The Travel Diary of Martin Folkes (1690-1754): Newtonianism, Antiquarianism, and Scientific Peregrination

by

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Abstract: Martin Folkes (1690-1754) was Newton's protégé, an English antiquary, mathematician, numismatist and astronomer who would in the latter part of his career become President of the Royal Society and the Society of Antiquaries at the same time. Folkes took a Grand Tour from March 1733 to September 1735, recording the Italian leg of his journey from Padua to Rome in his journal. This paper examines Folkes' travel diary to analyse his freemasonry, his intellectual development as a Newtonian and his scientific perigrination in which he used metrology to understand not only the aesthetics but the engineering principles of antique buildings and artefacts, as well as their context and place in the Italian landscape. Using Folkes' diary, his account book of his journey in the Norwich archives, and accompanying correspondence with other natural philosophers such as Francesco Algarotti (1712-64), Anders Celsius (1701-44) and Abbe Antonio Schinella Conti (1667-1749), I will also demonstrate in this paper to what extent this journey established his reputation as an international broker of Newtonianism as well as the overall primacy of English scientific instrumentation to Italian virtuosi.

Introduction:

Qui sera sera, 'Who or What will be, will be' is the opening phrase that Martin Folkes (1690-1754) chose as his personal motto and incribed in his travel diaries of his Grand Tour from 24 March 1732/3, returning to London 3 September 1735[1] (Figure one). Folkes was Newton's protégé, an English antiquary, mathematician, numismatist and astronomer who, in addition to becoming president of the Royal Society and the Society of Antiquaries at the same time, was a member of the Spalding Gentlemen's Society and the *Académie Royale des Sciences* (Figure two). Folkes became a friend of Voltaire, participant in French Salon culture and correspondent with one of its doyennes, Madame Geoffrin.[2] Folkes was a governor of Coram's Foundling Hospital, a patron of Hogarth and the first member of the gentry to marry a London actress, one Lucretia Bradshaw; antiquary William Stukeley related that Folkes' mother Dorothy Hovell 'grieved at it so much that she threw her self out of a window and broke her arm'.[3] Then again, Lucretia's debut play in the London Theatre was entitled 'The Royal Mischief,' and Dorothy was concerned with the family's reputation, as her older sister Etheldreda married William Wake, who later became Archbishop of Canterbury. Folkes was also Deputy Master of the Premier Grand Masonic Lodge of England and active in the short-lived Egyptian Society. He was possibly the best-connected and most versatile scientist and antiquary of his age, an epitome of Enlightenment sociability, yet he is today a surprisingly neglected figure. His was an intellectually vibrant world in which the long shadow of Newton—Folkes' patron and hero—has tended to obscure those who followed him.

Folkes recorded the Italian leg of his peregrination from Padua to Rome in his journal.[4] His travel diary, like Folkes himself, is little known in the historical literature, and, when it is assessed, it is to provide examples of historical topography, for more general commentary of the import of the Grand Tour or analysed with regard to Folkes' interests in coins and medals.[5]

According to Stukeley, Folkes went on his journey because he was "baffled" by his losing the election for the Royal Society presidency to Sir Hans Sloane. And, indeed, Folkes' 'vocal supporter and right-hand man, James Jurin . . . lost also his hard-won Secretaryship', handing over the Society's papers to his successor William Rutty on 7 December 1727.[6] Stukeley's opinion was, however partisan. He was hostile to Folkes' irreligion, claiming Folkes was 'an errant infidel' who 'professes himself a godfather to all monkeys'.[7] Folkes certainly entertained materialist philosophies before and after his tour of Italy; the Mancunian poet John Byrom recorded their conversation when at Folkes' house for Queen's Square for dinner on 26 February 1725/6, to see his 'books and rarities'. They talked with the surgeon William Cheseldon and the watchmaker George Graham about Mrs Folkes' pet monkey: 'the monkey was very comical, we disputed whether he had reason or no' …. concluding 'he was a man without reason'.[8] In later correspondence with microscopist Henry Baker, Folkes' discussions centred around whether a parasitic twin could be ensouled.[9] Their discussion was a result of Folkes' second tour of France in May 1739, where he met Madame Geoffrin, hostess of an illustrious Parisian salon, and where he was exposed to Abraham Trembley's work on the regeneration of hydra or polyps. As Ratcliff has eruditely shown, work on polyps challenged the Aristotelian Chain of Being, which had dominated understanding of the natural world and raised questions of vitalism, materialism and deism.[10] For instance, did the polyp have a soul, and could that soul be split into two? Was the ability of the polyp to regenerate support for preformation, the idea that all living things preexisted as invisible germs? Folkes and Baker asked similar questions about parasitic twins.

Stukeley's ire was also probably raised because, when younger, he had been exposed to heterodox notions from Folkes who was his close friend. Like Folkes, Stukeley was an active freemason when it was newly fashionable after the appointment of the Duke of Montagu as Grand Master in 1721, becoming a mason of the Salutation Tavern that year; by 1729, Stukeley admitted to Samuel Dale that he was 'in a manner voyd of religion'.[11] Stukeley's redemption and subsequent taking of holy orders as a priest in the Church of England in 1729 may have made him uncomfortable about his previous indiscretions.[12]

More practically, Folkes' Grand Tour was five years after his loss of the Royal Society election, and in the interim, he had been appointed Vice President by Sloane on 8 February 1733, so contrary to Stukeley's assertion, there must have been another reason for his journey. Charles Weld in his 1848 *History of the Royal Society* claimed the journey was so Folkes could 'improve himself in classical antiquity'.[13] Indeed, Charles Lennox, the 2nd Duke of Richmond (1701-1750), provided Folkes with a number of rather blustery letters of introduction, one to Alessandro Albani, the leading collector of antiquites in Rome, who Lennox described as "a very odd Curr, Ignorant enough, & proud as Hell; butt has the finest library, one of them, in Europe, & without exception ~~one of~~ the very best collection of bustos, in the World. You must flatter him upon his learning'.[14] Lennox also wrote a letter of introduction for

Folkes to Teresa Grillo Pamphili (d. 1763), the Genoese poet who led an important literary salon (the Arcadia) in Rome, referring to her rather uncharitably as the 'Ugliest Bitch, in the World, Damn'd proud also, & stark staring mad, butt a Develish deal of Witt, some knowledge, & altogether *Une Maitresse ferme, sans un brin de religion* [a resolute woman without a touch of religion]'.[15]

In a more serious vein, James Jurin wrote a letter for Folkes to Giovanni Poleni the Italian natural philosopher and expert in architecture and classical antiquity (who had also been engaged in the *vis viva* dipute with Samuel Clarke and other Newtonians). Jurin stressed that 'Folkes was an excellent gentleman of high achievement in every kind of literature, especially physics and mathematics; whom Newton valued so highly that, nor content to consider him worthy of his own close friendship, he voluntarily chose him to carry out the duties of Vice- President at the formal meetings of the Society in his own absence'. [16] Folkes subsequently met Poleni in Venice on 18 July 1733 with whom he discussed meteorology and the state of learning in England.[17]

