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A NEWLY-DISCOVERED ACCURATE EARLY DRAWING OF M51, THE WHIRLPOOL NEBULA

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Abstract: We have discovered a lost drawing of M51, the nebula in which spiral structure was first discovered by Lord Rosse. The drawing was made in April 1862 by Jean Chacornac at the Paris Observatory using Léon Foucault's newly-completed 80-cm silvered-glass reflecting telescope. Comparison with modern images shows that Chacornac's drawing was more accurate with respect to gross structure and showed fainter details than any other nineteenth century drawing, although its superiority would not have been apparent at the time without nebular photography to provide a standard against which to judge drawing quality. M51 is now known as the Whirlpool Nebula, but the astronomical appropriation of 'whirlpool' predates Rosse's discovery.

Keywords: reflecting telescopes, nebulae, spiral structure, Léon Foucault, Lord Rosse, M51, Whirlpool Nebula

1 REFLECTING TELESCOPES AND SPIRAL STRUCTURE

The French physicist Léon Foucault (1819–1868) is the father of the reflecting telescope in its modern form, with large, optically-perfect, metallized glass or ceramic mirrors. Foucault achieved this breakthrough while working as 'physicist' at the Paris Observatory in the late 1850s. The largest telescope that he built (Foucault, 1862) had a silvered-glass, f/5.6 primary mirror of 80-cm diameter in a Newtonian configuration (see Figure 1). It was first used on the night sky in early 1862, from Paris, prior to transfer to the clearer skies of Marseilles two years later. Among the stream of first results presented to the Académie des Sciences by Urbain Le Verrier (1811–1877), Director of the Observatory, were confirmation of the existence of the just-discovered companion to Sirius (Le Verrier, 1862a; see also Holberg and Wesemael, 2007), observations of a transit of Titan across Saturn's disc (Le Verrier, 1862b) and a drawing of the spiral nebula Messier 51 in Canes Venatici (Le Verrier, 1862c).

Spiral structure had of course been discovered in M51 seventeen years earlier using another reflecting telescope, the 'Leviathan of Parsonstown' built by the Third Earl of Rosse (William Parsons, 1800–1867). The Leviathan incorporated a 6-foot diameter, f/9 primary metal mirror in a Herschelian (or Lemairean) configuration, and the discovery of spiral structure was made during the first months of operation in early 1845.[1] The news was announced by Lord Rosse in June of that year at the Cambridge meeting of the British Association for the Advancement of Science.

The drawing of M51 handed round in Cambridge was found in the Rosse archives some two decades ago and published by Hoskin (1982). Soon afterwards, in an article devoted to Foucault's development of the silvered-glass reflector, one of the authors of the present paper (Tobin, 1987: 162) regretted that the sketch made with Foucault's telescope was lost, because it would have provided an interesting comparison of the two telescopes' capabilities. This lament was repeated in his recent biography of Foucault (Tobin, 2003: 223).

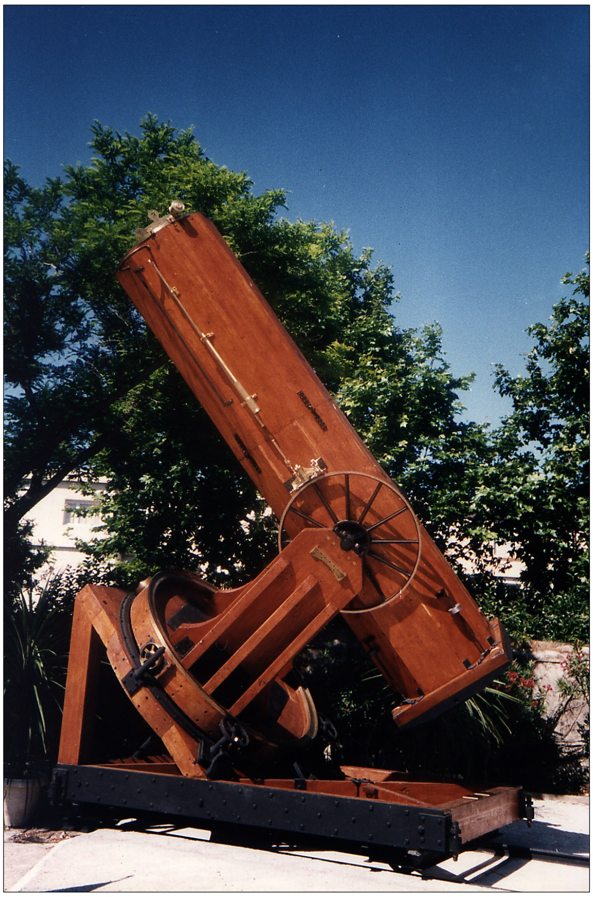


Figure 1: A recent photograph of Foucault's 80-cm reflector, at Marseilles Observatory (courtesy: Marseilles Observatory).

Well, the other author of this paper (Holberg) has now found the drawing! Logically enough, it was in the Paris Observatory archives, where the *carnets d'observation* of over thirty mid-nineteenth century observers have been preserved.[2] The observer assigned to the new 80-cm telescope was one Jean Chacornac (1823–1873).[3] Chacornac had begun a career in commerce in his natal Lyons and then Marseilles, where he was allowed to use the Marseilles Observatory's telescopes. He devoted himself to the study of comets and sunspots, and to the discovery of minor planets and its essential precursor of ecliptic mapping. In 1854 Chacornac transferred to Paris to continue ecliptic mapping as part of Le Verrier's reorganisation of the Paris Observatory. He was promoted to the grade of *astronome* (astronomer) in early 1857 and made a *chevalier* (knight) in the *Légion d'honneur* a few months later.

