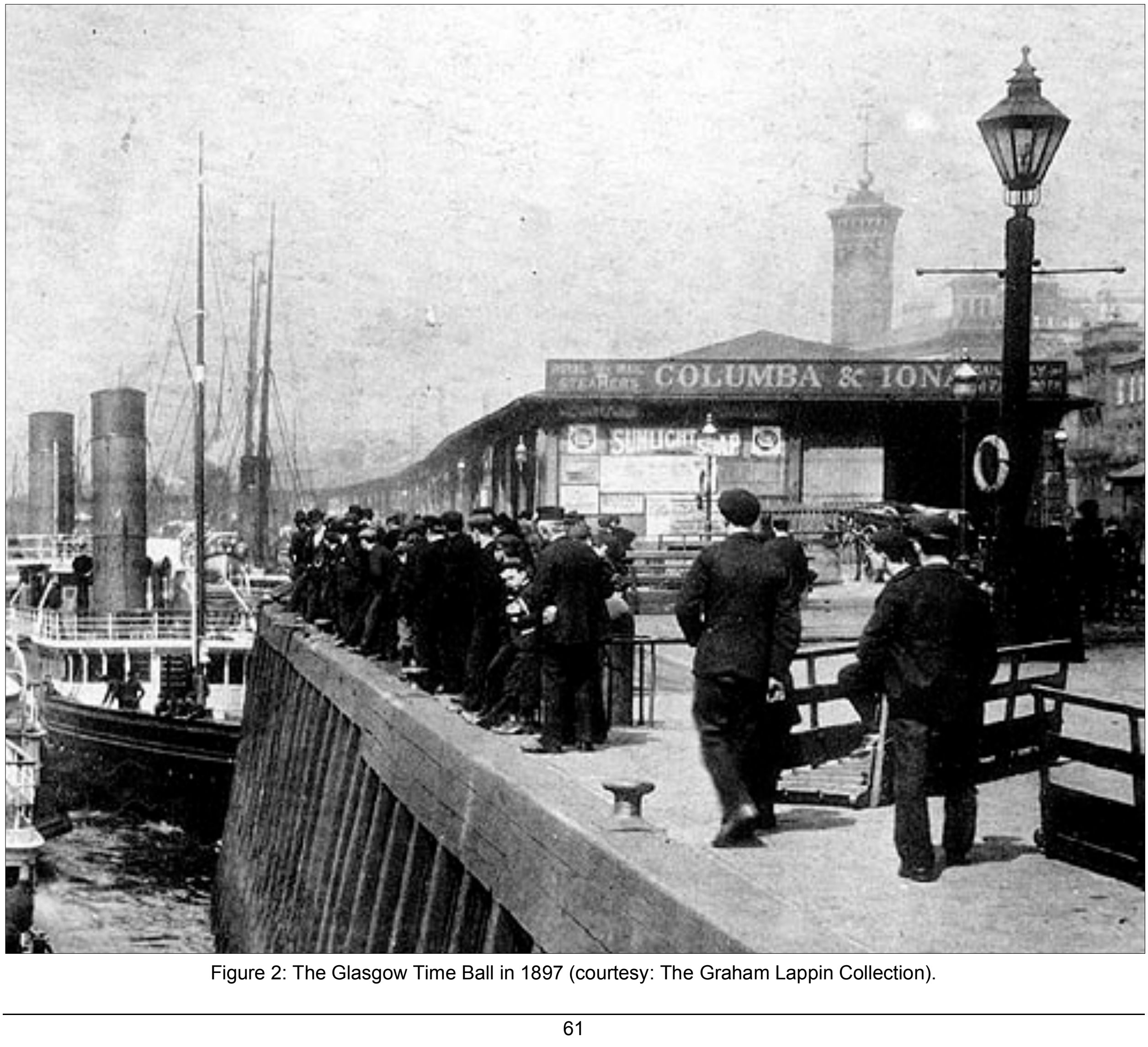

Figure 2: The Glasgow Time Ball in 1897 (courtesy: The Graham Lappin Collection).

2.3 Suppliers for Edinburgh

The Edinburgh apparatus was supplied by Maudslay, Sons & Field from London in 1853 (Kinns, 2011a), not Ritchie & Son. The solar mean time clock at Edinburgh Royal Observatory was, however, modified by Ritchie to allow automatic ball release, before the the time ball started official operation on 20 March 1854. Ritchie also modified the ball release mechanism on 22 August 1861 to increase its reliability (Time ball & Mean Time Clock Register, 12 June 1861 to 23 January 1863).

Brown's description of the Edinburgh gun operation is also misleading. The Edinburgh time gun was fired using a clock at Edinburgh Castle. This gun clock, supplied by Ritchie, was controlled by electric telegraph from the same mean time clock that released the time ball. The telegraph wire was routed via Nelson's monument, but it was separate from the wire that released the time ball (Kinns, 2011a). The Edinburgh time gun service commenced officially in June 1861, inspiring the observation by Brown (1862) that such a service might be introduced in Glasgow.

3 THE EDINBURGH INITIATIVES

Sir Thomas Brisbane promoted the idea of a Glasgow time ball when the Edinburgh ball was first erected in 1853 (Kinns, 2010). He took a close interest in the Edinburgh signal and helped to fund developments that would enhance its accuracy and usefulness (Kinns, 2011a).

3.1 The Telegraph Link with Glasgow

The Edinburgh time ball register includes a note on 12 September 1855 that the ball was dropped by hand "The necessary arrangements for dropping a Time Ball in Glasgow being in process of being made." ('Time Ball & Mean Time Clock' Register, 1854-55; see Kinns, 2011a: 273). These new arrangements culminated in a demonstration of a model time ball at a meeting of the British Association in Glasgow during October 1855 (Smyth, 1855):

> Furthermore our lines of wire from the Obs^{y} to the Railway were tested during the Association week by the carrying out also at Sir T. Brisbane's expense, his favourite desire of introducing Time Ball signals to the notice of the people of Glasgow.
>
> Extra batteries having therefore been brought up here, & temporary wires laid down in Glasgow from the Telegraph Station to Section G room in the College a large model Time Ball was dropped every day during the Association week, by the Edinburgh Obs^{y} Mean Time Clock.