Intellectual and aesthetic development was thus part of the reason for Folkes' tour, just as it was for natural philosopher George Berkeley before him who, in his case, cultivated a taste for Greek Doric Architecture. In 1713, Berkeley wrote Sir John Percival stating he was interested in the 'agreeable effects' of such buildings on his eyes, an interesting remark 'given the subjectivist theory of perception he recently articulated in his *New Theory of Vision* (1709)'. [18]

Like Berkeley, Folkes melded aesthetic and natural philosophical concerns, his tour one of of scientific peregrination, or 'science on the move' that was prevalent from 1650-1750.[19] The origins of the scientific peregrination were in the '*peregrinatio academia* of early modern aspiring scholars' and/or the *peregrinatio medica*, as medicine was the subject for which foreign travel was most valuable; medical students brought back new techniques, knowledge, and *materia medica* to their homeland.[20] Indeed, in the 1670s Thomas Bartholin when recalling his own *peregrinatio medica* noted, 'Today there are many travellers; indeed, it seems as if the whole of Europe is on the move'. Not only would young medical students travel abroad to earn professional credentials, but to attain accomplishments becoming gentlemen of quality and add polish to their English education. But by the time of Folkes' journey, I would argue that scientific tours apart from the reasons of *politesse* and medical pedagogy had long developed as a separate enterprise. Previous works such as botanist John Ray's later published travelogue of his journey on the Continent (editions in 1693 and 1738) reinforced the image of 'diligent natural philosophers, engaged in the pursuit of activities conducive to the public [and scientific] good'.[21] In 1698, physician and naturalist Martin Lister (1639-1712) wrote a guidebook of his *Journey to Paris*, intending it specifically to appeal to fellow natural philosophers.[22] Lister directed the reader to his interests in natural history using his mature judgment and own eyes, offering 'clean Matter of Fact, and some short notes of an unprejudiced Observer'.[23]

Although not a doctor or a naturalist like Lister or Ray, Folkes had similar sentiments reflecting his specialism in mathematics and interest in architectural measurement, his journey designed to answer particular questions of natural philosophy. His diary reflected 'antiquarian science', a form of perigrination in which he used metrology to understand not only the aesthetics but the engineering principles of antique buildings and artefacts, as well as their context and place in the

Italian landscape. Although Folkes followed in the tradition of past natural philosophers such as John Greaves, the Savilian Professor of Astronomy who desired to standardize and synchronize the 'weights and measures of all ancient and modern nations', we will see in the first part of the paper that Folkes also wished to verify Greaves's measurements of the Roman foot as an expression of his status as a Freemason and current interests promoted in the Society of Antiquaries. Using Folkes' diary, his account book of his journey in the Norwich archives and accompanying correspondence with other natural philosophers such as Francesco Algarotti (1712-64), Anders Celsius (1701-44) and Abbe Antonio Schinella Conti (1667-1749), we will then determine to what extent this journey established Folkes' reputation as an international broker of Newtonianism, particularly optics and the subsequent application of his mentor Newton's natural philosophy to geodesy, the ultimate form of metrology. We will then determine to what extent Folkes was successful in demonstrating the overall primacy of English scientific instrumentation to Italian virtuosi. His journey was an expression of the motto scrawled his diary, symbolic of who and what he would become.

Folkes, his diary, freemasonry and metrology

In her discussion of early eighteenth-century arguments between materialists and anti-materialists, and the formal foundation of modern Freemasonry with the establishment of the Grand Lodge in London in 1717, Margaret Jacob has suggested that 'tolerant-minded Newtonians . . . invented a new form of ritual to worship the Grand Architect of the Universe'; Jacobs argued freemasonry was an innovation sprung 'from Newtonian inspiration'.[24] Garry Trompf agreed, writing, 'The more one ponders Newton's axial principles … and then one relates this covert, Talmudically-inspired unorthodoxy to his fascination for the mysterious proportions of the Solomonic temple, the more one can sense the milieu of early Freemasonry.'[25] Folkes was not only a 'prestigious figure in the scientific and antiquarian communities' in Britain and the Continent but also a visible ambassador of Freemasonry's ideals of free thought and sociability and Newtonian scientific principles; it was rumored after Folkes returned from Italy, that he was the author of the scurrilous *Relation Apologique* (1738) for Freemasonry which applied Newtonian principles to government and communicated Masonry as primarily a scientific institution.[26]

Folkes was a follower of speculative Freemasonry, a non-sectarian group of freethinkers to which many fellows of the Society of Antiquaries and the Royal Society belonged; forty-five percent of the Fellows of the Royal Society were Masons in the 1720s.[27] Between 1719-42, he proposed eleven fellow masons of the Bedford Head and Maid's Head Lodge in Norfolk (which he founded) as fellows of the Royal Society.[28] Folkes' friend and patron, Charles Lennox, was Grand Master of the Bedford Head Lodge (installed in 1724/5), and a fellow of the Royal Society. Folkes also provided Lennox with antiquarian documents about freemasonry; Lennox wrote Folkes in 1725 apologising for missing the masonic feast day of St. John's, "guilty of such an omission that nobody less than the Deputy Grand Master of Masonry can make up for me." He then proceeded, "I thanke you for the Old Record you sent me, it is really very curious, & a certain proof at least, or our antiquity, to the unbelievers."[29]

Although the precise line that divided deism, natural religion and the revealed religion of the orthodox Christian was subtle in this period, Folkes' travel diary to Italy confirmed his freethinking beliefs. He noted that he considered Catholicism and Protestantism 'as only a tool of the state to keep the vulgar in awe', noting Venetian intellectuals were 'fond of any sort of freethinking book, and with what eagerness they speak on the subject and enquire after the ways of thinking of a nation more used to liberty of thought than themselves'.[30] That said, Folkes did go on to say 'The bible is in no ways known and I have met with stupendous instances of mistakes about the things contained in it . . .and it has been with the greatest surprise several have heard me speak of the measure of learning of all sorts that very antient . . . book contains'.[31] Like Newton, Martin Folkes considered the Bible an authoritative historical source (one among many), and he even helped Thomas Pellet edit a manuscript of Newton's *Biblical Chronology of Ancient Kingdoms*, 'a truncated version of Newton's more radical manuscript'.[32] Newton used data about the precession of the equinoxes to formulate his new chronology, and Folkes' astronomical expertise was useful in this regard. However, unlike Newton, Folkes did not identify with the vindication of religion, natural and revealed, admitting to his friend John Byrom that he was "a heretic about the book of Daniel." [33] Nor was Folkes a believer in natural theology, also admitting to Byrom that he thought William Derham's *Astro –Theology*, a corollary to the Boyle Lectures that used natural history and teleology to promote and prove a natural theology, was 'a silly book'.[34] It seemed an appropriate comment for someone with such a resolutely non-teleological personal motto.