2 CHACORNAC'S DRAWING

The Chacornac *carnets* are small (approximately 100 × 160 mm). Some forty are bound together in seven volumes spanning March 1854 to February 1863. The *carnets* are not systematic observing logs—several could be in use at once—nor are they complete; for example, they do not contain the drawing of the nucleus of Comet Swift-Tuttle made on 23 August 1862 with the 80-cm telescope, presumably by Chacornac, and published the following month in the popular weekly magazine *L'Illustration* (Guillemin, 1862). Rather, the later ones in particular are personal notebooks in which Chacornac jotted down, mostly in pencil, all manner of items—train times, quotations, gossip, interesting books—besides often-summary information on his observations.[4] From 1859 he often protected the privacy of gossip and gripes by writing some words in shorthand, and at all times he used common astronomical abbreviations such as '☿' for Wednesday and '☉' for Sunday. Concerning the 80-cm telescope, he for example observed the Sun with the bare mirror on 23 October 1861, and the Moon the next day. He concluded: "As long as this telescope is not silvered, these trials do not seem interesting to me." The following "☿ 15 January" he noted that the mirror had been silvered, though the result was "… a little marbled …"; a silver layer deposited the previous Friday had been judged inadequate and had immediately been removed by Foucault. By the 17th, the 80-cm mirror was back in its tube and "we" (presumably at least Chacornac and Foucault) were observing Venus and the Orion nebula. On 9 March, Chacornac recorded Le Verrier's hopes and plans for transferring the telescope to Marseilles and wondered "What will become of all these castles [in the air]???" The following day Toulon made a bid to host the new observatory, offering more land. By 1 June it seemed the telescope (along with Chacornac) would go to Montpellier. "But I do not want this," Chacornac commented, adding that he might go if necessary, but he would prefer England or the colonies. As mentioned above, the telescope ultimately went to Marseilles, where a new observatory site was developed to accommodate it (Tobin, 1987).

The observation that interests us was made on 25 April 1862 and is reproduced at its original size in Figure 2. Chacornac's comment that it was made "with the No. 1" doubtless refers to a low-magnification eyepiece.[5] An additional annotation indicates that the intensity is over-represented near the centre of the principal nebula (where Chacornac has over-written "*plus faible*"—'fainter' on one of the spirals) and near the apparent cross-over, which he has marked "*m*". We note that Chacornac was possibly already used to sketching M51, because in a lecture at the Sorbonne some two decades later, a drawing of M51 was shown that had been made by him with Foucault's earlier 40-cm silvered-glass reflector, which entered service in 1859 (Wolf, 1886: 129).[6]

3 COMPARISON WITH OTHER IMAGES OF M51

To evaluate Chacornac's drawing, we must compare it with the contemporary and modern images reproduced in Figure 3. In Figure 4 we have lettered various features to facilitate discussion. When Messier discovered this nebula in 1773 he saw it as single, but within a few years Méchain had recognised that it was double (e.g. O'Meara, 2006). Among subsequent designations for the companion (nucleus *n*) is NGC 5195, with NGC 5194 for the main nebula (nucleus *N*). It is possible that it is the gravitational interaction with NGC 5195 that has produced the two long, prominent spiral arms that are the defining characteristic of so-called 'grand-design' spiral galaxies (e.g. Murdin, 2001: 3518).

Figures 3(a)-(c) show drawings that predate Chacornac's. Figure 3(a) reproduces John Herschel's drawing from 1833 in which the main nebula comprises a bifurcated ring (Herschel, 1833a: Plate X, Fig. 25). Our attention need not be detained by this drawing, for which Herschel was "… rather disposed to apologize for the incorrectness than to vaunt the accuracy." (1833a: 361). Figure 3(b) shows Lord Rosse's drawing as carefully reproduced in 1846 by John Pringle Nichol (1804–1859), Professor of Astronomy at the University of Glasgow, in his *Thoughts on Some Important Points Relating to the System of the World* (Nichol, 1846: Plate VI), while Figure 3(c) shows the somewhat different drawing published by Rosse himself in the Royal Society's *Philosophical Transactions* in 1850 (Rosse, 1850: Plate XXXV, Figure 1). No doubt there were others.[7] The French science chronicler Abbé François Moigno (1804–1884) asserted that Chacornac's drawing exhibited "… incomparably more details than those given by Herschel and Lord Rosse." (Anonymous, 1862a: 381). We can agree concerning Herschel, but concerning Rosse, Moigno has been carried away by his usual irrepressible enthusiasm for all things French. Chacornac's drawing (Figures 2 and 3(d)) is not as detailed as either of Lord Rosse's: it is more fairly characterized as a sketch. It should be noted, however, that examination of Chacornac drawings of other objects either in his observing logs or in printed form (e.g. Chacornac, 1867) shows that he was an accomplished draughtsman, and we can be sure that every pencil line in his sketch was carefully placed. When compared to a modern, *V*-band image (to approximate scotopic vision) in Figure 3(e), we see that Chacornac has seized the overall design of the M51 spirals far better than his predecessors. In the south-west quadrant, he has seen at least the root of the secondary component *a* of the principal spiral arm *A*, as well as the inner and outer parts of the other principal arm *B*, none of which was delineated by Lord Rosse. The two fingers of emission *f* and *g* that arise from the nucleus and the inner part of arm *A* flank a dust lane, and there are hints of this in the split nature of the inner part of Chacornac's spiral arm *A*. To the north-east, the zig-zag break *z* in *B* has been amalgamated with the outer part of *A* such that, as described by Chacornac in the written text accompanying Le Verrier's presentation to the Académie on 28 April, "… in this region the entanglement of arms presents the appearance of a spherical triangle." (Le Verrier, 1862c: 889). On comparison with Figure 3(e), we can understand that such a characterization could be given.

