The Cometarium by John Taylor

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Introduction

A cometarium is a device that portrays the path of a comet in its orbit the Sun. Some cometaria use mechanical gearing to move a model comet along an elliptical track in accordance with Kepler's second law, which requires that the sun-comet line sweeps out equal areas in equal intervals of time.[1,2] Such mechanical cometaria were initially produced as orbital demonstration devices and were not intended to be predictive tools.[3] What might be termed analogue cometaria, however, have also been constructed, and while not mechanically driven they are computing devices that enable the ecliptic coordinates of a comet, with known orbital elements, to be determined at a specified time.

Nicolaas Struyck (1687-1769) constructed an early analogue cometarium *c.*1753, and this device was apparently capable of determining the sky locations of 14 comets as they rounded the Sun[4] (Fig.1). While the whereabouts of Struyck's cometarium is presently unknown, a similar such cometarium is currently on display at the Museum of the History of Science, in Oxford (Fig.2). The silvered brass base plate of this latter cometarium shows the inscription, '*John Taylor Invenit 1828, R. Adie Fecit, Liverpool 1833*'. To the author's knowledge the cometarium at Oxford is the only example of an analogue cometarium on public display, and this article is accordingly concerned with three specific questions: who was John Taylor, how does his cometarium work, and what can be said about its history and provenance?

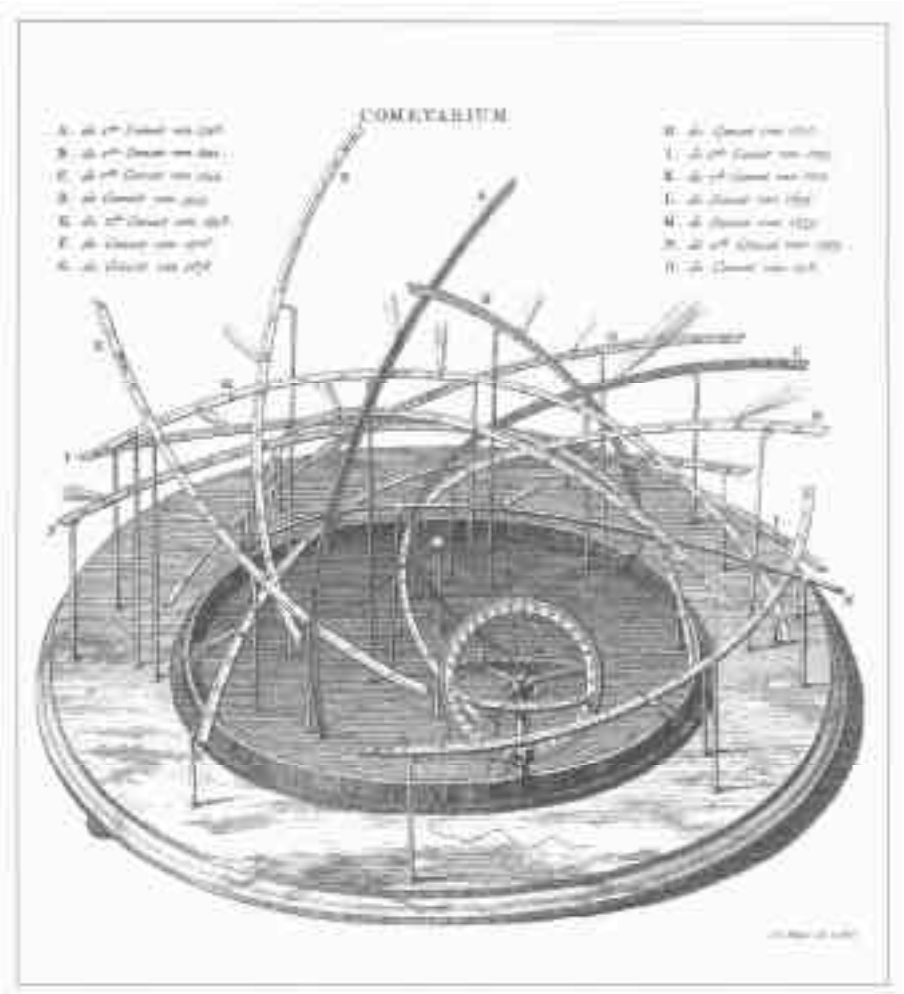

Fig. 1 *Cometarium by Nicolaas Struyck* (c. *1753). The Sun is located at the center of the ecliptic (base) plate, and the Earth is located at the center of the horizontal and vertical protractors seen towards the lower right. A total of 14 cometary orbits are modeled in this cometarium. Image courtesy of R.H. Van Gent.*

The Inventor

During his lifetime, Mr. John Taylor of Liverpool was neither a famed astronomer nor a well-known designer of scientific instruments. Indeed, we know very little about who John Taylor really was.[5] Some limited account of the 'old Mr. Taylor' can be found in a diary record by American astronomer Maria Mitchell, who writes for August 3rd, 1857:

> '*I brought a letter from Professor Silliman to Mr. Taylor, cotton merchant and astronomer; and today I have taken tea with him. He is an old man, nearly eighty I should think, but full of life, and talks by the hour on heathen mythology. He was the principal agent in the establishment of the Liverpool Observatory, but disclaims the honor, because it was established on so small a scale, compared to his own gigantic plan. Mr. Taylor has invented a little machine, for showing the approximate positions of a comet, having the elements..... He struck me as being a man of taste, but of no great profundity. He has a painting he believes to be by Guido; it seemed to me too fresh in its coloring for the sixteenth century.*'[6]

From Mitchell's comments we learn that Taylor must have been of some standing within the community of amateur astronomers in the Liverpool area[7], and that he was involved in petitioning for the establishment of the Liverpool Observatory.[8] Beyond Mitchell's account, however, the only compilation of letters published by Taylor is that contained within a pamphlet[9] produced by the Reverend Richard Sheepshanks in 1845.

Websters Instrument Maker Database (www.adlerplanetarium.org/history/websters) indicates that in addition to the cometarium, Taylor also designed a perennial celestial globe.

Preserved by Controversy

It is probably not unfair to say that we only know of John Taylor and his cometarium in the modern era because of his very public and distinctly vitriolic exchange of letters with the Reverend Richard Sheepshanks. While Taylor may be reasonably labeled as an amateur astronomer, Sheepshanks, in contrast, was a member of the British scientific elite.[10] Educated at Trinity College Cambridge, Sheepshanks was a Fellow of the Royal Society, a barrister, a founding member of the Royal Astronomical Society and a member of the Board of Visitors of the Royal Greenwich Observatory. He was also a man that it was unwise to fall foul of.[11] Indeed, Sheepshanks engaged in a number of public controversies, crossing swords at one stage with Charles Babbage over the development (or lack of it in the eyes of Sheepshanks) of Difference Engine number 1[12], and astronomer Sir James South on another. The latter controversy was particularly savage, and the two combatants publicly exchanged innuendo, insult and libel.[13]

The origins of the dispute between Taylor and Sheepshanks stem from criticisms made by Taylor on the location of the Liverpool Observatory. Specifically, Taylor took issue with several comments written by Sheepshanks in the February 14, 1845 Report to the Council of the Royal Astronomical Society. In this Report Sheepshanks wrote, 'The observatory is admirably situated for this purpose [the dropping of a time-ball similar to the one at Greenwich], on the brink of the Mersey, at the entrance to the Waterloo Dock….'. Responding to this statement in the *Liverpool Times* for April 1st, 1845, Taylor argued, 'according to the writers of this RAS Report, the proper situation for our observatory is in the lowest point of land that can be found, surrounded by hills that cut the true horizon, …. filled with smoke and fog….where sun, nor moon, nor star is ever seen, or was ever seen, to rise and set…'. Taylor concluded his letter with the comments, 'such a situation for an observatory may be thought a good one by the RAS of London, whose great learning may enable them to see things with eyes of peculiar perspicacity; but to other men the place will probably appear a condemned hole'. Needless to say, Sheepshanks rose to this challenge, defending both his, and obliquely the Astronomer Royal's involvement[14] in the selection of the location. He also challenged Taylor about the role of the observatory. In a letter written on April 8th, but published in the *Liverpool Times* of April 22nd, Sheepshanks argued, 'the main purpose of the Liverpool Observatory, and the proper business of the observer, is to get, keep, and communicate true Greenwich time to the great port of Liverpool'. The true reasons for Taylor's initial 'attack' become clear in his reply to Sheepshanks, also published in the April 22nd issue of the *Liverpool Times*. Here, Taylor comments that it was a great shame to limit the purpose of the observatory to just 'time keeping'; 'to so limited a purpose, is the very thing to which I, for one, have from the first objected. The Liverpool Observatory ought to be on a much greater scale as to equipment, and as to the number of officers appointed to it…'.

We need not follow the details of the entire newspaper debate between Taylor and Sheepshanks here, but it certainly grew in bitterness and rancour, with the exchanges becoming increasingly less 'gentlemanly' with time.[15] The ultimate response from Sheepshanks, however, was to publish a small pamphlet outlining (as he saw it) the details of the dispute. Indeed, in a letter to the *Liverpool Times* for May 10th, 1845, Sheepshanks warned, 'there are gross and perpetual blunders in this and in every portion of Mr. Taylor's writing which I have seen ….. if I should thus be forced to republish Mr. Taylor's contributions to science, *cum notis variorum*, I promise him a most unenviable notoriety'. In this respect, it is somewhat ironic that the pamphlet prepared by Sheepshanks to 'expose' Taylor's supposed scientific 'blunders', provides important clues as to the origin and construction of the cometarium now housed at the Museum of the History of Science, in Oxford.