The experiment was noted by Smyth in his 1858 report (see Kinns, 2010: 199). It was clearly feasible to drop a Glasgow time ball from Edinburgh by telegraph. Indeed, the Deal time ball was dropped by telegraph from Greenwich with a return signal to confirm the drop, from the start of its official operation on 1 January 1855. The 102 km distance between Greenwich and Deal, on the Kent cost, was 50% further than the 68 km distance between Glasgow and Edinburgh. At that time, there was no telegraph link between Glasgow Observatory and the

Figure 3: Print showing the Glasgow Time Ball and mast at extreme lower left, in the late 1870s (published by James Deas; courtesy: Royal Scottish Geographical Society).

City Centre. Such a link was not established until 1863, when another Edinburgh initiative using time guns brought matters to a head.

3.2 The Time Gun Experiments

Edinburgh inaugurated a time gun signal in June 1861. The gun on Edinburgh Castle was fired by a slave clock at the Castle whose pendulum was synchronised with the Observatory mean time clock by Jones's method. It was an accurate signal, well-received by the citizens of Edinburgh, and inspired developments elsewhere. The gun on Edinburgh Castle, high above most Edinburgh residences, could use a charge that made it audible over large distances. That was much more difficult to replicate in locations such as Glasgow, with building density and topography making it difficult to strike an acceptable balance between audibility and damaging disturbance.

The plan to introduce time guns in Glasgow that were controlled from Edinburgh was hatched without involving the relevant Glasgow authorities. A summary of the experiments is given by Kinns (2010). The initial announcement was published in Glasgow on 26 September 1863 with the following opening paragraph (The New Time Gun, 1863):

> The arrangements for the new time gun experiment - the report of which came upon the community a day since with startling suddenness - are now progressing steadily, but there still remains so much to be done that the trial cannot be made for several days yet. The approaching experiment has originated with the Universal Private Telegraph Company, who have very spiritedly set to work to carry out their plans. Mr. Nathaniel Holmes, the engineer of the company, has undertaken the superintendence of the arrangements, and the valuable co-operation of Professor Piazzi Smythe [*sic*], Astronomer Royal for Scotland, has been obtained in furtherance of the scheme. In casting about for a suitable site for the gun, the attention of the Company was directed to a green which forms an eminence overlooking Sauchiehall Street and is entered from Renfrew Street, at the west side of the Corporation Galleries. This ground belongs to the City Bank, and the directors, on being applied to, generously granted it for the use of the experimentalists, while Mr.Long, at the back of whose gymnastium it is situated, frankly sanctioned the placing of this probably rather noisy neighbour in the immediate vicinity of his establishment, and on ground which he held as tenant.

This introduction was followed by details of the gun and its charge, including an assurance about the care that would be taken to avoid damage:

> The proper charge of powder for the piece is 6 lbs, but owing to the present position of the gun in the midst of dwelling houses, not more than from 1½ lbs. to 2 lbs., will be used. As it is to be placed under the care of an experienced gunner, every assurance may be felt that no damage will be caused to the property in the vicinity, nor any unnecessary alarm occasioned to neighbouring residenters.

A letter by Grant in response to the announcement of the time gun experiments was published simultaneously on 26 September (Grant, 1863a). Clearly, he had been invited by the Editor of the *Glasgow Herald* to comment on the forthcoming development of which Grant was completely unaware. At the time, Grant was busy promoting his preferred system of controlled clocks, referring particularly to their successful introduction in Liverpool some years before. The complete announcement and response by Grant are included in Clarke (2012).

Following overtures already made, Grant immediately wrote to the Lord Provost of Glasgow, Chairman of the Clyde Navigation, emphasising his responsibility as Director of Glasgow Observatory. His letter of 28 September (Grant, 1863b) was published in the *Glasgow Herald* on the following day:

> My Lord. - You will no doubt have perceived, from a statement which appeared in the *Herald* of Saturday last, that arrangements are being made by the United [*sic*] Private Telegraph Company for firing a time-gun in Glasgow in connection with the Edinburgh Observatory. It would seem, also, that the originators of the scheme contemplate establishing the gun permanently, and placing similar guns on different points of the Clyde.
>
> Permit me to inform you in reference to this matter, that by an express engagement entered into and with her Majesty's government, the University of Glasgow is charged, through the instrumentality of the Observatory established in connection with it, to afford all necessary facilities for supplying the shipping of the Clyde with correct time.
>
> I need scarcely assure your Lordship that under no circumstances whatever will the University consent to forgo this engagement, or permit the usurpation by any other observatory, of the duties which it imposes.
>
> The importance of placing the arrangements for the transmission of correct Greenwich time from this Observatory on a better footing than heretofore, has not failed to occupy the attention of the Professor of Astronomy, who, some time since, submitted his views on the subject to the consideration of the Town Council. I beg further, as a proof of the desire of the University to fulfill the obligation which it has contracted with the Crown in reference to this object, to call your attention to the enclosed copy of a memorial on the Observatory, which has been recently addressed by the Senatus Academicus of the University to the Lords Commissioners of Her Majesty's Treasury.
>
> I would earnestly invite the Clyde Trustees to a consideration of the urgent necessity which exists for rendering the resources of this Observatory more effectually available to the shipping of the Clyde. Our instrumental means for the determination of correct time are unsurpassed anywhere, but they are rendered to the great extent powerless by the isolated condition of the Observatory, in regard to electric communication with the City of Glasgow and the Clyde. The Observatory will cordially receive from the Trustees any proposal in reference to this important object.

Grant had made his points well. The Glasgow time gun experiments proceeded, but their days were numbered.