As for NGC 5195, Chacornac wrote that "… it too presents a spiral form and is not a planetary disc surrounded by a uniformly-distributed atmosphere." He clearly saw the halo *h* with inner darker regions to east and west of the nucleus *n*. Note that Chacornac was not using 'spiral' in the sense of modern extragalactic astronomy, but as a simple geometrical term. In this he followed Rosse (1850: 505) who characterized as 'spiral' any "… curvilinear arrangement not consisting of regular re-entering curves …" and who the year before Chacornac had given a new sketch of the outer nucleus, which he stated was "… unquestionably spiral." (Rosse, 1861: 728).

Concerning the nuclei *N* and *n* of this 'double nebula', Chacornac noted their "… clearly defined stellar appearance …", and added that

> … the central nebulosity of the larger presents, under strong magnification, the aspect of a *tourbillon* [vortex or whirlpool] of small stars about a central object that does not have the planetary character indicated by Lord Rosse. These stars are not the only new ones: one counts as many as nine, distributed along the spirals of the large nebula and which are not recorded on Lord Rosse's drawing. [8]

Had Chacornac read Rosse's paper carefully, he would have found that Rosse had already resolved the nuclei with his smaller 3-feet telescope and that his drawing explicitly omitted all stars whose positions had not been measured (Rosse, 1850: 510, 511; see also the diatribe against Chacornac presented in Darby, 1864: viii).

Continuing the comparison with Rosse's drawing, Chacornac remarked that "… the diverse branches of this spiral nebula intersect in a different fashion. The configuration of the brightest spirals, as our diagram indicates, restores credibility to Sir John Herschel's drawing". Well, perhaps ...

When we look at subsequent naked-eye drawings of M51,[9] we remain impressed by the quality of Chacornac's sketch. Figure 3(f) shows a drawing made a few months later by William Lassell (1799–1880) with his 48-inch speculum-metal reflector in Malta (Lassell, 1867: Plate VI, Figure 27). He has a similar cross-over to Chacornac's *m*, but saw no detail in NGC 5195 nor other finer details such as the secondary arm *a*. Figure 3(g) shows a drawing made by Rosse's assistant, Samuel Hunter, in 1864 using the Leviathan, although this was not published until 1879 (Rosse, 1879-80: Plate IV). After Chacornac's, this is the drawing that best stands comparison with a modern image of M51, but it too misses finer details such as the secondary arm *a*. The drawing made in 1884 by H.C. Vogel (1841–1907) with the new 27-inch Grubb refractor in Vienna is even more approximate (Figure 3(h), Vogel, 1884: Plate 3), missing the double nature of the spirals entirely and introducing a phantom outer arc towards the east-south-east.[10] Also approximate is the drawing made by Admiral W.H. Smyth (1788–1865), presumably in the 1850s or 60s (Figure 3(i)), and published posthumously (Chambers, 1890: viii, 74).

Sir Robert Ball (1840–1913; Astronomer Royal for Ireland 1874-1892) worked as Lord Rosse's 'astronomer' in 1865-1866, in succession to Hunter. Ball recalled that the discovery of spiral structure "… was received with some degree of incredulity. Other astronomers ... thought it must be due possibly to some instrumental defect, or to the imagination of the observer." (Ball, 1895: 286). "Spiral! hem! rather say, coil-tracings left on the face of the speculum by the grinder, or the polisher!" said others (as reported by Darby, 1864: viii). But Lord Rosse was vindicated in the 1880s when "… a witness never influenced by imagination …" came forward in the form of dry gelatine-bromide plates which provided the sensitivity needed to photograph nebulae (Ball, 1895: 286).[11] The Orion Nebula, visible to the naked eye, was the obvious first target, but telescopes were soon turned to M51. A.A. Common (1841–1903) reported that he took a 30-minute exposure with his 36-inch silvered-glass reflector in Ealing in 1883 (Common, 1888), but the first published photograph appears to have been taken on 11 April 1888 by Eugen von Gothard (Jenö Gothard, 1857–1909) using an ≈ f/7 10-inch Browning silvered-glass reflector at his private observatory at Herény, near Szombathely in Hungary (Vogel, 1888: plate).[12] Von Gothard's 2 hr 35 min exposure yielded an image of M51 that was only 4 mm across. It proved impossible to make an enlarged print (with the available optics, presumably) so Ingenieur S. Widt was employed to make a sketch, which we reproduce in Figure 3(j). In this drawing, we begin to see the fine details of modern blue-sensitive imagery, such as the *B* image reproduced in Figure 3(k).