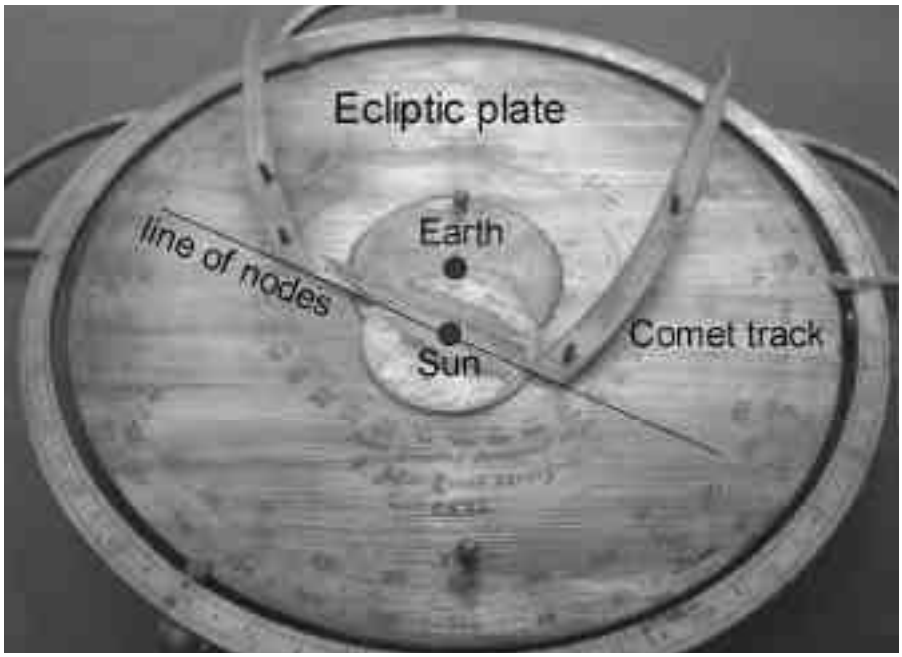

Fig. 2 *The cometarium designed by John Taylor (1828) and constructed by Richard Aidie (1833). The Earth is located at the center of the large ecliptic base plate, and the Sun disk supports the plate (arcs) depicting the orbit of the comet. The cometary orbit cuts through the plane of the ecliptic along the line of nodes. Photograph by the author and reproduced courtesy of the MHS, Oxford. An image of the complete cometarium and its associated orbit plates can be seen at www.mhs.ox.ac.uk/database/brief.htm?Invno=84080.*

Design and Construction

In a supplement to his *Correspondence*[16], Sheepshanks sets out to criticize Taylor for the publication of an article that appeared in the *Liverpool Mercury* newspaper for September 5th, 1845. This particular article (actually dated June 4th, 1845), entitled *A New Cometarium*, begins with the preface details: 'Description of an Instrument for finding the Geocentric Positions of a Comet….invented in the year 1834 by John Taylor, and published[17] in the *Racolta Scientifica* for August 15, 1845'. Presumably Taylor arranged for the article on his cometarium to be reproduced in the newspaper in rebuttal[18] to the criticisms leveled by Sheepshanks in his letter to the *Liverpool Times* of May 10th, 1845.

We need not consider all of the details within Taylor's September 5th article here, but the cometarium is essentially described as being an analogue device for the determination of a comet's geocentric ecliptic latitude (β) and longitude (λ). To work correctly, the comet's orbital parameters must first be known, and the location of the comet in its orbit (at some given time) must be specified. In this fashion the cometarium enables the conversion of the comet's heliocentric ecliptic latitude (ψ) and longitude (l) to those of an Earth based observer. Figure 3 indicates the geometrical relationship between the heliocentric and geocentric longitude, while Figure 4 shows the geometrical relationship between the heliocentric and geocentric latitude. Certainly, there are a set of equations that link the comet's heliocentric coordinates (l and ψ) to those of an Earth based observer (β, λ) at a given solar longitude (L), but rather than solve these equations algebraically, Taylor's cometarium allows for them to be determined geometrically.

The cometarium is constructed so that a 23-cm diameter silvered brass base plate represents the plane of the ecliptic and the Earth is 'located' at its center (Fig.2). The perimeter of the base plate is divided according to half-degree intervals, from a zero-degree mark corresponding to the direction of the vernal equinox (Υ). The perimeter also shows the signs of the zodiac, appropriately positioned with respect to the equinox. The ecliptic base plate is allowed to rotate inside of a brass ring. The outer support ring is overarched by a semicircular brass arc which has been divided into half-degree intervals running from zero on the ecliptic to 90-degrees directly overhead of the Earth. The scale on this arch is used to determine the comet's ecliptic lati-