Notwithstanding prior assurances to the contrary, initial firings of a single gun during the first week of October 1863 did cause damage to property. This is illustrated by the following letter, signed with an appropriate pseudonym (Fugit, 1863):

> Without attempting to question the scientific merit of this experiment, I venture to call the new time-gun a nuisance if it is to remain longer where it now stands. For the first two or three days we were a little startled in this neighbourhood when we heard the one o'clock

> explosion, but for the sake of the Broomielaw and science, we did not care to complain. Today, however, the charge of powder has been increased, if we are to judge by the increased din. Now, I am a tenant in this locality, and I find my ceilings cracking, and in some places giving way altogether. That this is the result of the explosion there can be no manner of doubt, as, at one o'clock today one of the youngsters narrowly escaped a thump on the head from a yard or so of falling plaster. Nor is it all. The neighbourhood is surrounded by educational institutions, and I am told that some of the children attending them get quite sick when the gun is fired, and that, today, many of them got a greater fright than usual. On the whole, I think there is exhibited a woeful lack of common sense in placing the gun where it now is, more especially since, as I am informed, there be few at a distance that can hear it. Hoping to hear of its speedy removal, I am &c. T. FUGIT

Various time gun locations were then tried, as exemplified by an article published on 7 October:

> The present position of a gun in Garnethill being too confined to admit to a proper charge of powder, arrangements are being made to remove the gun to a more elevated position, from the immediate vicinity of the houses, so that the volume of sound from the gun can be increased to be audible over the entire City. It is expected that, about Wednesday next, the gun will be fired from its new position.

The subsequent search was for an effective compromise between audibility and unwanted disturbance. According to an article published in Hobart, Tasmania, four guns were operating in parallel by the end of November 1863 (Abbott, 1865; see Kinns, 2010: 200). Three were near the centre of the City. The other was at Greenock, a port on the Clyde 38 km west north west of Glasgow. Their dates of introduction were:

1) October 1863; initially Sauchiehall Street but then moved (as described above);
2) 29 October 1863: St. Vincent's Place (Abbott);
3) 10 November 1863: The Broomielaw (Abbott);
4) 21 November 1863: Greenock (Abbott).

The letter of 3 February 1864 that gave notice of the end of the time gun trials was explicit about the use of four guns (Holmes, 1864):

> I desire through your columns to inform those interested in the establishment of correct time signals for Glasgow, Greenock, and the surrounding parts, that the four time-guns hitherto fired daily at 1 P.M., Greenwich Mean Time, will cease firing on Saturday the 6th instant. The experiment I had the honour of introducing to this city has proved successful; and if it is desired to have guns – having laid the matter before the several authorities – the guns can be resumed as soon as the necessary arrangements have been made.

The early problems with damage to property led to reduction of the powder charge, leading to poor audibility of a single gun. The same problem arose in Hobart (Tasmania) during 1875, but it was possible to relocate the Hobart gun and restore its audibility. The Hobart time gun service then continued for half a century (Kinns, 2011b). The addition of other guns in Glasgow increased the area over which they could be heard, but it is easy to imagine the confusion caused by the slow speed of sound propagation (about 340 m/sec) and the multiple echoes from nearby buildings. Simultaneous firing of several guns by telegraph was technically successful, but fundamental problems with sound propagation in a densely populated area were insuperable.

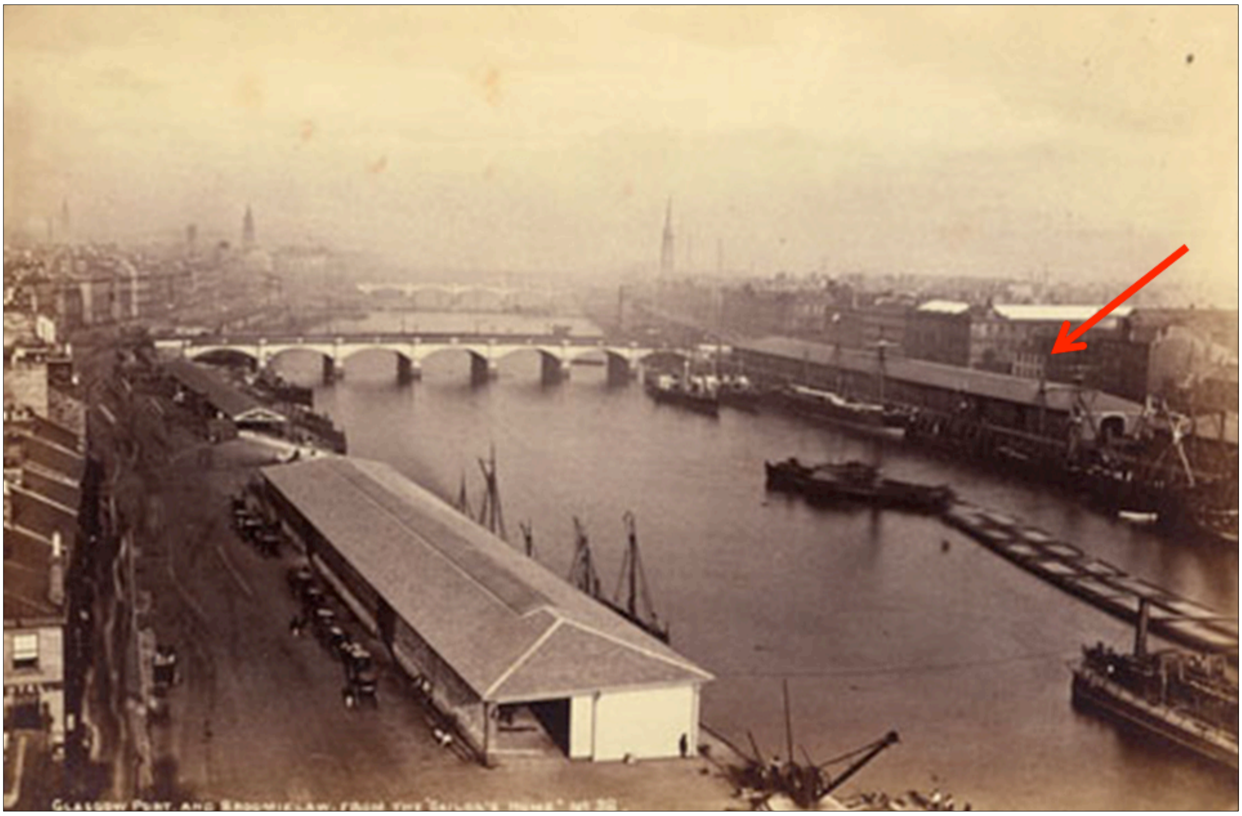

Figure 4: Photograph showing McGregor's premises on the south side of the river, 1876 or earlier (courtesy, the Thomas Annan Collection, Glasgow City Libraries).