The following year (1889) saw the presentation of the first photographic enlargement of M51 to the Royal Astronomical Society, taken by Isaac Roberts on 28 April 1889 with a 20-inch silvered-glass reflector and a 4 hr exposure (Figure 3(l); Roberts, 1889).[13] Other nineteenth-century photographers of M51 included Carte du Ciel workers in Potsdam in 1891 (Schouten, 1919); S.K. Kostinsky (1867–1936) in Russia in 1896 (Kostinsky, 1916); W.E. Wilson (1851–1908) in Ireland in 1897 (Wilson, 1900; see also McNally and Hoskin, 1988); and J.E. Keeler (1857–1900) in California in 1899, using Common's telescope relocated to the Lick Observatory as the Crossley Reflector (Keeler, 1908).

4 SPECULUM METAL vs SILVERED GLASS

We now return to the question that sparked this paper: the relative optical quality of the Rosse and Foucault telescopes.

Much ink has been spilt concerning the image quality of the Leviathan. We will cite a nineteenth century example first. When discussing the advantages of reflectors for spectroscopy, the astronomy popularizer, Richard A. Proctor (1837–1888), noted (1869: 755) that heavy metal mirrors deform easily

> … [and] do not present objects in a perfectly distinct manner … It is on this account that we hear so little of any discoveries effected within the range of our own system by means of the great Parsonstown reflector. Far better views of the planets have been obtained by much smaller telescopes … [but resolution was less crucial] for the tiny cloudlets which shine from beyond the great depths of space.

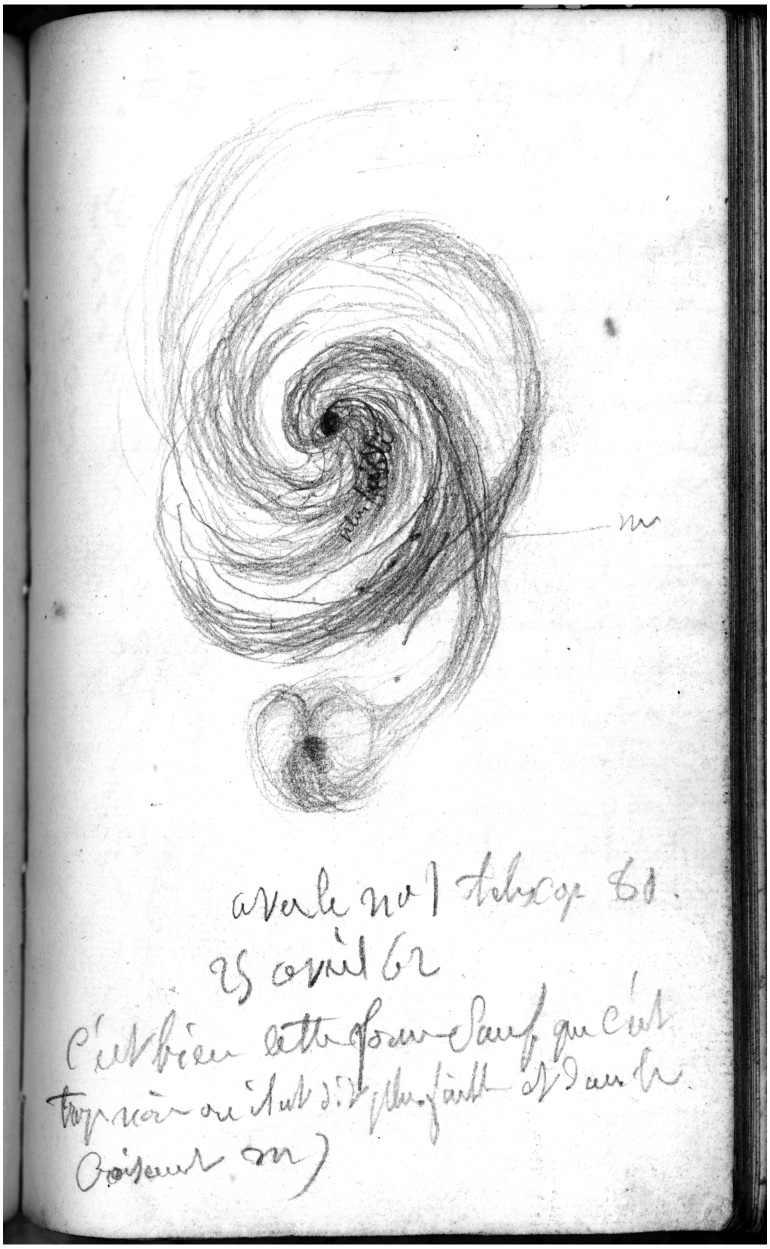


Figure 2: Page from Chacornac's notebook dated "19 Avril 1862 au 19 Juillet 1862" on which he pencil-sketched the appearance of M51 through the 80-cm silvered-glass reflecting telescope at Paris Observatory. South is up. The notes read "*avec le N° 1 télescope 80. 25 avril 62. C'est bien cette forme sauf que c'est trop noir où il est dit plus faible et dans le croisement* m." On the drawing itself the central part of the arm coming out to the north is marked '*plus faible*' and the apparent cross-over of two arms is indicated '*m*' (courtesy: Bibliothèque de l'Observatoire de Paris.).