However, one of the pieces of biblical wisdom in which Folkes was interested from the viewpoint of freemasonry and as a mathematician and astronomer was metrology, whether it was the clarifying the scripturally ambigious dimensions of the sacred cubit of the Hebrews used to build Solomon's Temple or the dimensions of the Roman foot.[35] He took as his motto in the *album albicorum* (friendship book) for the Egyptian Society 'omnia in mensura et numero et pondere diposuisti', or 'thou has ordered all things in measure and number and weight (Book of Wisdsom, 11:21)'. And, Folkes' interests reflected the current intellectual milieu, as speculative masonry emphasis 'upon a mathematical diety accorded well with the Newtonian conception of the universe, with a grand mathematician or architect at the centre'.[36] Previously, Newton had written a dissertation upon the sacred cubit which would also be republished in 1737 along with the works of John Greaves by antiquary Thomas Birch, who wrote the *History of the Royal Society* (1757). And, as Haycock noted,

> in 1723 the English publication of the French priest Bernard Lamy's *Apparatus Biblicus*, which included detailed engravings of both the Tabernacle and Temple, was published. The following year a grand model of the Temple, 'lately brought over from Hambourg', was put on display for the public in London, whilst in 1726 William Whiston advertised 'a small, but curious Course of Lectures' on astronomical subjects which also included 'Sacred Architecture past' . . . as well as 'Sacred Architecture Future . . . It was also in this very same period that Freemasonry was first taking off in London, with prominent Newtonians . . . playing an active role.[37]

Therefore it is not surprising that one Folkes' first tasks when he arrived in Venice was to measure the height of the Campanile by its shadow, concluding it was 140 feet high and then measuring again to confirm his conclusions; to do this, Folkes figured out the conversion factor between Venetian palms and English feet. (Figure three). He the proceeded to measure the Rialto Bridge in Venice to confirm his determination and comparison of past standards of measurement, recording on 8 July 1733 that 'writers not agreeing perfectly with one another about its dimensions, I went this morning to take its dimensions my self, and in order to be sure that I did I made the scetches on the other side to show the lines I really took the measures of' using packthread and a plumb bob.[38] He carefully compared his measures of the Antonio da Ponte's Bridge to those of it taken by Francesco Sansovino, the son of Jacopo Sansovino (1486-1570), the *proto* or chief architect of Venice who was responsible for the rebuilding of *Fabbriche Nuove di Rialto* complex (seat of the Magistrates in charge of customs and duty).[39] Disturbed that his measurements of the bridge were different than Sansovino's, he wrote, 'I would readily think may be partly owing to defect in my own measure, partly perhaps an inaccuracy in the building the bridg itself to the intended model, and perhaps again in the not having to perfect these proportions between the English and Venetian foot.'[40] After making some enquirys after the original standard of the Venetian measures which I find to be fruitless, he 'took some measures of St Geminianos Church in order to have made something out by them, but thinking upon comparing the measures I have taken, it was not built by the Venetian foot but by the Roman Architectonick palm whose length comes out very exactly by it'.[41]

It was a perceptive comment. St Geminiano was in the Piazza San Marco, part of the 'wholesale remodelling of the piazza, the piazzetta and surrounding building' by Sansovino in Renaissance Venice in the classical style; the 'effect was to superimpose an evocation of ancient Rome on the existing Byzantine elements'. [42] St Geminiano, directly across the piazza from San Marco, was a focal point of the architectural complex designed by Jacopo Sansovino in Vitruvian proportion to evoke the ancient Roman forum (Figure four). Hence, Folkes suspected and proved that Sansovino used Roman measurements to create his building, particularly as Vitruvius in his third book of *De Architectura* gave a thorough description of the Roman foot or *pes* and palms (one-quarter of the foot).[43] In this manner principles of measure and geometry would ensure harmony and aesthetic appeal in the building's design. In other words, Folkes was investigating architectural metrology to provide what we would term archaeological information about architects and builders of Renaissance Venice, and as we will see, ancient Rome.

Queries about ancient metrology began in 1573 with the publication of *De Mensuris et ponderibus Romanis et Graecis* by Lucas Paetus. That publication spawned an active debate about the exact length of the *pes*. Dissatisfied with inconsistencies in textual evidence, John Greaves, Professor of Astronomy at Oxford, visited Rome in 1639, to 'examine as many ancient measures, and monuments, in Italy, and other parts, as it was possible,' and then compared 'these with as many Standards, and Originals, as I procure the sight of'.[44] He thus measured brass measuring rods in Roman ruins, the foot measure on the tomb of Titus Statilius Aper and on the statue of Cossutius. He then stated 'to transmit both these, and them to posterity, I exactly measured some of the most lasting monuments of the Ancients,' including for example the distance between the milestones on the Appian

Way, finding with pleasure that paving stones were exactly 'three of those Romane feet on Cossutius' monument'.[45] Greaves then did comparisons between the Roman foot to the iron standard of the English foot in the London Guildhall and published his findings on *Discourse on the Romane foot and denarius* in 1647, concluding that the Cossutian foot was the "true" Roman pes. Greaves also claimed that he thought he could find a relationship between pes and the sacred cubit, something which Newton also noted in his own treatise on the cubit.

Folkes followed the same methodology as Greaves in his own travels. In 1736, Folkes identified the Root Canonical Greek foot as 1.0057142 times the English measure, and the Roman pes of .966 the English foot, noting them as being engraved on a Standards stone tablet at the Roman Capitol that might have been the actual record of the pes monetalis. His paper about the stone was subsequently published in the *Philosophical Transactions of the Royal Society*; Folkes recorded 'setting the point of my Compasses' in the lines in the stone that represented the measures, and he also noted that 'my chief Attention was given to the Roman foot, as of greater Consequence than the other measures'.[46]

In making his conclusion, Folkes considered previous measurements made by Fabretti, but recorded in his diary that also measured the height of the Trajan Pillar "using an exact two-foot rule brought from London" which 'I find, from the Ground to the Top of the Cimatium of the Capitol, to be 115 feet 10 inches 5/8; and this Height divided by 120, gives nearly 966 for the quotient'; he confirmed that the Roman foot was 0.966 English feet and used frequently in Roman architecture.[47] This was because the height of the shaft of the column from the plinth of the base to the abacus of the column was said to measure exactly one hundred Roman feet, as a *columna centenaria*.[48] Now, of course, studies of metrology and measurement surveys of ancient buildings consistute some of the most important work in archaeology. [49] Ironically, Folkes' exactitude of measurement has not been borne out in modern studies as there appears to be some slight variations in the Roman pes, partially to be 'attributed to the Augustan decree to standardise Roman metrology, which would have been most easily implemented by the transport of replicas of the *pes monetalis* at Rome to the colonies'.[50]

During his tour, Folkes also discussed his work with the Trajan Column in more depth with the Venetian Francesco Algarotti, interested not only in its measurements, but its use in visual perpective.[51] Algarotti had associated himself with 'radical conversazioni and early masonic lodges' at some point during his tours of Padua and the Veneto, then Florence and Rome in the early 1730s where he met Folkes.[52] Algarotti was best known for his popularisation of Newton's precepts in his *Newton for Ladies*, but he also wrote a number of letters and essays on aesthetics, one in which he analysed the helical frieze on Trajan's column depicting the two Davian Wars. . In a letter to Jean Paolucci, Algarotti recalled he discussed with Folkes that if the bas relief on the Trajan column gave them any reason to 'presume that the ancients had not the slightest knowledge of the proportions of perspective'.[53] Folkes noted that 'it has been said by some, that the bas-reliefs on the shaft of this pillar increase in size upwards, in order to appear of the same size below; but this is not true; and I had an opportunity of satisfying myself from the plaister-cast of the whole pillar, kept at the French academy of painting and sculpture in Rome,where….I measured several of the fairest figures'.[54]