4 RENEWED CRITICISM OF THE TIME BALL OPERATION

Correspondence about the time guns soon extended to consideration of the way the Glasgow time ball was being operated, reviving concerns expressed years before (Nichol, 1859). Figure 4 includes a red arrow to indicate the location of McGregor's business and transit instrument, on the opposite side of the Clyde to the time ball. The precise date of the photograph is uncertain, but it clearly predates the 1876-1878 construction of the first Caledonian Railway Bridge (cf. Figure 3).

A published letter suggested that McGregor's transit instrument was subject to traffic-induced vibration and that it would be an excellent idea for the transit observations to be subject to independent scrutiny by Grant (Taylor, 1863). The following paragraph is an extract:

> Now, if the Town Council, or the Clyde Trustees, or whoever the gentlemen may be who sanction the dropping of the time-ball, could only visit the place of observation annually, or say half yearly to see that the instrument is in a state of efficiency, the instrumental adjustments and the general routine necessary for obtaining Greenwich time properly conducted, they would act very judiciously. This inspection shall take place not as a matter form, but as a matter of real utility and consequently should be superintended by the astronomer to the University - a gentleman who is really practically acquainted with these affairs, and who would conscientiously report when he considered the present place of observation in any way suited for the mounting of a transit instrument, and whether there is sufficient stability in the building itself to depend upon the instrumental error deducible from the observations (if any).

Taylor concluded with a statement that was hardly likely to appeal to McGregor & Co., who had a contract to operate the time ball:

> Only imagine that Glasgow, boasting, as it does, of its nearly half a million of inhabitants, is rendering itself conspicuous in astronomical history by allowing the time-ball to be dropped by an agency altogether independent of the Professor of its University. If I were a member of the Town Council, I would blush to think that a city like Glasgow, superior both in population and wealth to Edinburgh, should bow so humbly as to accept of the proposed scheme for giving us Greenwich mean time. What would be the natural conclusion arrived at by a person unacquainted with histories of the two cities? Why, that Edinburgh possesses facilities for determining Greenwich mean time which Glasgow was deficient of. But such is not the case. Glasgow has both a scientific institution generously equipped with instruments by its own citizens, and a Regius Professor possessing both zeal and abilities are and all the necessary qualifications for superintending time-ball regulations. Professor Grant states that the method of having the time by a signal-gun "has much of a sensational character, which cannot fail to recommend it to popular feeling, but on grounds of real utility and methods practised at Liverpool appear to me vastly preferable!" Now this opinion must evidently be unanimous in the minds of those who give the least attention to this matter.

This led to an immediate response from W. Church, an employee of McGregor & Co. Church (1863) found it insulting to think that the astronomical observations made by his company should be subject to independent scrutiny. The tenor of his rather intemperate response is illustrated by the following extract:

> The firm of D. M'Gregor & Co., will not notice attacks attacks upon their establishment, except where principals are concerned; but I, as being employed in the working of the time-ball, would request your permission to reply to some portions of Mr. F.G.Taylor's letter. I am not acquainted with the writer, but I infer from his letter that he possesses a very comfortable assurance of the value of his judgment and authority in matters relating to time-measurement, and that he shares a delusion, fostered by professional prejudice, that accurate time cannot be got or maintained outside the precincts of a public observatory. The firm of M'Gregor & Co., however, are not likely to attach much importance to his opinions respecting the transit observations, and they are certainly quite as well aware as he is of the great importance of attending to the adjustment of a transit instrument, as, without such attention, it would be impossible to obtain true time.

He then sought to defend the quality of the company's transit observations before commenting on the history of the arrangement with the Clyde Trustees. He argued, fairly, that Glasgow Observatory was not equipped to control time ball operation when the ball was first erected in 1857, but made only a qualitative remark about signal accuracy:

> Mr. Taylor expresses astonishment at the apparent anomaly of a time-ball being worked independent of the Observatory; but if he is really ignorant how the matter stands, the explanation is easily rendered. At the time when the time-ball was first established, the Observatory, whatever its present position may be, was not in a proper state of efficiency to maintain a correct standard of time; and the Clyde-Trustees, to whom the time-ball belonged, appointed the firm of M'Gregor & Co. to manage it, having, I suppose, sufficiently valid reasons for the confidence which they placed in them. I intend no illusion here to the astronomical instruments of the Observatory. Its transit circle might have been unsurpassed anywhere, but that could only have been used for the purpose of getting, but not maintaining, true time. The maintenance of a correct standard of time during intervals of bad weather, so frequent in our climate, must depend solely on the clocks of the Observatory, which ought to have been of the very first class, and sufficiently numerous for the purpose.
>
> If the Observatory is now in a high state of efficiency - and we have Mr. Grant's assurance to that effect - by all means let it provide the time for the city of Glasgow; but I certainly consider that it is a very paltry mode of trying to attain this object, on the part of the advocates of the Observatory, by attempting to lower the credit and depreciate the services of other parties, and the Observatory might well exclaim "Oh! save me from my friends." Being itself not quite invulnerable, it has hitherto acquired no laurels in such a contest, the initiative in which has never been taken by the firm M'Gregor & Co., nor is it likely to do so in the present instance through the advocacy of Mr. F.G.Taylor; for, notwithstanding what he, or other parties, may assert, who possesses not the means of forming a judgment as to facts, I have no hesitation in saying that the time-ball has been, and is now, a standard of time sufficiently accurate for the purpose of rating chronometers the most important of all uses to which it can be applied.

Another letter, supportive of independent scrutiny by Grant, was published on 8 October 1863 (Tempus Verum, 1863). The stature of the Edinburgh time ball had been enhanced by Smyth's willingness to allow public scrutiny of the measurements and calculations that demonstrated its accuracy ('Time Ball & Mean Time Clock' Registers). Church would have done better to welcome independent scrutiny than to oppose it quite so emotionally.