The Fourth Earl (Lawrence Parsons, 1840–1908) felt impelled to respond to this perceived slight on his late father's memory, and reprinted a letter from the always-eulogistical Robinson, who wrote of good observations of stars in 1845 and 1848 (Rosse, 1879-80: i), although another letter from observing assistant, G. Johnstone Stoney, was more measured (Rosse, 1879-80: iii), and Otto Struve remarked:

> … certainly with regard to definition (particularly where the mirror is considerably out of horizontal position) there are other instruments superior to it [the Leviathan]. (Rosse, 1879-80: v).

The Fourth Earl himself noted that every time the mirror was repolished, the Leviathan became

> … optically speaking a new one. It would be exceedingly difficult to give an estimate of its qualities in various seasons, and in the great majority of cases the value of an observation has been limited by bad atmospheric conditions [he is referring to poor seeing] rather than by imperfection of the instrument. (Rosse, 1879-80: 4).

The Fourth Earl added that the heavier of the two speculums made for the Leviathan was repolished frequently in early years when great efforts were being made to push the telescope's penetration to the utmost, and to improve the polishing process.

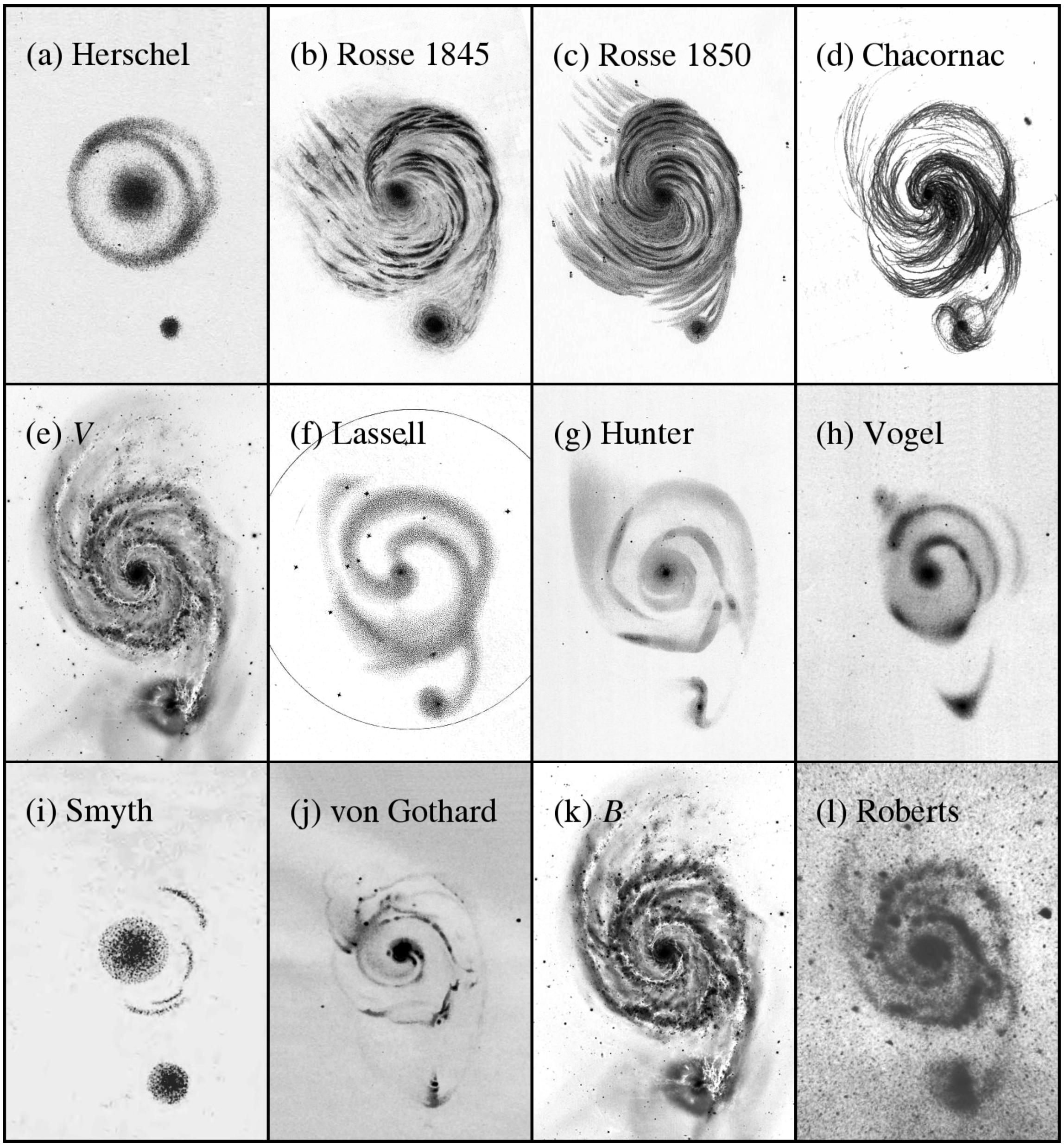
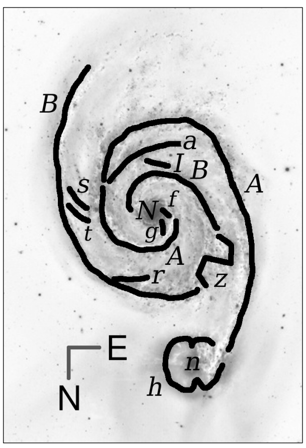