Algarotti also recounted in his conversation with Folkes the arguments of Charles Perrault, who rose in the French Academy to champion modern authors in the quarrel between the ancients and moderns which divided French cultural loyalties between 1687 and 1715. Perrault admitted that while the ancients excelled in sculpture, which in his opinion demanded little 'reflection' and abstract thought, bas-reliefs and painting required a deeper understanding of perspective and spatial relations which the ancients did not have, and he expressed his disappointment with which the 'impatiently awaited casts of the Trajan Column' had been received in Paris.[55] However their discussion revealed their skepticism about Perrault's claim, Algarotti writing 'the defects which are believed to been seen in the ancient bas-reliefs, and especially in the Trajan column, prove nothing against the knowledge of the ancients in regard to perspective'. Rather, the artist used fewer emblematic forms to represent the events of the war; perspectival tricks could not assist the artist in highlighting 'certain figures, groups, or parts of the composition.' Indeed, the composition is characterised by diagonals so the 'figure of the emperor is emphasised along with the direction of gazes and actions of the figures surrounding him'.[56] To make the figures and iconography intelligible to a spectator who was on the move and at a great distance, the composition required a multi-perspectival approach and simple converging and diverging orthogonals were not appropriate. Folkes and Algarotti concluded that the artist was more like a great captain employing a strategm of sophistication, but the technique remained a mystery. As we will see, Folkes' conversation with Algarotti reflected his pervasive interest in optics, optical illusion, and perception.

Folkes, Venice and Newtonianism

Folkes met and cultivated other fellow mathematicians and Newtonians during his travels in Italy, particularly those who were interested in Newtonian optics. Before he left for his journey and during his time on the Council of the Royal Society, he was exposed to a constant stream of accounts 'of the present state of Learning and Experimental Philosophy in Italy,' from the English Jacobite Thomas Dereham, their contact in Florence. Dereham was the translator into Italian of *Astro-Theology*, a five volume set of the *Philosophical Transactions of the Royal Society* (published by Felice Mosca between 1729-34), and a work by Newtonian physician George Cheyne.[57] Dereham relied on luminaries such as Eustachio Manfredi, the (chair of mathematics in Bologna, discoverer of a comet and asteroid, and observer of the transit of Mercury) for natural philosophical news to pass onto the Royal Society. [58]

Venice, in particular, was also a favourite haunt of Newtonian mathematicians and their intellectual circles, and Folkes went there to convince their virtuosi of the truth of Newton's work in optics. Twenty years previously Newtonians had fought a campaign against Italian supporters of Leibniz in the calculus dispute. In Padua and Venice, after 1710, Jakob Hermann and Nicolas Bernoulli were 'promoters of a fierce campaign against Newton's methods of fluxions in the calculus'.[59] Hermann had taught differential and integral calculus using Leibniz's method at Padua from 1707-13. However, Newton had friends as well, and hoped to diminish the prestige of Leibniz through the offices of Abbè Antonio Schinella Conti (1667-1749), who was born and educated in the Veneto but spent several years abroad before returning to Venice in 1726; Conti was in London between 1715 and 1718 to become part of

Newton's intellectual circle where he met Folkes. In his travel diary of 1733 Folkes noted, 'I had known the Abbè very well in England above 16 years ago, I had a very agreeable conversation with him as he is a Gentleman of great knowledg and politeness, and indeed the most knowing man of all the Italians of his side the country'.[60] Conti would also serve as a go-between Leibniz and Newton in the calculus affair, and through Conti's offices, 'Newton probably hoped to diminish Leibniz's prestige, which was at its height in Italy during the calculus dispute'.[61]

Folkes had also been tutored by Abraham De Moivre (1667-1754), his correspondence showing that he and Edward Montagu dined with their former teacher on de Moivre's eightieth birthday in 1747. [62] De Moivre would subsequently be an intermediary in a mathematical dispute between Newton and Bernoulli, so Folkes was intimately au fait with the history of the Newton Wars.

Before his journey, Folkes had attended a series of Royal Society meetings in which the Society reponded to the refutation of Newton's optical work by Giovanni Rizzetti (1675-1751), a Paduan nobleman who belonged to the circle of the mathematician Jacopo Riccati (1676-1754) of Castlefranco Veneto. The Royal Society journal book for 27 June 1728 reported, that the society received Rizzetti's 'De Luminis Affectionibus Specimen Physico Mathematicum...the tract was referred to Dr Desaguliers which he promised to make an extract of'.[63] Rizzetti denied that he could reproduce Newton's experiments regarding the 'refrangibility of the Rays of Light' ; refrangibility is the degree to which light refracts passing from one medium into another, or a 'predisposition, which every particular Ray hath to suffer a particular degree of Refraction' [64] In particular, Rizetti claimed he could not replicate the experiments in Book 1 of the *Opticks* in which Newton used a candle to illuminate a two-coloured card with black silk threads wrapped around it, demonstrating the principle of chromatic aberration.[65]

Newton had placed a glass lens at a distance of six feet from the card, and used it to project the light coming from the illuminated card onto a piece of white paper which was at the same distance from the lens on the other side. He moved the piece of white paper back and forth, taking note where and when the red and blue parts of the image were most distinct. The black threads indicated distinctness of the image (when the lines created by the thread were sharpest). Newton found it 'impossible to focus the image of black silk-thread lines upon a blue background at the same distance as when the same lines are placed against a red background; the distance between the two positions of sharp focus was as much as one and half inches'.[66] In other words, to get a distinct red image, the paper had to be held 1.5 inches further away than it was to obtain a distinct blue image. Newton thus concluded that the blue light was refracted more by the lens than the red, and was more refrangible.[67]

Red and blue light were not strictly homogenous, and so not all the blue light was more refrangible than all the red light, something Newton admitted. However, he did indicated this experiment demonstrated a general effect: 'But these Rays, in proportion to the whole Light, are but few, and serve to diminish the Event of the Experiment, but are not able to destroy it'.[68] Newton thus described an ideal experiment.

The inability to create these ideal conditions was the point which Rizzetti had seized upon. The popular lecturer John Theophilus Desaguliers (1683-1744) refuted Rizzetti's claims in a series of optical experiments performed at the Royal Society in

1728 in response to Rizzetti's *De Luminis Affectionibus*. In his article published in *Philosophical Transactions*, Desaguliers noted 'we hear indeed in a letter from Sir Thomas Dereham to Sir Hans Sloane, President of the Royal Society, that now Signior Rizzetti alledges, that he was deceived in his experiments by reason of the badness of his prisms which he had from Venice'. [69] In other words, Rizzetti claimed he did not have ideal experimental conditions due to the quality of his prisms.