Towards the end of 1863, when the Observatory had been connected by telegraph with Glasgow College and the City, Grant wrote again to the Lord Provost (Grant, 1863c). He suggested the following arrangements:

> 1. The erection of a Turret Clock, with large dials, on some commanding position of the Broomielaw, the said Clock to be furnished with a Jones' magnetic-electric pendulum, and to be controlled by an electric current directed from the Standard Clock of the Observatory.
> 2. The erection of a small Seconds' Clock, similarly controlled from the Observatory ...
> 3. The dropping of the Time-Ball on the Sailors' Home by a mechanism acted upon electrically from the standard Mean-Time Clock of the observatory.
> 4. The firing of a Gun from some central position on the Broomielaw.
> 5. The establishment of an office for the rating of Chronometers, to be placed under the control of the Clyde Trust, and to be supplied with special facilities from the observatory for ascertaining the correct time.

It appears from this letter that the time ball was still in operation at the end of 1863, continuing the earlier arrangement with McGregor & Co. The experiment with time guns was underway at that time.

Grant noted in an 1878 letter to Sir George Airy that the time ball ceased to operate once the system of controlled clocks became operational (Grant, 1878). He said that the year was 1863 in his letter, but that is probably an error of memory for 1864 (Kinns, 2010: 202). The time gun experiments were terminated in February 1864 (Holmes, 1864). A large number of letters and articles in the *Glasgow Herald* from March 1864 onwards referred only to the system of controlled clocks. There was no further mention of the time ball or time guns (Kinns, 2010; Clarke 2012). The system of clocks was then extended over a period of more than 50 years and served Glasgow well (Clarke, 2012).

5 CONCLUSIONS

It is known from 1858 and 1862 articles that the 1857 Glasgow time ball machinery was supplied by Alexander McKenzie, mechanist, and operated by Messrs. McGregor and Co. The mechanical apparatus used a rack and pinion mechanism and an air-cushioning cylinder, while the ball had a thin skin on a wooden frame, as at Edinburgh. There is uncertainty about the drop height, variously given as 8 ft. and 14 ft. The weight of the ball and moving components was stated to be an implausible 15 cwt. The Glasgow time ball was operated using electrical connections to a mean time clock in the Glasgow Sailors' Home from 1857 to 1864. This clock had to be adjusted by hand each day, prior to the ball drop, to compensate for its losing rate. Occasional checks were made using a chronometer that was brought from the premises of the McGregor & Co., chronometer makers, who had the contract for time ball operation and maintenance. No independent records were kept of the accuracy of the time ball drop. This lack of independent scrutiny and the requirement for manual intervention were criticised by Nichol and Grant, respectively Directors of Glasgow Observatory during the period of time ball operation. In other respects, the arrangement of the clock and its electrical connections were similar to those introduced in Edinburgh in 1853-1854.

When the Glasgow time ball was introduced in 1857, there was no telegraphic link between Glasgow Observatory and the City. It had been demonstrated in 1855 that a time ball could be dropped from Edinburgh, but the Clyde Trustees preferred a local arrangement. The relative prestige and status of Glasgow and Edinburgh observatories was an important issue and Grant had been pressing for the telegraphic connection since his appointment in 1859. Another Edinburgh initiative using time guns fired from Edinburgh caused great offence in Glasgow towards the end of 1863, partly because of the underhand way in which they had been introduced and partly because of poor audibility and damage to property. That stimulated renewed criticism of the way the time ball was operated without involvement by Glasgow Observatory. The time gun trials were abandoned in February 1864 and the time ball soon ceased to operate. Grant argued successfully that a system of slave clocks controlled from Glasgow Observatory would be far superior to either a time ball or time guns that gave a signal only once per day. Over 10 clocks were established in the City and along the Clyde from 1864 onwards and were in operation for over 50 years. The time ball and guns were never re-established.

6 ACKNOWLEDGEMENTS

We are grateful to the Science and Technology Facilities Council and the Syndics of Cambridge University Library for permission to use material from the Royal Greenwich Observatory archives in this paper. We also thank Barbara MacLeod for finding the 1858 article which included an elusive description of the mechanical apparatus.

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Dr David Clarke is an Honorary Research Fellow in the School of Physics and Astronomy at Glasgow University. He is Emeritus Reader of Practical Astronomy and was Director of the University Observatory from 1980 to 2001. His research interests have involved observations of Earth atmospheric scattering phenomena and buoyancy waves, interplanetary dust, stellar atmospheres and magnetic fields, and the interstellar medium. He has developed instruments, particularly polarimeters, which have been applied to make observations in the areas above. In 1972, he was part of a team involved with the Pioneer 10/11 missions. He has published over 130 papers within optics and astrophysics. In 2010 his book on *Stellar Polarimetry* (Wiley-VCH) was published. He is co-author (with J.F. Grainger) of *Polarized Light and Optical Measurement* (Pergamon) and (with A.E. Roy) *Astronomy – Principles & Practice* (4 editions) and *Astronomy – Structure of the Universe* (3 editions, Institute of Physics). A book entitled *Reflections on the Astronomy of Glasgow* is scheduled for publication by Edinburgh University Press.

Dr Roger Kinns is a Senior Visiting Research Fellow in the School of Mechanical and Manufacturing Engineering at the University of New South Wales in Sydney, Australia. He was the first Maudslay Research Fellow of Pembroke College, Cambridge, and is presently Honorary Treasurer of the Maudslay Society and Maudslay Scholarship Foundation. This association led to a recent fascination with the history of engineering and particularly time ball mechanisms. He joined YARD Ltd in 1975, to develop and apply techniques for the acoustic design of ships and submarines. He lives in Clynder, Scotland and has worked as an independent consultant since 1999, with principal research interests in underwater noise due to marine propulsion systems. During 2009-2010, he was Deacon of the Incorporation of Gardeners, one of the fourteen crafts that constitute the Trades House of Glasgow.

Journal of Astronomical History and Heritage, 15(1), 68-69 (2012).