Figure 3: Twelve images of M51 plotted with the same orientation and scale. South is upwards and east to the right. The separation between the nuclei of the two nebulae is 4.6 arc minutes. (a) John Herschel's drawing of 1833. (b) Rosse's drawing of 1845, as given by Nichol (reproduced in negative). (c) Rosse's drawing of 1850. (d) Chacornac's drawing of April 1862. (e) Modern CCD image in the *V* band captured with the CFH12K camera on the Canada-France-Hawaii Telescope. (f) Lassell's drawing of June 1862. (g) Hunter's drawing of 1864, published in 1879. (h) Vogel's drawing of 1884. (i) Smyth's drawing published in 1890 (reproduced in negative). (j) Widt's drawing of von Gothard's photograph of 1888. (k) CFH12K CCD image in the *B* band. (l) Roberts' photograph from 1889 (reproduced in negative).

Figure 4: Identification of certain features in M51 (see the text). Catalogue designations specific to the principal nebula (surrounding *N*) include h1622, GC3572 and NGC 5194, with HI186, h1623, GC3574 and NGC 5195 for the companion.



An example of recent discussion of Leviathan image quality is provided by Thomson (2001), who compared Rosse descriptions and drawings with Digitized Sky Survey images and concluded that "… to have been able to see the amount of detail recorded in the descriptions I have selected, the telescope had to have been performing at an acceptable level." Yet much of this polemic seems unnecessary, for the Third Earl himself—who was renowned for his caution—recorded (1850: 502-503) that

> … we have not found that flexure, even to the extent of materially disfiguring the image of a large star, interferes much with the action of the speculum on the faint details of nebulae … [and that] it has often happened that a speculum which has subsequently proved to be incapable of very fine definition, has remained in the telescope during a succession of

moderately good nights, when a great deal of work was done …

This was essentially Proctor's point.

What is remarkable about the early Rosse drawings is how both show long, thin structures (about 10 arcsec wide) within the spirals and to the south west. It is known that a low light levels, the eye is most sensitive to structure of a degree or so in extent, though the sensitivity extremum is broad, e.g. see Clark (1990; 2008) and Torres (2008). From information given by both these authors we have calculated that M51's spiral arms are sufficiently bright to be well above the detection threshold in both the Rosse and Foucault telescopes. Although we cannot be certain, we think the 'No. 1' eyepiece employed by Chacornac may have corresponded to 90× magnification[14] (and 7°, or about 7 resolution elements, between nuclei *N* and *n*), whereas the Leviathan was probably used at magnifications of 216 or more (Dewhirst and Hoskin, 1991: 263). (We note that both these minimum magnifications correspond to exit pupils slightly larger than the probable diameter of the observer's dark-adapted pupil.) It is now accepted that drawings of deep-sky objects need to be made using several magnifications,[15] and perhaps the thin structures noted in Figures 3(b) and 3(c) resulted from the higher magnification employed. Some of these fine structures are visible in both early Rosse drawings (e.g. at the eastern extremity of arm *A*, and on the outer south-east flank of arm *B*), but it is far from clear that the drawings represent independent observations. The double inner part of arm *A* in the 1850 drawing corresponds to a dust lane clearly delineated in the modern *V* image. But if they are real, what do the other long structures correspond to? They are missing of course from Herschel's drawing (lowest "… magnifying power habitually applied …" of 180×, Herschel, 1833b: 74), but also from Lassell's drawing, which was made mostly with 285× magnification (Lassell, 1867: 46), and, most-tellingly, from Hunter's drawing made with the Leviathan in 1864, which is much more alike in resolution of structure to the drawings made with other telescopes.

Kessler (2007) has noted the greater contrast between the arm and inter-arm regions in Rosse's 1845 drawing compared to his 1850 one, and has suggested that this may have been due to the desire to present a more visually-compelling image to the more-generalist audience at the British Association in the same way that the Hubble Heritage Project images of M51 are presented with more appealing colour and contrast than when the same imagery is reproduced in the scientific literature. Perhaps this was the case, but drawing nebulae was not an objective art. In a paper comparing the metal-mirrored Great Melbourne Telescope to Foucault's and other contemporary reflectors, Gascoigne (1996: 119) has noted a tendency for different observatories to develop individual artistic styles: "… drawings made with the Rosse telescope were bold and dramatic, those at Melbourne much more delicate." Rosse himself noted that in the feeble lamp-light necessary for sketching, the observer had a tendency to make stronger pencil marks than justified, and that in any case "… different eyes form a different estimate of the relative intensities of a nebula and its representation on paper." (Rosse, 1850: 509). Further, Figure 3(b) is considerably fatter, and Figure 3(c) is considerably thinner east-west than the reality; and the stars in the latter are on average some 20 arcsec different in location in the drawing from the measured positions tabulated by Rosse (1850: 510).[16] We conclude that the Rosse drawing should not be interpreted too literally. Indeed Rosse himself remarked concerning Figure 3(c) that "This nebula has been seen by a great many visitors, and its *general resemblance* to the sketch at once recognized even by unpractised eyes." (Rosse, 1850: 504; our italics).