As Simon Schaffer has shown in his essay, 'Glass Works', the quality of the prisms was important; Francesco Algarotti's attempts in Bologna in 1726 to replicate the *experimentum crucis* were described by Rizzetti as failures as he could not isolate a single red ray of light; Algarotti eventually realised that his prisms were defective, and he had success at replicating the *experimentum crucis* when he tried again with some top-quality English prisms. [70] Schaffer shows us how *and why* acceptance or denial of the specific experimental apparatus became a flashpoint in disputes over knowledge and method; we see the beginnings of the establishment of standards for professional instrumentation, or what was termed the sociology of calibration.

But Schaffer did not analyse as much the debate over Newton's *Opticks* in Italy which continued long after Desaguliers' 1728 demonstrations in the Royal Society.[71] Part of the reason for Folkes' travels in Venice, was so he could serve in Desaguliers' stead as the Newtonian demonstrator, and the quality of Folkes' prisms were still the focus of inquiry. As Ferrone has indicated, 'well after Isaac Newton's fame had been recognized throughout Europe, scientists in the Veneto maintained an attitude of critical acceptance, if not open aversion'.[72] It seemed particularly important that Folkes first prove the truth of Newtonian optics in the city whose glass had been the 'standard against which other glass was to be compared' and second, demonstrate the inherent virtue of the English prisms and instrumentation.[73] Folkes' status as a protégé of Newton and his fluency in Italian and French were also helpful assets.

On 9 July 1733, Folkes received a letter from Abbè Conti who began, 'I beg you to bring these Italian manners to an end and to treat me as a friend, that is the first favour I am asking you'.[74] Conti related that his colleague, Giovan Bernardo Pisenti (d. 1742), having heard of the success of past demonstrations of Newtonian optics, requested 'to see demonstrated geometrically the order of the colours of the image'.[75] Pisenti was a Somasco cleric educated by the Jesuits who also studied with Eustachio Manfredi in Bologna, and he himself served as a personal tutor to Girolamo Ascanio Giustiniani; Folkes' diary shows he spent much of his time in Venice at the Guistiniani Palace with their family, so it is likely he met Pisenti there.[76] Pisenti was also the translator of George Berkeley's *An Essay towards a New Theory of Vision* (1709) into Italian, and dedicated his translation to Berkeley's friend Sir John Percival with whom he was also acquainted.[77] In scholar Antonella Barzazi's opinion, the initiative to publish Berkeley's work was probably born in the wake of the Newtonian optics controversy aroused in the Venetian world from the attacks of Rizzetti.[78] Berkeley refuted an account of distance vision which requires tacit geometrical calculations.

Malebranche and Descartes argued that distance was judged by the geometry of angles between the eyes and the perceived object, or via the angles of light ways that fell upon the eye.[79] One thus judges distances by the optic axes of the eyes which form an angle at the object; whether than angle is great or small, we judge if the object is far or near. Berkeley rejected those accounts and was quite negative about using Euclidean geometry of the visual world as a basis for visual perception. Berkeley argued against the classical scholars of optics by claiming that space is perceived by experience. 'Berkeley argues that the visual perception of distance is explained by the correlation of ideas of sight and touch. This associative approach does away with appeals to geometrical calculation while explaining monocular vision and the moon illusion, anomalies that had plagued the geometric account'.[80]

And visual perception of distance was also of great interest to Folkes. We recall his conversations with Algarotti about the friezes on Trajan's Column. Folkes also gave advice to Robert Smith FRS, Plumeian professor of astronomy at Cambridge University, in his *A Compleat System of Opticks in Four Books* (1738). The work was most 'famous book dealing with the subject' after Newton's own *Opticks* (1704).[81] Smith acknowledged Folkes for his 'curious remarks' on fallacies in vision, applying optics to explain phenomena such as the moon illusion, 'the sun's apparent distance, on the apparent figure of the sky, on the appararent curvity of the sides of long walks and ploughed lands, and the changes of curvity by the observer's motion'.[82]

Folkes had also spoken to Algarotti about Molyneux's problem in some depth.[83] The Irish natural philosopher William Molyneux (1656-1698) had asked John Locke that if a blind person could suddenly see, would he or she be able to recognise by sight an object's shape they previously only knew by touch. Presented with a globe and a cube, could she determine which was which just by looking? An affirmative answer meant that one believed in a rationalist and innate conception of space that was common to touch and sight. A negative answer indicated an empiricist view, that this was a relationship that we learn only through experience. Locke responded in his *Essay Concerning Human Understanding* that the formerly blind person would not be able to say with certainty 'which was the globe, which the cube . . . though he could unerringly name them by his touch'; the connection between the senses was learned.[84] Berkeley also offered a negative response, that a perception of distance was an 'act of judgment grounded on experience'.[85]

However, well before Diderot's famous essay, *Letter on the Blind* (1749), Folkes spoke to Algarotti about Molyneux's problem in reference to the case of Nicholas Saunderson (1682-1739) , the blind Lucasian professor at Cambridge and fervent Newtonian who lost his sight at twelve months from smallpox and who could purportedly judge the size of a room and his distance from the wall by sound. Sanderson made Newton's *Opticks* the basis of several lectures that he made at Cambridge, including some on the theory of vision. [86] Folkes was a close colleague of Saunderson and commissioned a painting of him. Saunderson affirmed he could have distinguished the objects with his sight restored, namely because he innately understood the mathematical definition of a sphere and cube and could identify them from the number of vertices they would present to him, as well as the shape of their cast shadows. This was an argument drawn out of Saunderson's *Treatise of Algebra*, in which he proved that the cube could be divided into six equal pyramids having their vertices at the centre of the cube and the six faces as their bases ; 'this is used for an elegant proof that a pyramid is one-third of a prism having the same base and height'.[87] Folkes as a Newtonian mathematician believed there was an innate geometrical quality to vision and was a very supportive subscriber to

Saunderson's *Treatise of Algebra,* putting money in for 8 books, ' 4 Royal and 4 common paper'.[88]

In order to create a demonstration to counter directly Rizetti 's disavowal of Newtonian optics and tacitly Berkeley's rejection of optics as a means of explaining vision, Conti indicated to Folkes that he made a figure 'to show visibly the different relative refrangibility,' showing 'the different perpendiculars with which are made the angles of the refraction of the exiting rays; these angles are as small as the others that are made with the internal perpendicular are large'[89] He then indicated to Folkes: 'You would do me a favour if you told me whether you imagine that in the same way. The obscurity of Mr Newton's book consists in failing to give the Theory of the refractions of the rays exiting a prism, that is what he had to start with in order to remove any doubt'.[90]

Conti was right. Newton had only conjectured in the *Opticks* about these issues rather sparsely; for instance, although Newton analogised about the the behaviour of light and matter, he really did not even assert the materiality of light. As Geoffrey Cantor has shown, later popularisers of Newton such as Desaguliers, Smith, and later Willem 's Gravesande (1688-1742) interpreted Newton's *Opticks* as if it were 'an appendix to the Principia,' in which forces were employed to explain all those phenomena in which light deviated from its natural rectilinear path'.[91] In this form of projectile optics, light was postulated to travel in a straight line with finite velocity, and refraction was explained by the influence of attractive forces. One could say for instance that refractive dispersion was due to a particulate model of light, the rays of bodies being of different sizes, the violet-making rays the smallest and the red-making ones the largest and heaviest. [92]

Conti then went on to mention the work of Paris lawyer and anglophile Nicolas Gauger, who in 1727 produced a long account defending Newtonian optics. In July 1727, Gauger had written Conti a twenty-page letter which was publicly printed addressing the danger of Rizzetti's attacks on the Newtonian system, with particular mention of the two-colour card experiment.[93] But five years later, Conti lamented to Folkes 'although Mr Gauger has given it quite amply . . . I don't know if his book is still being printed. It is certain that if the ray was not divided into several threads, so they made different angles, you would see the image differently from how we see it. I am waiting for your decisions on this'.[94] But such pedagogically clear, if sometimes superficial explanations by Newtonian pedagogues had not reached or convinced all Venetian ears; hence Conti's plea to Folkes for a proper diagram and clarification of refrangibility.