Comet plate	Perihelion	Year made	Hemisphere
Encke's comet	1832, 1835	1835	North ecliptic
Biela's comet	1832, 1839	1835	North ecliptic
1. Halley's comet	1835	1836	North ecliptic
2. Halley's comet	1835	1836	South ecliptic
3. Halley's comet	1835	1833 (?)	North ecliptic

Table 1: The cometary orbit plates for Taylor's cometarium. Column 1 identifies the comet, while column 2 indicates the year(s) of perihelion passage close to the time of the cometarium's construction (1833). Column 3 shows the year of fabrication as stamped on the cometary plate.No date is actually stamped on Halley's comet plate number 3 and I have assumed that it was made in 1833 along with the main cometarium components.Halley's comet plates 1 and 2 depict the orbit in the northern and southern ecliptic hemispheres (as indicated by column 4). Halley's comet plate 3 consists of two arcs representing the northern hemisphere portion of the comet's orbit (this plate is the one currently attached to the cometarium – Fig.2).Technically plates 1 and 3 for Halley's comet should be identical, but it has not been possible to compare the two orbits in detail – clearly, however,Taylor had a new set of orbital plates made in 1836,presumably because the original plate (number 3?) was found wanting in some manner.

tude (β). The central part of the ecliptic base plate has been cut out and replaced with an independently rotating disk (of diameter 6.5-cm) centered upon the Earth's location.Attached to this central disk is another independently rotating disk whose center corresponds to the location of the Sun.The diameter of the Sun-centered disk is 5-cm,and this sets the cometarium scale to be 1 astronomical unit per 2.5-cm measure. The Sun-centered disc supports a curved plate (or a set of extended arcs) that represents the heliocentric orbit of the comet.The circumference of the Sun-centered disk is marked at intervals corresponding to 5 degrees,with the zero point corresponding to the vernal equinox.The line of nodes for the comet's orbit (see Figs 2 and 3) is placed so that the ascending node is Ω degrees away from the vernal equinox. Disks representing the orbits of comets Halley, Encke and Biela were constructed for use in the cometarium (see Table 1).

The ecliptic longitude (λ) of the comet is determined by first rotating the Sun-centered disk so that the Earth (at the center of the ecliptic base plate) is at its appropriate ecliptic longitude (angle L in Fig.3).The independently rotating Earth-centered disk is then turned (carrying the Sun-centered disk with it) until the line projected from the Earth through the Sun intercepts the outer edge of the ecliptic base plate at the angle corresponding to the Sun's ecliptic longitude at the time of interest.The geocentric ecliptic longitude of the comet can then be derived by projecting a line from the Earth through the position of the comet (as indicated on its orbit plate) to the graduated scale of the ecliptic base plate.The geocentric ecliptic latitude (β) is derived by rotating the base plate until the Earth-comet line is aligned with the semi-circular arch.A thin string stretched from the Earth to the semi-circular arch that just touches the comet plate, at the comet's specified location, will then indicate the geocentric ecliptic latitude.Two brass slides, to which the thin string would be connected, run along the semi-circular arch to help in the measurement of the latitude.

Clearly, given the above methodology, the cometarium is not going to provide a highly accurate sky location for the comet,but with some practice it might reasonable provide ecliptic coordinates to within (say) ± 5 degrees. For a bright comet, such as Halley's this error is probably acceptable (in the sense that the comet could be found on the sky),but for inherently faint comets such as Encke's a more refined analysis would probably be required to actually locate the comet.