What we find compelling about Chacornac's drawing is that he has seen the faint structures *a*, *r* and *h*, which are recorded on no other drawings. We find it difficult to believe that the Parisian sky was darker than at Parsonstown, and other things being equal, these features should have been more visible in the bigger telescope. We wonder if the Leviathan was more subject to scattered light. (Gascoigne (1996: 116) invokes scattered light as the reason why the Melbourne telescope failed to confirm Asaph Hall's discovery of the satellites of Mars.) Foucault himself was unimpressed by the Leviathan when he saw it in 1857: "Lord Rosse's telescope is a joke …" he wrote to a friend (Tobin, 2003: 204). In any case, it is clear that empirical polishing of speculum mirrors produced images which in no way rival modern ones. The spiral structure of M51 is visible in a modern reflector with 6-inches (150 mm) aperture (Clark, 2008), whereas it was not seen by John Herschel with 18¼-inches aperture but required Lord Rosse's 72 inches. Further, visual observations are not as uniform and reproducible as photographic plates or solid-state detectors. As Isaac Roberts (1889: 390) noted, "… all drawings alike fail to present to the eye proportions, details, and outlines as they are shown on photographs."

What is clear is that the combination of telescope and observer was better for the 80-cm than for any other nineteenth century drawing of M51, although of course this would not have been apparent at the time. We must regret that Chacornac never made a more polished drawing of M51 using Foucault's telescope. Perhaps he was put off by criticisms of its presentation to the Académie in the *London Review* a fortnight later (reprinted by Darby, 1864: viii), for soon afterwards he unambitiously claimed that he had no intention of comparing "… the Foucault telescope in point of power with the giant at Parsonstown." (Anonymous, 1862b: 482). There can, however, be little doubt of the 80-cm's superior optical performance, both because of its novel test-and-correct polishing procedure, and because, unlike the Leviathan, it *was* used for planetary and stellar observations, and continued in use for a hundred years. Gascoigne (1996) has pointed out that the speculum-mirrored Great Melbourne Telescope was more a conceptual than a technical failure: its major problem was that with an f/41 Cassegrain focal ratio it was only useful for drawing nebulae, which by the time it was built was an astronomical dead-end. The failure in the 1870s of large silvered-mirror telescopes at the Paris and Edinburgh Observatories (with apertures of 120-cm and 24-inches, respectively) set back the cause of reflectors, but ultimately the astonishing quality of nebular photographs obtained with metal-on-glass reflecting telescopes was a major factor that led to the dominance of these instruments in the twentieth century (see Osterbrock, 1985).

5 FROM M51 TO THE WHIRLPOOL NEBULA

While on the question of M51, it is interesting to inquire when the popular name 'Whirlpool' became associated with this object. The burgeoning availability of full-text search capabilities on digitized nineteenth century journals, newspapers and books makes it possible to address this question, and the example of the Whirlpool has been presented fully elsewhere as a case study (Tobin, 2008). To summarize the findings, the astronomical use of 'Whirlpool' probably originates with Nichol, who used it as early as 1833, well before the discovery of spiral structure, as a metaphor in discussion of the Kant-Laplace nebular theory for the origin of the Solar System (Nichol, 1833: 63). As early as three years after the Leviathan's discovery one finds reference to "Lord Rosse's Whirlpool or Spiral Nebula …" (Mitchel, 1848: 336) where it is unclear whether 'Whirlpool' and 'Spiral' are used nominatively for M51 alone or as descriptive of a class of objects of which M51 is but one. Both usages occur in subsequent decades, but by the beginning of the twentieth century 'spiral' had become associated with the class, with 'Whirlpool' reserved for M51 alone. The 'Whirlpool' appellation for M51 first appeared in an astronomical journal in 1903, in the *Astronomical Journal* (Schaeberle, 1903: 182).

6 CONCLUDING REMARKS

Le Verrier had a reputation for firing staff who incurred his displeasure, and he tried to remove Foucault at least twice (Tobin, 2003: 204, 211). In January 1862 Chacornac recorded that a M. Harlant, one of the *aides astronomes*, had been told to quit the Observatory

> … on account of recidivist behaviour and scaling the Observatory railings with a ladder … [and that] M. L[e] V[errier] had the intention of giving his position to someone else ... and it was imperative that he should be dismissed as soon as possible ...

On 3 February, Chacornac noted "First news of M. Biot's death. I have lost my ..." and then to preserve the privacy of his musings, he slipped in a word in shorthand, which we have been able to decipher as "Excellency", in the now-archaic sense of an excellent personality, followed by "L[e] V[errier] is going to [mistreat] me …" where "mistreat" is again in shorthand.[17] Here we can see forebodings of Chacornac's expulsion from the Observatory a year later. According to Le Verrier (1863), Chacornac had been "… carried away by Parisian life …" and had neglected his duties at the Observatory, failing, for example, to beat the Americans to the detection of the companion of Sirius. But, in addition, Chacornac was losing his reason, provoked possibly by unfounded accusations of theft of Observatory cash and other crimes. On the night of 3-4 June 1863 he roamed around Paris, ending up in police custody. Struck with *alienation mentale* at the age of 39, he was put on sick leave at half pay and retired to Lyons. Others saw these events less starkly. One of Chacornac's obituary writers, Georges Rayet (of Wolf-Rayet stars), later penned the following evaluation: "… his exaggerated sense of responsibility and anxieties repeatedly renewed ... slowly affected his health." (Rayet, 1873: 334). We can sense Le Verrier's baneful influence by reading between the lines of the "anxieties repeatedly renewed". The Abbé Moigno's comment was similar when he "… greatly regretted the very sad combination of circumstances that broke both his career and his strength." (Moigno, 1873). In Lyons, Chacornac constructed a small private observatory and devoted time to the study of sunspots.