OBITUARY: HILMAR WILLI DUERBECK (1948–2012)

Born in 1948 in Klarenthal (near Saarbruecken in Germany), Hilmar Duerbeck studied physics from 1966 to 1969 at the Universität des Saarlandes (University of the Saarland) in Saarbruecken. He then went to Bonn University to study astronomy and physics, where he graduated in 1972 with a thesis entitled "Astronomical observations with a photoelectric area photometer". In 1974 he obtained his Ph.D. with a dissertation on "The eclipsing binary VV Orionis". From 1975 to 1985 he was Scientific Assistant at the Hoher List Observatory in Germany, and during the same period he was astronomy Lecturer for the European Division of the University of Maryland in Germany. During that period he obtained his habilitation in astronomy from Bonn University with a dissertation on "Eruptive variables — observations, analyses, models".

From 1985 to 1991 he was a Lecturer in astronomy at the University of Muenster, Germany, and from 1996 on he was an honorary Professor at the same university.

From 1994 Hilmar occupied various educational and research positions abroad: Exchange Professor at the Universidad Catolica de Chile in Santiago and at the Universidad Catolica del Norte in Antofagasta (Chile). He was repeatedly Senior Visiting Scientist at the European Southern Observatory in Chile and at the Space Telescope Science Institute in Baltimore, USA. For more than a decade he was Senior Scientific Collaborator at the Vrije Universiteit in Brussels Belgium, and a couple of years ago he was appointed as an Adjunct Professor at James Cook University in Australia.

Hilmar was a member of several international organisations and commissions, including the International Astronomical Union (Commission 42, Close Binary Stars) and the Historical Astronomy Divsiion of the American Astronomical Society. He served on numerous panels and commissions (viz., the Hubble Space Telescope and the International Ultraviolet Explorer), and he served on scientific organizing committees of IAU Colloquia and other meetings. From 2003 on he also was Secretary of the "Arbeitskreis Astronomiegeschicht" of the Astronomische Gesellschaft in Germany, and he also chaired the IAU Working Group on Venus Transits.

He was an expert on novae, nova remnants and supernovae, and on cataclysmic variables and flare stars. His best-known papers are catalogs and atlases of eruptive stars. He was also a keen observer: for example, in 1975 he visually noticed Nova Cygni (V 1500 Cyg) at declination +48 degrees from ESO La Silla Observatory located at –30 degrees latitude, and promptly secured sequences of crucial spectrograms.

Hilmar was a very prolific writer (ADS lists more than 450 entries), and a very active editor: he was a member of the Editorial Board of the *Information Bulletin on Variable Stars* (Budapest, Hungary) and of the Editorial Board of the book series *Acta Historica Astronomiae* (Frankfurt, Germany). As Associate Editor of the *Journal of Astronomical History and Heritage* (James Cook University, Australia), and as Co-Editor of the *Journal of Astronomical Data* (University of Brussels, Belgium), he helped and coached many authors.

From 1975 until her death in 2007 Hilmar was married to astronomer Waltraut C. Seitter. Hilmar died suddenly and unexpectedly on Thursday, 5 January 2012 at his home in Schalkenmehren, Germany.

Besides his professional dedication, and his legendary encyclopedic knowledge, Hilmar will be best remembered as a quiet and caring personality and as a very helpful and friendly person, who was always kind and generous to his colleagues. In addition, he was most encouraging to students — his own students as well as others' — and at any time was ready with good advice, always topped with a big smile.

The main-belt asteroid 1989 SW2 has been named 9327 Duerbeck.

Christiaan Sterken
Vrije Universiteit Brussel
Pleinlaan 2, 1050 Brussels, Belgium

Hilmar Duerbeck served as an Associate Editor of the *Journal of Astronomical History and Heritage* from 2007 until his untimely death on 5 January 2012. I joined the journal later that year, and for more than four years I had the pleasure of working with him to help Editor Wayne Orchiston publish as accurate and error-free a journal as we could.

I never had the pleasure of meeting Hilmar in person, but we exchanged hundreds of e-mails, and I grew to admire his many excellent qualities: his broad knowledge of so many areas of the history of astronomy, his command of English that enabled him to correct grammatical and spelling errors of native speakers, his wide knowledge of the astronomical and historical literature in several languages, and his good humor and patience. I feel that I have lost a good friend as well as an able colleague.

Joseph S. Tenn
Sonoma State University, USA

The late John Perdrix and I established the *Journal of Astronomical History and Heritage* in 1998 following the 1997 General Assembly of the IAU, but it was only when I moved to James Cook University in 2005 and John stepped down as Managing Editor (at the time I was the Papers Editor) and the University and I took over full responsibility for the journal that the need for an Associate Editor emerged. It did not take me long to identify Hilmar Duerbeck as the ideal candidate, and although he already had a heavy schedule he immediately accepted my offer. After that, Hilmar and I worked closely together, and in 2007 we were joined by a second Associate Editor, Joe Tenn. Hilmar's role in the production of a successful journal was monumental, not just in deciding on policy, reviewing papers, dealing with authors and referees, but especially in proofreading and providing corrections for bibliographical entries in German, French and other languages. Although Richard Strom has kindly stepped into the vacuum created by Hilmar's very sudden and totally unexpected death, he will be sorely missed.

But Hilmar's association with James Cook University did not end there, for we also appointed him as an Adjunct Professor in the Centre for Astronomy, and in this capacity he was busy co-supervising the thesis research of two off-campus Ph.D. candidates. Clifford Cunningham (USA) and Keith Treschman (Australia) respectively were investigating British observations of and comments about the first four asteroids, and historic total solar eclipses observed from Australia and their contribution to solar physics. We will all miss Hilmar's valued input.

My other close association with Hilmar was through the IAU. In 2000 we formed the IAU Transits of Venus Working Group and I served as the inaugural Chairman. I subsequently passed this office on to Steve Dick and when his term expired it was Hilmar who inherited it. He was still serving in this role when he died, and it is sad that I have had to step in and carry the WG through to the August 2012 Beijing General Assembly of the IAU when it will be wound up. The WG has served its purpose: it has been the driving force behind several international meetings and has been the catalyst that encouraged many of us to write up and publish papers on the historic transits of Venus. Hilmar's role in all this has been monumental.