The Instrument Maker

From the base plate inscription we know

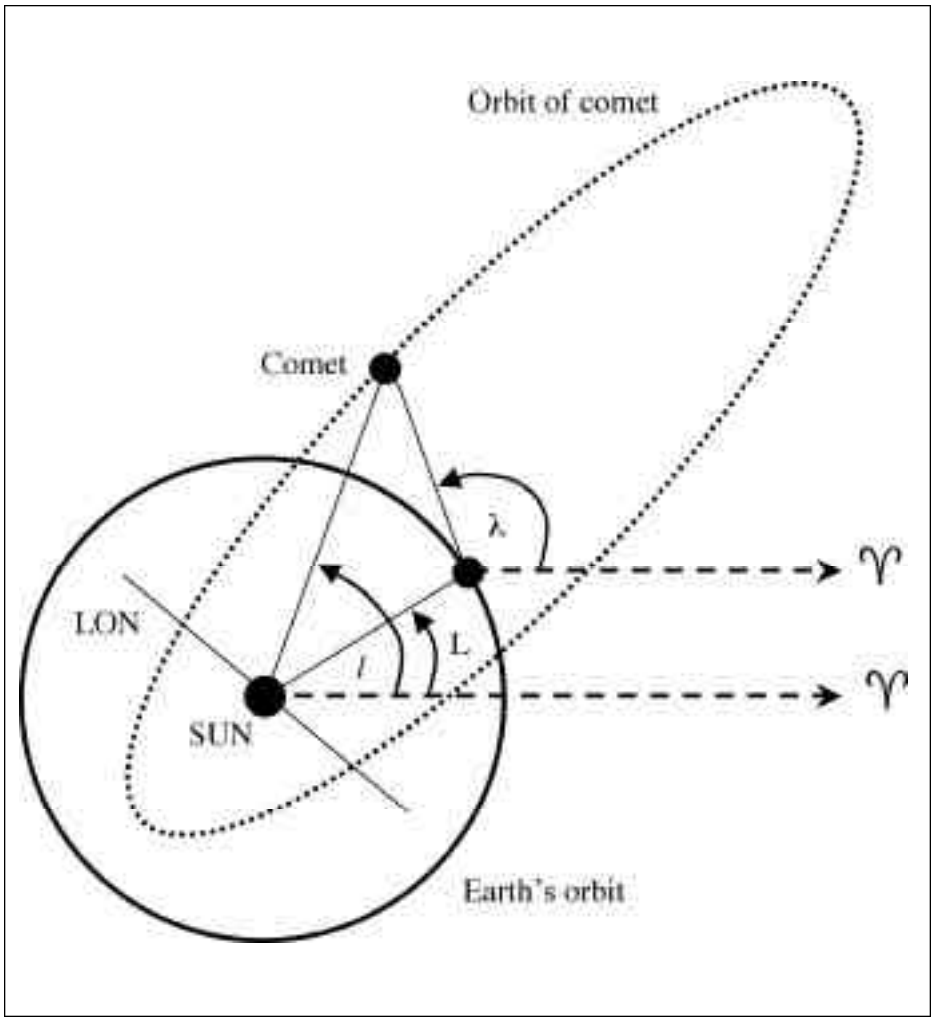

Fig. 3 *The relationship between the Earth's ecliptic longitude L, the heliocentric ecliptic longitude l, and the geocentric ecliptic longitude λ. The cometarium is used to determine λ from the known values of L and l.The line of nodes (LON) indicates where the plane of the comet's orbit intersects the ecliptic.*

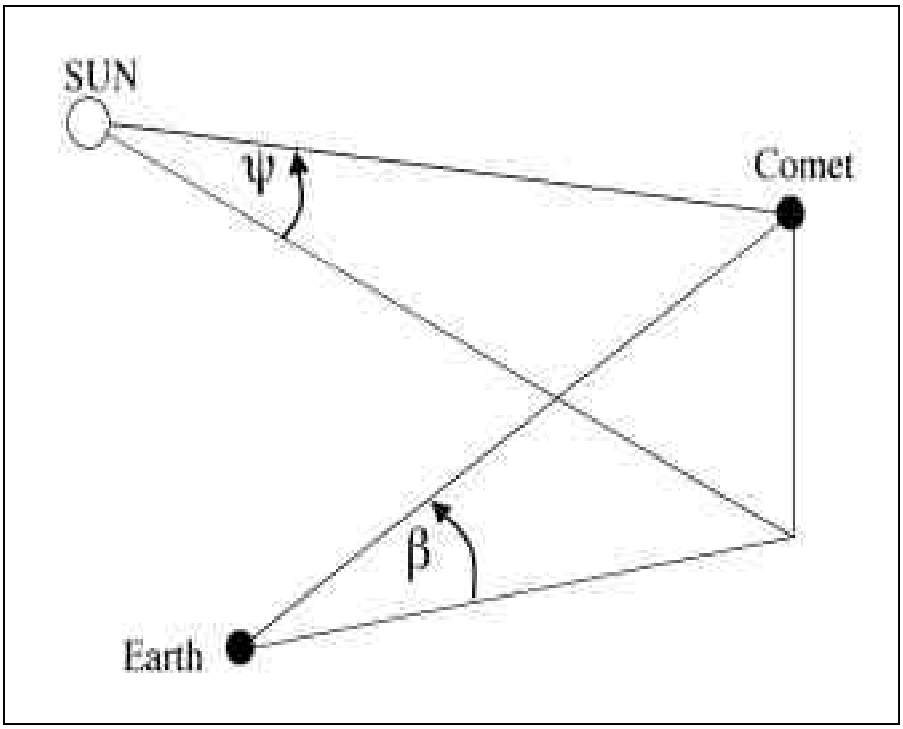

Fig. 4 *The relationship between the heliocentric ecliptic latitude* ψ, *and the geocentric ecliptic latitude* β.

that Tayler commissioned Richard Adie to construct the cometarium in 1835. Richard Adie (1810-1881) was third son of instrument maker Alexander Adie (1775-1858) who worked from Edinburgh.[19] It is recorded that Richard Adie worked from Bold Street in Liverpool during the mid to late 1830s[20], but moved to Edinburgh in 1857 to take over the everyday running of the family business following the death of his elder brother John Adie (1805-1857). The charge by Taylor to build his cometarium would presumably have been one of the first commissions received by Richard Adie, who only started trading in Liverpool in 1835. It is interesting to note (in the sense of the interconnectedness of lives and stories) that John Adie actually spent time in London, at the workshop of Troughton and Simms, in 1827, as part of a commission to construct a mural circle for the Edinburgh Astronomical Institute. In addition, Sheepshanks[21] writes that the Liverpool Observatory was equipped with 'a standard barometer (Newman's construction) by Adie of Liverpool'.