Chacornac's sketch is the most accurate of the pre-photographic images of M51. Although it cannot be used to make a stringent comparison of the performance of the Foucault and Rosse telescopes, it does testify to the quality of both the French telescope and the French observer. We must regret that, unlike Rosse's drawings, it was not widely publicized. This perhaps reflects the institutional contexts. Lord Rosse, as an amateur, could choose to participate in nebular research, which was still in its descriptive phase (even though the discovery of spiral structure had immediately raised dynamical speculations).[18] At the Paris Observatory, however, where the dominant theme was analytical celestial mechanics, the study of nebulae was considered as marginal. Nevertheless, the major use of Foucault's telescope once in Marseilles was the discovery of over 500 faint nebulae (e.g. Esmiol, 1916), so it is fitting that one of its first uses should have been to produce such an astounding representation of the Whirlpool Nebula.

7 NOTES

1. As has recently been pointed out (Bailey, et al., 2005), some mystery surrounds the discovery of spiral structure. M51 was observed with the Leviathan by Rosse, Dr Thomas Romney Robinson and Sir James South in early March 1845, but spiral structure was not explicitly noted. Bailey et al. speculate (with plausible supporting evidence) that this was because the immediate concern was the nature of nebulae and their resolvability into stars; it was only once the observers had addressed this question that they remarked upon the extraordinary spiral structure.
2. All at call number F14.
3. Administrative files relating to Chacornac's career can be found in the Archives Nationales under call numbers F^{17} 2844(1), F^{17} 22785, F^{17} 40062 and L467033. For obituaries, see Rayet (1873) or the very-similar Fraissinet (1873). The latter disagrees with Poggendorff (1898: 256) concerning the date of death, which both (along with Figuier, 1874: 549) claim occurred in Villeurbanne, near Lyons. From the French *état civil* we have ascertained that Chacornac in fact died at St Jean en Royans, in the *département* of the Drôme, on 6 September 1873.
4. Despite their personal nature, their survival is presumably due to the authoritarian Le Verrier having deemed them to be Observatory property.
5. Venus was observed with "No. 3", presumably at higher magnification.
6. This drawing is not in Chacornac's notebooks, although there are splendid drawings of Jupiter and Saturn made with the 40-cm Foucault telescope on 6 May 1860.
7. A painting of Rosse surrounded by several drawings of spiral nebulae is reproduced by Brück (1988: Figure 7). Kessler (2007: 481) reproduces a sketch of M51 from the Birr Castle observing books as well as Rosse's BAAS drawing.
8. The absence of any stars on Chacornac's drawing—or any notes about them in his notebook—raises the

question of whether he might have made a second, more-detailed drawing that night, which would then have been the one presented to the Académie. We cannot exclude this possibility, but given the precision of the drawing presented here we do not believe it likely that he immediately embarked on a second drawing. Keen to keep up a stream of results from the new telescope, we feel Le Verrier would not have hesitated to present the sketch reproduced here, which does not contradict the following description provided by Moigno (1862): "The motion in spirals or vortexes of the nebular matter is perfectly outlined, and in addition one sees that the centres of the two vortices are occupied by two stars." As mentioned by Tobin (1987: note 44), there is no drawing in the *pochette* (file) relating to the meeting in the Académie archives.

9. Identified via the NASA Astrophysics Data System, general reading, and two 1870s bibliographies (Knobel, 1876 and Holden, 1877).
10. Holden (1877: 76) notes that an earlier drawing of M51 is to be found in some copies of Vogel (1867), but there was no drawing in any of the three copies that we have been able to consult.
11. For the development of astronomical photography, see Rayet (1887) or Norman (1938).
12. On von Gothard, see Vincze et al. (2003).
13. Roberts (1889) only discussed the photograph, which was reproduced later (Roberts, 1893: Plate 30).
14. Although the draft of the contract with the optician specifies a set of eight eyepieces (Observatory archives, MS 1060 III-B-11 "Paris le 18 septembre. Construction d'un télescope en verre argenté et du diamètre de 0,^{m}80"), it is far from clear that these were immediately available, though the prism and relay lenses to bring the Newtonian focus outside the tube must have been. From Chacornac's jottings concerning eyepieces in his final notebook we think that he may have used an eyepiece borrowed from the 'micromètre de Gambey à fils fin' which we deduce had a focal length of 50.0 mm.
15. Clark (2008) presents a series of drawings of M51 made with a 12-inch telescope and different magnifications that illustrate the finer detail detected at higher magnification.
16. Mean difference calculated assuming the *nN* distance tabulated by Rosse is correct, whereas it is actually about 5% too small. Adopting the modern value reduces the mean difference by about 10%.
17. Chacornac's shorthand is essentially that devised by Aimé Paris (1798–1866), e.g. Paris and Queyras (1862).
18. E.g. Rosse's own comment on M51 (1850: 504) that "… we cannot regard such a system in any way as a case of mere statical equilibrium …"; or Nasmyth (1855).

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