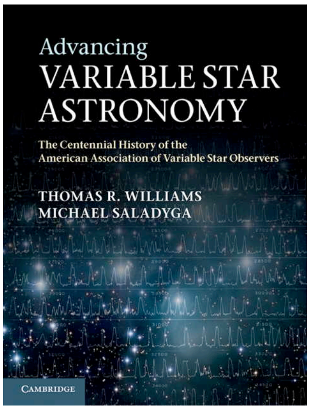
For me personally, Hilmar was a never-ending source of encouragement and support in my day-to-day astronomical life. He was always quick to provide feedback on my ideas, or respond to my urgent requests for help when such occasions arose. If a paper arrived for the journal and I could not think of a suitable referee, Hilmar was always (well, almost always) able to suggest one. And as Chris Sterken and Joe Tenn have said, Hilmar had an encyclopaedic knowledge of astronomy and of the astronomical literature, which I was frequently able to tap into. Hilmar was a close friend and a wonderful colleague to work with, and I will miss him terribly.

Wayne Orchiston
James Cook University, Australia

Journal of Astronomical History and Heritage, 15(1), 70-72 (2012).

BOOK REVIEWS

***Advancing Variable Star Astronomy. The Centennial History of the American Association of Variable Star Observers*, by Thomas R. Williams and Michael Saladyga (Cambridge, Cambridge University Press, 2011), xvi + 432 pp., ISBN 978-0-521-51912-0, AU$130:00 (hardback), 195 × 252 mm.**



Advancing
VARIABLE STAR
ASTRONOMY
The Centennial History of the
American Association of Variable Star Observers
THOMAS R. WILLIAMS
MICHAEL SALADYGA
CAMBRIDGE

During my teenage years I was an avid variable star observer, and the late Ignace Debono, Director of the Variable Star Section of the New South Wales Branch of the British Astronomical Association in Sydney, religiously sent my monthly magnitude estimates of stars with northern declinations to the AASVO while those from the southern sky went to the late Frank Bateson and the Variable Star Section of the Royal Astronomical Society of New Zealand. These two organisations were highly respected internationally, and were charged by the IAU with co-ordinating amateur variable star astronomy worldwide. It is particularly appropriate, therefore, that we now have a history of the AAVSO published on the occasion of its centenary.

This weighty tome is divided into six Parts, which in succession deal with "Pioneers in Variable Star Astronomy Prior to 1909", "The Founding of the AAVSO – The William Tyler Olcott Era", "Recording and Classification – The Leon Campbell Era", "The Service Bureau – The Margaret Mayall Era", "Analysis and Science – The Janet Mattei Era" and "Accelerating Observational Science – The Arne Henden Era". Apart from Part 1 (with just two chapters), these titles and the associated 20 chapters clearly identify the ways in which the nature of variable star astronomy evolved within the AAVSO over the time-span of five successive 'Directors' (or 'Recorders' as they were initially called).

These twenty chapters contain a wealth of information on the development of variable star astronomy internationally and through the AAVSO, and on the ever-changing and sometimes volatile relationship between the Association and the Harvard College Observatory as individuals with very different personalities and motives played their respective hands. The changing relationship between amateur astronomers and their professional colleagues is also discussed, as is the changing role of instrumentation as photoelectric photometry gradually came within the financial means of the amateur. All of these chapters are well illustrated, and it was a pleasure finally to be able to put 'faces' to many of the names that have been so familiar to me for so long. Another illustration that particularly caught my eye was Figure 8.8 on page 101 which plots the "Annual totals of variable star observations received by the AAVSO, 1911-1951". While it appears that WWI hardly dented the ardour of the international amateur variable star fraternity, WWII did have a major impact.

After Chapter 22 there is a 2-page Epilogue that looks—albeit briefly—at the AAVSO and the future of variable star astronomy. This is followed by seven different Appendices, which collectively span 20 pages. These include recipients of various AAVSO Awards; AAVSO Officers; Council Members; and people who held other leadership roles on committees, etc.; plus lists of the top visual and photometric observers, where the international support the AAVSO receives is very apparent. For example, of the top 100 visual observers listed, 8 are from Australia; Belgium, Canada, France and Germany each contribute 5; nations with 4 observers are Hungary, New Zealand and South Africa; while Poland has 3 observers; Argentina, England, Greece, the Netherlands and Romania each contribute 2 observers; and Croatia, India, Israel, Italy, Japan, Norway, Slovakia and Spain all have a single observer. Thus, collectively non-US observers account for 61% of the top 100 observers, demonstrating clearly that the 'American' in the AAVSO name is somewhat of a misnomer! And for those who are wondering, the top-ranking observer is Albert Jones of New Zealand with 448,449 observations as of the 2007-2008 financial year, followed in second place by the late Dannie Overbeek of South Africa with 292,711 observations. For the record, the final observer in the 'Top 100' list, Belgium's Hubert Hautecler, has 28,426 observations.

The other Appendix that I found particularly fascinating is the first one, which in a mere 2.5 pages tries "… to correct some mistaken views of the history of the AAVSO that have developed over a number of years." (p. 331). Most of these relate to the founding of the association, where Olcott's true role has been downgraded in various ways—both intentionally and unintentionally—by a number of astronomers. This makes for entertaining reading!

After the Appendices come 58 pages of Notes that provide vital references for and comments on the text. Most of the information readers will require for any follow-up studies or investigations is here, which adequately explains the trim 4-page Bibliography that follows. Finally, the book ends with a very detailed and useful 20-page Index.

It is hard to quibble about a book like this which is packed with a wealth of worthwhile astronomical reading, but perhaps in Chapter 1 the authors could have used the AD 1054 supernova (SN) to mark the 'founding date' of variable star astronomy instead of the SN of 1572. While there were earlier probable SNe, the 1054 spectacle was widely observed and documented in Asia. Although Stephenson and Green (2002) were not able to plot a light curve, with the passage of time the marked change that occurred in its magnitude was noted. By all accounts then it was the first widely-recognized and widely-documented 'variable star'.

This fact aside, *Advancing Variable Star Astronomy* is a well-researched, carefully-written and beautifully-illustrated volume that will long remain a classic in the history of variable star astronomy. It informs on far more than the AAVSO and deserves to feature on the bookshelves of all those with an interest in variable stars. And in a world of ever-escalating book prices, at just AU$130 it is still affordable.