Provenance

Accompanying the cometarium display at Oxford is a small brass plaque with the inscription: '*Presented to the RAS by M^rs^ Hannah Jackson-Gwilt, April, 1880. This cometarium was originally the property of Mrs Jackson Gwilt's friend Sir James South.*' While the plaque indicates that the cometarium was presented to the Royal Astronomical Society in 1880, it is not entirely clear why, before this particular date, it was in the ownership of either Mrs. Jackson-Gwilt or Sir James South. The diary account of Maria Mitchell suggests that when she met Taylor in August 1857 he still had the cometarium in his possession. If Taylor died in the same year that he met Mitchell[9], then it was presumably about this time that the cometarium passed into the renowned collection of instruments owned by Sir James South.

South was mostly known to his contemporaries for his extensive and highly regarded binary star observations, and, indeed, he was knighted in 1830 for his services to astronomy. Prior to his knighthood, South had also been awarded, in 1826, the Gold Medal of the Royal Astronomical Society and the Copley Medal of the Royal Society for his observational work. After falling-out with most of the British astronomical community during the Troughton and Simms affair[13], however, South essentially abandoned his astronomical researches from *c.*1838 onwards. All this being said, it is still not clear how South became the owner of Taylor's cometarium. Clearly the two men had a common adversary in the Reverend Richard Sheepshanks, but it is not known if they knew each other personally or if they engaged in direct correspondence.[22] South died in October of 1867 and the cometarium presumably passed at about this time to Hannah Jackson-Gwilt. South's instrument collection was dispersed by auction[23] in August of 1870, but I have not found any specific account of a cometarium being sold at that time.

Dreyer[24] described Hannah Jackson (d. 1893) as 'a somewhat eccentric lady', and no details have so far come to light concerning how and at what level she might have known Sir James South – other than as a 'friend'. Hannah Jackson was the daughter of architect and writer Joseph Gwilt (1784-1863). While Joseph Gwilt was a Fellow of the Royal Astronomical Society, there is no record of his ever publishing any observational works or collaborating with Sir James South. In 1861 Jackson provided funds to the Royal Astronomical Society in support of a new award – the Hannah Jackson (*née* Gwilt) gift (still awarded to this very day). Taylor's cometarium is the only scientific instrument that Jackson donated to the Royal Astronomical Society, and in 1931 it was presented as a gift to the Museum for the History of Science, in Oxford.[25]

Acknowledgments

Many thanks are extended to Rachel Mellor at the Museum of the History of Science for help and assistance during my visit to view Taylor's cometarium in July of 2005.

Notes and References

1. M. Beech, 'The Mechanics and Origin of Cometaria', *Journal of Astronomical History and Heritage*, **5**-2 (2002), pp. 155 – 163.

2. M. Beech, 'Cometaria and the Demonstration of Kepler's 1st and 2nd Laws', *Bulletin of the Scientific Instrument Society*, No. 82 (2004), pp. 82, 29-33.

3. M. Beech, 'On Ptolemy's equant, Kepler's Second Law, and the Non-existent Empty-Focus Cometarium', *Journal of the Royal Astronomical Society of Canada*, 99-4 (2005), pp. 120 - 123.

4. Struyck described the cometarium in his *Vervolg van de beschryving der staartsterren* (Amsterdam: Isaak, Amsterdam, 1753). Although 14 cometary orbits are depicted on the cometarium, the orbit of Halley's comet is interestingly not one of them. Indeed only two of the orbital tracks correspond to known periodic comets – the rest are long period comets seen during just one perihelion passage.

5. *The Oxford Dictionary of National Biography*, H.C. G. Mathew and B. Harrison, eds (2004) Oxford University Press, vol. 53, lists a total of 31 John Taylors. Most of these entries can, of course, be dismissed according to our time frame of interest. One entry that we should briefly comment upon, and then exclude, however, is that for John Taylor (1779-1863). This particular Taylor was the well-known mining expert, entrepreneur, Fellow of the Geological Society of London, and founding member of the British Association for the Advancement of Science. In addition, we note that E. G. R. Taylor (note 20), p. 466 mistakenly attributes the cometarium built by Richard Adie to the London-based optical instrument maker John Taylor (fl. 1825-7).

6. P. M. Kendall, ed., *Maria Mitchell: life, letters, and journals* (1896). See: www.pinetreeweb.com/maria-mitchell.htm.