Shortly after this exchange, on 5 August 1733, Folkes met Rizetti himself, recording that Somascan father Giovanni Crivelli 'calld on me with Sigr. Rizetti author of a book which he gave me of the nature of light and colours against Sir Isaac Newton'.[95] Crivelli had written *Elementi de fisica* in 1731, a textbook which was a reinterpretation of recent discoveries in natural philosophy within an Aristotelian framework, considered to be a 'meaningful record of the attitude of a large segment of society in the Veneto with regard to Newton's works'.[96] While the first volume offered the most complete, if dispassionate explanation of Newtonian gravity that appeared in Italy (he for example rejects Newton's concept of a vacuum in space), the explanation of the Optics is equally neutral. Crivelli presented both Newtonian optics and the objections of Rizzetti as if he 'subtly desired to neutralise every scientific truth, hence bankrupting them and making them illusory'; he did the same thing with astonomy, noncommittally describing Copernican, Tychonic and Ptolemaic hypotheses with little comment. [97] Although from reading his manual one receives the impression that there was wide-ranging knowledge of Newtonian theory in the Veneto, one also 'clearly gets an image of local scholars rejecting what we might define any sort of Newtonian orthodoxy'.[98] In this light, Crivelli's visit with the antagonistic Rizetti in tow may be interpreted as an challenge to the Newtonian Folkes.

After Rizzetti's visit and a short period of illness (Folkes and his wife contracted a kind of heat rash termed *scotture*), Folkes met Conti on 23 July who had just come to town and upon hearing about Rizetti's visit to Folkes, proposed they act and publicly 'make some of Sir I[saac] Newton's experiments on fryday next'. Folkes subsequently indicated in his travel diary on Friday 27 August 1733: 'I was of the Palace Justinian in the morning, to have made some of Sir Isaac Newtons optical experiments but the Sun not stirring I could no more than get things in order for another day. The apparatus belonged to Abbe Conti who was home and he had brought some very good prisms from England'.[99] Clearly on the hunt for apparatus, Folkes had three days earlier indicated '. . . I was also at another person who is a practical Mathematician to see some instruments but nothing was particular what he had best were some English things'.[100]

On 28 August 1733, Folkes recorded triumphantly that 'I was again at the Guistiniani Palace and made most of the experiments of the first book of opticks with very good success and to the satisfaction of all that were here which were . . . men of the first people of Venice'. [101] Folkes was rewarded by Guistiniani with a present of 'spanish Chocolate'.[102] On 2 and 7 September, Folkes then indicated:

> I was again to prepare some of the Experiments of the Opticks at Sr. Guistinianis, our Experiments there have made a good deal of noise and many of the chief Nobility are very desirous to see some if them which I have promised to repeat on ~~Saturd~~ tuesday next though it is but in a gross manner I can make them want of a convenient apparatus. They are very satisfactory and carry demonstration to all that are capable of comprehending them . . . I made the Experiment I had intended at the Justinian Palace. I have now shewn all that are considerable in the Book of Opticks in the first book, and though my apparatus was none of the best I was sufficiently satisfyd with them and am told it is what was never done with any success here before, there were several of the Chief nobility and some others here present. and every one that has any sense seems thoroughly satisfyd as far as he understands. tho I was a little surprised at some mistakes Crivelli fell into and was pretty obstinate . . . a great while which showed me he is not so perfect master of the philosophy as I thought before [103]

Considering Crivelli's stance of presenting natural philosophy in an Aristotelian frameworks in his *Elementi,* his behaviour during the demonstration was not surprising. Rizetti also continued his anti-Newtonian campaign until the 1740s, with diminishing success.

Nonetheless, Folkes' performance had the required effect. When he left Venice, Folkes noted on 22 September that his experimental success showed that he had 'conversd with many of them [the Venetians] in a manner no English man almost has done before me'. In a letter from the physician Pietro Michelotti to John Machin, secretary of the Royal Society, Michelotti indeed indicated that Folkes had spent several days staying with him in Venice, indicating close familarity.[104] Several of the Newtonian adherents in Venice that Folkes indicated in his diary that he met in Venice, including Ludovico Riva (1698-1746), Professor of Astronomy at Padua were subsequently put forward for election in the Royal Society and became fellows.[105] English prisms and Newtonianism were vindicated.

Folkes continued his Newtonian campaign when he travelled to Florence, but he still worried about the quality of his equipment. In a ca. 1734 letter to Sir Philip Stanhope (who was on his own Grand Tour at the time) Folkes wrote:

> The morning promising very finely Dr Cocchi has just sent to me to desire if I could to try to make some to Sr Isaacs Prismatic Experiments at his house; at which both he and my self should esteem your Lordships company a great honour . . . I can make them but in a bungling sort of a manner by reason the tackle is very indifferent . . . [106]

Folkes' son, also named Martin, was sent to take Earl Stanhope to the house of Antonio Cocchi where the experiments were performed, a well-known physician and defender of Newton whom Folkes met in 1723.[107] It does not seem Folkes' comments about his equipment were the result of a false modesty, as the presentation was important; Folkes also invited 'Mr Rhodes', secretary to Charles Fane, the British minister in Tuscany and 'Mr Mann' or Sir Horace Mann, 1st Baronet

(1706-1786), the long-standing British resident in Florence. (Folkes and Mann had been at Clare College, Cambridge together where they initially met).[108]

The presentation was much less public, probably because outside the safety of the Venetian Republic, the Inquisition was active and dangerous; it placed Locke's *Essay on Human Understanding* on the Index in 1734. Algarotti's *Newton for Ladies* had also been condemned as Masonic and the Inquisition denounced Newtonian Antonio Conti whom Folkes met in Venice. As Casini has reminded us, we must remember that even 'Open acceptance of the law of gravitation was hindered by the fact that the Catholic Church still banned belief in the motion of the Earth,' and refutation of Newtonian colour theory in itself was an implicit opposition to a moving earth.[109] Although we do not know the specific outcome, we do know that upon Folkes' return, when he informed Cocchi of his intention of visiting Italy again, Cocchi noted he was 'overjoy'd', offered to make domestic arrangments, reminded Folkes to bring a telescope and microscope from England, and said 'I should very proud if you would habilitate my Terrace with Some of your Astronomical Observations . . . and other physical experiments which would be very much admired here'.[110] Folkes in his correspondence in subsequent years also successfully cultivated Stanhope as a fellow mathematician working on problems of series and probability, so his demonstration was probably convincing.[111] Even, when Folkes was in Venice, he recorded in his diary that he was questioned by the patrician, member of the Sarotti Academy and instrument-collector Cristino Martinelli about "a scheme from the Resident of the Popes Lottery which he desired me to tell him the disadvantage of. It is rather a game than a Lottery but . . . there is 26 percent in the best cases against the player and in the others 40 and 70 per Cent yet are all the people at Rome we are told mad after it'. [112]