Reference

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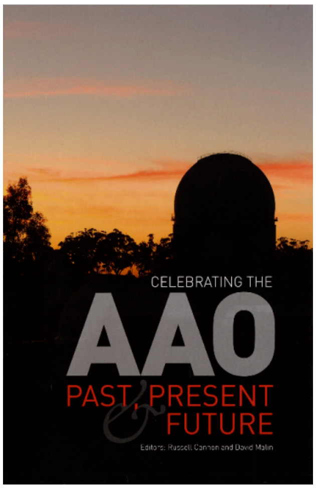
Celebrating the AAO: Past, Present and Future: Proceedings of a Symposium Held in Coonabarabran June 21-25, 2010, to Commemorate 35 Years of the AAO and its Transition to the Australian Astronomical Observatory, edited by Russell Cannon and David Malin (AAO Associates), (Canberra, Australia Department of Innovation, Industry, Science and Research, 2011), pp. xii + 353, ISBN 978-1-921916-04-5, $A45.00, 175mm x 250mm.



This book is not a definitive history of the Anglo-Australian Observatory (now the Australian Astronomical Observatory), but rather a collection of papers highlighting the scientific results and technical achievements, along with the people involved, of Australia's premier optical observatory. For those readers interested in the history of the AAO's formation and the building of the Anglo-Australian Telescope, *The Creation of the Anglo-Australian Observatory* by Ben Gascoigne, Katrina Proust and Malcolm Robins (CUP, 1990) may be of more interest. However, *Celebrating the AAO: Past, Present and Future* provides an excellent (although of necessity, brief) overview of the vast contribution to astronomy that the AAO has provided over the past 35 years as well as looking to the future of the observatory.

In June 2010 the AAO held a conference in Coonabarabran to celebrate 35 years of scientific observations and the final withdrawal of the UK from the Anglo-Australian collaboration that had birthed and operated the AAO. Over 50 papers were presented at the conference and are reproduced in this book, with numerous historical photographs scattered throughout (many more photographs were provided than could be included in the book, and the editors are in the midst of creating an electronic archive of these). The papers cover a wide range of topics, from the Observatory's scientific and technological achievements, through to the role of the people involved and the future of the Observatory. One of the most interesting aspects of the book is that almost every paper is given by people directly involved with the topic in question, thus providing their own personal account of events, with a number of authors providing fascinating anecdotes. Many of the papers are not overly scientific and even the science papers often deal as much with how the science and technology came about as the actual results obtained.

Reading through this book as an ex-AAO employee (who was unfortunately unable to attend the conference) I was most impressed by the common theme that comes through very strongly in the book. That is, the success of the AAO has been (and still is) very much due to the remarkable people who have been involved and the passion and drive that they brought to the Observatory.

Overall I feel that the book is a good read for those who have an interest in the scientific history of Australian and UK astronomy and the remarkable impact the AAO has had on astronomical research. The format of the book (as a collection of short papers) does not lend itself to a flowing read and does not go into any topic in real depth, but as an overview of the remarkable achievements of the AAO, *Celebrating the AAO: Past, Present and Future* does an admirable job. I look forward to the future of the AAO (as a now wholly Australian operated entity) being as productive and interesting as the past.

Dr Stephen Marsden
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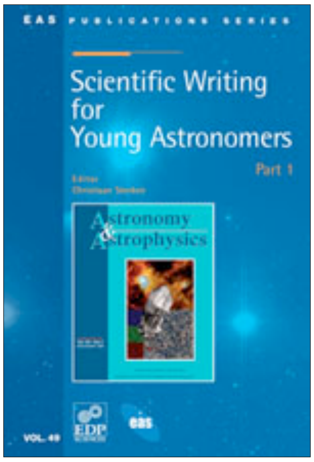
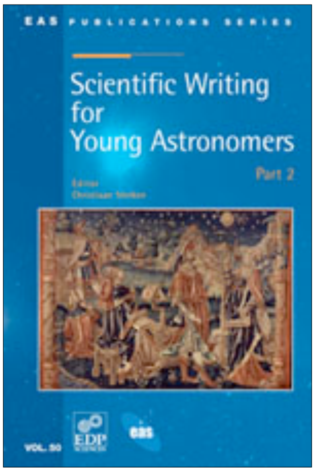
Editorial Note: The following incomplete book review was the last contribution that our late Associate Editor, Hilmar Duerbeck, was preparing for *JAHH* when he died. We therefore decided to include it in this issue of the journal without any editorial changes, as his last formal publication in the *Journal of Astronomical History and Heritage*, and as our salute to him for his years of dedication to our journal.

Scientific Writing for Young Astronomers, Parts 1 and 2, edited by Christiaan Sterken (Les Ulis, EDP Sciences, EAS Publication Series Volumes 49 and 50), pp. 185 and 298, ISBN 978-2-7598-0506-8 and 0639-3, US$29.95 and €32.05, 35 x 155 mm.



These books originated in lectures given at two 'schools' for young astronomers, held in the sea-spa of Blankenberge, Belgium, and may at first glance be of little interest to historians of astronomy. But this is not the case: it is at least a quarry for historians of modern astronomy, offering an insight into the strata of a major journal: *Astronomy and Astrophysics.* The first volume consists of seven contributions by various authors. They describe the review process and its evolution, the production line following an article 'from acceptance to publication' as seen through the publisher's eyes. The next two sections describe in detail the language editing, in general that is sponsored by,



as well as a guide for clear writing. The last two sections describe astronomical libraries and the astronomical databases Simbad and Vizier (also covering ADS, arXiv, search machines, open access journals, etc.).

The three sections of the second, more substantial volume were all written by the editor of the set, Christiaan Sterken. They come to the core of writing a scientific paper. The first section deals with the writing process and its ‘products’ (p. 1-63): regular papers, letters, reviews, data and instrumentation papers, invited, contributed and ‘ticket’ papers from conferences, and products like ‘salami papers’, hoaxes, or duplication papers.

The editorial process […]

The second section (p. 61-170) is a very erudite discussion of another side of preparing a scientific paper, “communication by graphics”.

The final section (p. 173-282) […]

Professor Hilmar W. Duerbeck
Centre for Astronomy, James Cook University