7. In the early to mid-19th century there was a rich talent of 'amateur' astronomers in the Liverpool area. Amongst the best known of these would be William Lassell (1799-1880) and the Reverend William R.

Dawes (1799-1868).While Dawes is mostly remembered for his studies on binary stars and for the independent discovery of Saturn's crepe ring,Lassell is best known for his discovery of numerous planetary satellites.Indeed, Lassell discovered Triton, the largest of Neptune's moons, with his newly constructed 24-inch aperture telescope (the largest in Britain at that time) just a few days after it saw first light in 1845. One of Taylor's 'complaints' about the Liverpool Observatory, which also began systematic observations in 1845, was that it was equipped with only an 8-inch aperture telescope.

8.The suggestion that an astronomical observatory be constructed in Liverpool was first made in 1834, see J. E. Jones,'From Astronomy to Oceanography: a brief history of Bidston Observatory', *Ocean Challenge*, **9**-1 (1999),pp.29-35.The town council deliberated upon the idea and eventually a committee to oversee the construction was struck in 1839. Funding for the observatory was obtained through the 1841 Liverpool Dock Act,and systematic observations began under the Directorship of John Hartnup (Assistant Secretary to the Royal Astronomical Society: 1843-1845) in 1845. Ironically, and in partial proof of Taylor's complaints, the Liverpool Observatory was closed down in 1864 with the equipment being moved to Bidston Hill, where a new Observatory was established in 1867. Further historical details can be found at www.nbi.ac.uk/home/history.html.

9. A copy of the pamphlet produced by Sheepshanks is held in the US Library of Congress,in Washington, and the reference information there indicates that Taylor died in 1857. It was presumably late in 1857 that Taylor died since Mitchell's meeting with him took place in August of that year. If this year of death is correct, and Mitchell's estimate of Taylor being 'nearly eighty' when she met him is sound,then the available information would suggest that John Taylor was born *c.* 1777.

10.It would seem that Taylor had a liking for attacking the British 'astronomical establishment'.He can be found, for example, criticizing the Nautical Almanac Office and the Astronomer Royal (Sir George Biddell Airy) in a letter posted to the London *Times* newspaper for November 18,1835,concerning the manner in which the ephemerides for Halley's comet were being constructed. In the *Liverpool Albion* for December 10, 1838,Taylor takes the Reverend W. R .Dawes to task over some supposed observations of Encke's Comet. And, in the *Liverpool and Lancashire General Advertiser* for December 11, 1846 Taylor writes in support of Urbain Le Verrier's priority claim, over that promoted by the supporters of John Couch Adams, for being the first person to predict the position of the newly discovered planet Neptune.

11. In an anonymous obituary account, Sheepshanks was described in the following terms:'A strong, abiding, and self-sacrificing devotion to what he held good and true, and a keen,sarcastic, and laughter-loving contempt for all that pretended to be what it was not. … with no lack of allowance for every well-meant and honest effort, his temperament did not permit him to work out an average from the head of gold and the feet of clay… Had he been a physician, his fanciful and self-tormenting patients would have thought him the worst of their ills'. (*Monthly Notices of the Royal Astronomical Society*, **16**, (1856), p.96).

12. D. Swade, *The Cogwheel Brain:Charles Babbage and the quest to build the first Computer* (London: Abacus books, 2000).

13.Much has been written about the 'famous'controversy centered on the construction, by Edward Troughton and William Simms,of Sir James South's Camden Hill Observatory (see e.g., J. L .E .Dreyer, *History of the Royal Astronomical Society: 1820-1920* (London: Wheldon and Wesly Ltd, 1923),pp. 52-55;M.Hoskin,Astronomers at War:South versus Sheepshanks, *Journal of the History of Astronomy*, **20** (1989),pp.175-212;and F.Watson, *Stargazer: the life and times of the telescope* (Cambridge,MA.:Da Capo Press,2004),pp.191-197).Briefly, however, the story begins in 1829 with South acquiring an exquisite 11.75-inch diameter objective lens from Robert-Aglae Cauchoix in France.South wanted to mount this lens in a new, state of the art telescope, and house the instrument in a custom built observatory, where it could be employed in in the study of binary star systems. Accordingly renowned instrument maker Edward Troughton was hired to construct the telescope and dome.The irascible South, however, declared himself dissatisfied with the construction of the observatory and the telescope-mount made by Troughton.An acrimonious quarrel followed and legal proceedings were opened,with costs eventually being awarded against South in 1834. In a rage South smashed the whole mounting and in late 1836 put the material up for auction as scrap.The Reverend Richard Sheepshanks provided technical advice to Troughton and Simms, and while South and Sheepshanks were fellow officers of the then fledgling Royal Astronomical Society (as President and Secretary respectively),they never apparently saw eye to eye and soon became life-long enemies. Troughton was certainly a skilled instrument maker, but as Ashworth (1994) has noted the project required much more of Troughton than the skills needed to make a good telescope. See W. J. Ashworth, 'The calculating eye: Baily, Herschel, Babbage and the business of astronomy', *British Journal of the History of Science*, **27** (1994),pp. 409-441.