V. Folkes, Venice and Celsius

Not only did Folkes establish the primacy of Newtonian optics as well as awareness of standards of professional equipment during his journey, but he had another encounter that also would contribute to the primacy of Newtonianism and English instruments. On 18 September 1734 when he was in Venice, Folkes recorded in his diary a meeting with '2 Swedish Gentlemen. Mr Schelsius Prof. of Astronomy at Upsal, and a young Gentleman who travels at the Kings expense to study Architecture. they are very well bred understanding men and make a handsome figure. Mr Schelsius presented me with a book he has published on the Aurora borealis'[113]

Schlesius was of course Anders Celsius, his work on the aurora borealis, the *Nova Methodus distantiam solis a terra determinandi* (*New Method for Determining the Distance from the Earth to the Sun,* which was first read to the Royal Society on 8 April 1736, and printed in *Philosophical Transactions*; Celsius was also one of the first to suggest a connection between aurorae and changes in the Earth's magnetic fields, and he would also make observations of sightings in England.[114] Folkes would have been very interested to talk to Celsius as Folkes himself made some of the earliest sightings of aurorae from King's Lynn, Norfolk, not too far from his country seat Hillington Hall; 'At the end of the Maunder minimum (1715), centres of population such as London, Plymouth and King's Lynn were ideally placed to observe aurorae' in the early part of the century.[115] (Figure five).

Folkes then noted the next day,

> I had invited the 2 Swedish Gentlemen, and I passd the day with them, they gave me several curious accounts both of their own country and their observations in Germany, they also gave me the measure and weights of their own country in which they have been both been very curious, and I am so well satisfied of their acquaintance that tis a satisfaction they are going the same way and will be of service to me observing the same things as my self.

Folkes indeed would be involved with the scientific work of Celsius. When he met Folkes, Celsius had just been to Paris on a grand tour of European observatories and had met Algarotti in Italy.[116] And, when they arrived in Paris together at the end of the summer of 1734, Algarotti introduced Celsius to Maupertuis and his colleagues. Here the idea for the Lapland Expedition to measure the true shape of the earth was born and given a royal warrant five months later to find and provision a ship to take the travellers to Stockholm.[117] The expedition would help settle a dispute that Maupertuis had with French cartographer Jacques Cassini over whether the earth was prolate (longer along its axis from North to South), or oblate (longer along its diameter at the equator). Cassini believed that the earth was prolate like a lemon. Maupertuis, like Newton, proved it was oblate. The expedition to Lapland measured an arc of the meridian from Tornea to Kittis, lasting from July 1736- to March 1737.

The scientific party consisted of Maupertuis, Clairaut, Camus, Le Monnier, the Abbè Outhier, and of course, Celsius who would measure the meridean arc near the North pole. Another expedition organised by the French to South America (1735-43) near the equator to measure the meridian arc would eventually demonstrate that Newton was correct about the earth's shape.

The travellers would use a fixed-length pendulum clock, a theodolite and a zenith sector that could the measure the shape of the Earth in tropical, temperate and Arctic latitudes. The first method depended on the comparison of the periods of pendulum clocks at different latitudes, eliminating a temperature-dependent variable (clocks went a second a day slower for every two divisions of temperature-rise on the thermometer).[118] Newton in his *Principia* noted that astronomers found pendulum clocks moved slower near the equator to 'support his theory that the increase in weight in passing from the equator to the poles is as the square of the sine of the latitude'.[119] Other than comparing the period of pendulum clocks, one could use a theolodite and surveyors' rods to measure out a large distance (60-70 miles) and using a zenith sector, measure the degree of arc that distance covered, a more direct means of measuring the Earth's surface.

As Celsius was on his way to London, Maupertuis was able to get him to 'agree to acquire several instruments by George Graham'. [120] Maupertuis desired a model of Graham's portable zenith sector, for observing the transits of fixed stars that allowed for the calculations of latitude; it was this sector with which in 1728, James Bradley had also discovered the aberration of starlight measuring Gamma Draconis. Gamma Draconis has a high northerly position of 51.5 degrees north of the celestial equator which takes it through the zenith, as seen from London. The atmosphere of the earth causes refraction of light which makes stars appear higher than they really are, but using a star that passes directly overhead like Draconis solves such problems. It was thus used to measure stellar parallax. However, in his work with Samuel Molyneux, Bradley detected a small apparent motion of Draconis not due to parallax (the annual timetable for Draco's parallax was different), but instead resulting from the finite speed of light and the orbital motion of the earth.[121]

Maupertuis and Folkes had become friends in 1728 during the Frenchman's own Grand Tour. Folkes was a chief patron of Graham, having nominated him to the fellowship of the Royal Society, on 8 December 1720.[122] Folkes also appended to his travel account book a list of prices for Graham's watches, often securing them as gifts for his scientific correspondents (Figure six), and they were close friends, recorded in John Byrom's diary as often in various taverns such as the Sun after Royal Society meetings.[123] When Celsius was in London in 1735, he observed a lunar eclipse from Graham's house using some of Bradley's new telescopes.

Celsius was also invited to attend meetings at both the Royal Society where he discussed aurora borealis he had seen in Sweden, and to meetings of the Society of Antiquaries, showing his deep connections between the two organisations. For instance, on 13 November 1735, Celsius presented at Antiquaries 'a draught of two kinds of Runic Characters, nemly the Vulgar and Helsingic together with some remarks on them,' runes on the Malsta stone in Rogsta, Há/lsingland, Sweden[124] (Figure seven). This paper on runes was published by the *Philosophical Transactions of the Royal Society* in 1737 with an attempt to date the stone by examining the genealogy of the family it described and applying rationale used to date events in Newton's Biblical *Chronology of Ancient Kingdoms*.[125] In Folkes' presence, Celsius attended the Society of Antiquaries again on 9 March 1735/6 and on 18 March 1735/6, where Celsius 'delivered an account of an ancient Albaster vase found in Sweden . . .at the Antiquarian College of Stockholm . . . which was read, likeways presented the Society with a wooden print of the said vase'.[126] As Celsius received his instruments, Folkes' friends received an antiquarian present, part of a time-honoured exchange of gifts characteristic of the Republic of letters, the ties between the Royal Society, Antiquaries, and Newtonianism strengthened.