14. Sir George Biddell Airy (Astronomer Royal,1835-1881) had advised that the observatory consist of a transit-room and a dome that could house a large equatorial telescope,see R.Sheepshanks,'Report of the Council of the Society', *Monthly Notices of the Royal Astronomical Society*, **6**-13 (1845), pp.185-186.

15.The editor of the *Liverpool Times* was eventually drawn into the 'debate',and his response (in the October 3rd, 1845 issue of the *Liverpool Times*) to the publication of Sheepshanks' *Correspondence Respecting the Liverpool Observatory* (1845),see note 16 for full reference, was blunt and to the point. 'This very silly gentleman [Sheepshanks],whatever he may be as a professional astronomer has written a pamphlet not at all likely to be purchased by 'a discerning public' in which bad logic, worse temper, and most untenable assumptions have made him appear more ridiculous than ever, if such a thing be possible…. As regards the two disputant astronomers, the stipendiary and the amateur, we would ask, what has Mr. Sheepshanks ever done – what has he the ability to ever do – for the service of science, equal to the invention by Mr. Taylor of the perennial celestial globe.Do six lines of title,in close newspaper type,balance this practical good? We think not'.The other side of the coin is evident in the anonymous obituary account (*Monthly Notices of the Royal Astronomical Society*, **16**, (1856),p.94) for Sheepshanks,which reads,'Some discussion which arose about the site of the Liverpool Observatory led him into controversy, the result of which was a pamphlet exposing the futility of the objections made'.

16.R.Sheepshanks, *Correspondence Respecting the Liverpool Observatory between Mr. John Taylor and the Rev. R. Sheepshanks, MA.* (London: George Barclay, 1845).

17. I have not been able to track down a copy of Taylor's original article in *Raccolta Scientifica*. Nor have I been able to obtain any additional information on Dr. Clemente Palomba. At the time that Taylor's paper was published, however, Father Francesco De Vico,S.J., a well known 'comet hunter' was director of the Observatory in the Collegio Romano (see S. Maffeo, *In the Service of Nine Popes: 100 years of the Vatican Observatory* (Published by the Vatican Observatory and the Pontifical Academy of Sciences,(1991).In addition,a total of eight new comets were discovered from the observatory from 1844 to 1847, so it is not surprising that Taylor's cometarium was of interest to the researchers in Rome.In his article, Taylor states that the cometarium was invented in 1834, but the inscription on the base plate of the cometarium indicates '*invenit* 1828' and '*fecit*, Liverpool 1833'. In addition, the various plates depicting the cometary orbits are dated 1835 and 1836.The design and construction of the cometarium was presumably, therefore,several years in both gestation and fabrication.

18. Taylor's final letter to Sheepshanks was actually published in the *Liverpool Mercury* for May 13th, 1845. He ends his letter with the comment,'His obloquy I hold in supreme contempt; and I set his threats of vengeance, by future libels, at utter defiance'.

19.A.D. Morrison-Low, in *TheOxford Dictionary of National Biography*, H. C. G. Matthew and B. Harrison, eds (Oxford: Oxford University Press, 2004).

20.E. G. R. Taylor, *The Mathematical Practitioners of Hanovarian England: 1714-1840* (Published for the Institute of Navigation by Cambridge University Press, Cambridge, 1966).

21. See Sheepshanks note 14.

22. Sheepshanks in his *Correspondence* (1845), writes that towards the end of 1838 both South and Taylor were guilty of 'running a-muck'with respect to their comments and observations concerning the return of Comet Encke. This comment by Sheepshanks may have been one avenue by which South became aware of Taylor and his cometarium. This said, South claims to have returned the pamphlet to the publisher unread.Indeed, South took out an advertisement in the London *Times* for October 1, 1845 in which he begins:'I very much regret having again to soil my pen in writing the name of the Rev. Richard Sheepshanks'. Clearly, South was still fuming over the Troughton and Simms court case that had gone against him (in 1834),and the role that Sheepshanks had played in the trial. Sheepshanks in his *Correspondence* does claim,however, that Taylor and South must have been in close communication, and that that South was fully aware of 'Mr. Taylor's half of the controversy'.

23.An account of the auction, and the prices fetched for the principal instruments sold is given in *The Astronomical Register*, **8** (1870,pp.196-199), and it is apparent from this anonymous account that the auction was generally a sad affair. Sad that is with respect to both its organization and with respect to the low prices realized by the instruments.

24. Dreyer note 13.

25.H. D. Howse. 'The Royal Astronomical Society Instrument Collection: 1827-1985', *Quarterly Journal of the Royal Astronomical Society*, **27** (1986), pp. 212 – 236.

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