Folkes also gave advice to Celsius when he was on expedition. In December 1736, Celsius wrote Folkes stating he was 'one thousand times grateful for the courtesies you did for me during my stay in London'. He continued 'We have observed the difference of latitude between Torne and Pello with Mr Graham's instrument. The observations were made in September in Pello, having not found any suitable star other than the Dragon. We then observed it in October here in Torne'.[127]

In other words, Graham's sector measured the angle at which a particular star, in this case Draco or the Dragon near the zenith passed the meridian (star's altitude), and then the expedition moved to another mountaintop at Pello and repeated the same measurement. The difference between the star's altitudes was due to their having travelled south (changing latitude). As Sorrenson stated, they then had to 'establish the distance between the two mountains by surveying a series of triangles and measuring several of the baselines with wooden poles'.[128] Once they had the distance between the two points and the difference in angles, they 'calculated that the length of one degree of arc near the polar circle was longer than at Paris', and concluded the earth was oblate, vindicating Newton. There was one problem. As Celsius continued,

> and since this star is close to the ecliptic pole, the declination changed in the meantime.[129] That is why I beg you, Sir, to send me the rule according to which one calculates the change of declination from one month to the next. We don't have here in memory what Mr Bradley gave about this in the Philosophical Transactions. And I would like to know as well if Mr Bradley has established anything yet about the irregularities that he found in the stars located around . . . the equinoxes, since our star of the Dragon is very close to that location'.[130]

Although Folkes' reply is not extant, apparently Bradley's calculations regarding stellar aberration were communicated, as Maupertuis in his publication about the shape of the earth incorporated Bradley's work, using its precision as an example of new standards of astronomical practice only possible with the best instruments. Maupertuis stated, 'Mr Bradley very kindly shared with me his latest discoveries on the motions of the stars, and communicated to me the necessary correction to the arcs we observed'. As Terrall has shown, this precision of English instruments was used as a weapon against Cassini's claims for a prolate earth. When Maupertuis's book finally did appear about the shape of the Earth (*Le figure de terre*) in 1738, he wrote Folkes

> It is my turn now to thank you after the obliging[131] letter that you did me the honour of writing me. The most flattering reward I could get from a work[132]

> that has faced many difficulties and risks[133] is to see it has the approval of an excellent judge such as you. Such approval makes me well strong against the injustice of those who were not pleased by our measures, and their conspiracy. It is true that it is something singular and that it will be difficult to understand that the Astronomer [Cassini][134] who has the highest reputation in France was mistaken 5 different times in the measures he undertook and that he has always found that the Earth is elongated in 1701, 1713, 1714, 1733, and 1734. It seems that if there had been chance only, it should have led him better. But I am nevertheless convinced that the Earth is flattened[135]

He then continued, 'It has been very sweet to me, Sir, to find myself still in the honour of your memory after such a long time . . . I [send you my book] to you as one of the first scholars in Europe'.[136]

Folkes' interest in stellar parallax, aberration and the modification of the constellations over time were demonstrated by a model he had made of the globe which he he demonstrated to the Society of Antiquaries on 7 July 1736 when he returned to England. It was a Plaster of Paris copy of the Farnese Globe, the oldest surviving depiction of this set of Western constellations; Folkes recorded in his travel diary 'Diam of the Farnesian Globe. 2f. 5 inch. 1/10 English Measure,' likely indicating he saw and measured in it Rome.[137] The globe puts the celestial figures against a grid of circles comprising the celestial equator, the colures, the ecliptic, the tropics and the Arctic and Antarctic Circles. This allows for the constellations to be positioned accurately. It was noted at the Antiquaries meeting that 'the colure of this globe passes by those parts of the asterism by which it is said to have past in the days of Hipparchus but the intersection of the Equator and Eccliptic is not at the Colure'. This was a reference to how the 26000 year precession or axial wobble on the earth that Newton discovered shifts the positions of the celestial circles over time, so the observed positions on the Farnese Atlas can be traced to a particular date in celestial time. 'The declination of the Arctic and Antarctic Circles will correspond to a particular latitude for the observer whose observations were adopted by the sculptor . . . a detailed analysis of the globe will reveal the latitude and epoch for the observations incorporated in the globe'.[138] The Antiquaries entry noted that its age could be determined to be during the time of the Antonine emperors.

Geodesy also continued to be a preoocupation of Folkes when he eventually realised his goal of being appointed president of the Royal Society, and then the Society of Antiquaries nearly a decade after his initial Italian visit. Folkes became one of the strongest supporters in the Royal Society of John Harrison and his longitude clock, convinced of Harrison's 'strong impulses of a natural and uncommon genius'.[139] And, in 1745, Folkes intervened when Antonio de Ulloa, who went on the Peruvian expedition to measure the meridian arc near the equator, was captured by the English as he sailed home when the expedition was completed, as at the time Spain and Britain were at war. Ulloa's calculations were confiscated and he languished in prison in Portsmouth, until he was granted leave to travel to London at the request of the Royal Society. Folkes mediated, and on 8 May 1746, used his knowledge of Spanish to summarise the details of Ulloa's expedition in 33 pages of manuscript which he presented to the Society later that month[140]; Folkes reproduced Ulloa's triangulation and its results, which confirmed Newton's predictions of the shape of the earth (Figure eight). Folkes noted if the "proportion resulting of the Axis of the Earth" from the Maupertuis expedition "to its Equatorial Diameter" of Ulloa's measurements "will be nearly 223 to 222 surprizingly near to that given from calculation only, by the great Sir Isaac Newton, of 229 to 230, in the last edition of his Principia".[141] Rather ironically, Folkes noted that 'Dr Bradley's aberration of the fixed stars from the successive propagation of light is not brought into the account'.

Folkes also recorded their barometric observations made in the Andes, as well as the heights of the mountains, and included Ulloa's ethnographic information about the Peruvians and descriptions of the flora and fauna, including the deadly coral snake. Folkes noted that he did not want the material to be made public, as Ulloa intended to publish a book about his exploits when he returned to Spain (accomplished in 1748 with twelve subsequent editions in French, English, Dutch and German); Folkes was 'very unwilling anyway to diminished the pleasure the publick will without dobut receive from the communication of an account so exact and I am satified so faithfull'.[142] Apart from the evident esteem Ulloa and Folkes developed for each other, vindication of Newtonianism was all the more powerful from an outside entity. Ulloa was made an FRS, his papers were returned to him by order of the Lords Commissioners of the Admiralty and it was arranged that he would get travel to Portugal which was a neutal in the war, so Ulloa could get back to Spain.

Conclusion

Whether in defence of Newtonian optics, or in support of Maupertuis's flattened earth, Folkes' Travel Diary reveals that he made a case for the primacy and precision of English instruments and measurement in natural philosophy. This precision of measurement would also extend to antiquarian questions in which conversion factors were sought between the English and Roman foot to comprehend Roman architectural engineering. The diary also represented the manifestation of Folkes as an international broker of Newtonianism. Folkes' diary more importantly demonstrates that the impression among scholars that the eighteenth-century Royal Society was moribund has been mistaken. Sorrenson has noted this unedifying impression stemmed from the belief that the Royal Society failed to match the standard that Newton had set in the *Principia*; this perception also stemmed from negative opinions voiced by the Society's critics such as John Hill and from the popularity of Babbage's Reflection on the *Decline of Science in England* (1830).[143] It seems however the Royal Society in the eighteeenth century in fact manifested considerable strengths in technological innovation, setting new standards in experimental precision.

And as Folkes' journal shows, during his journey to Italy, and shortly after he returned, he was in the very centre of an intellectual network, brokering and furthering these aims. His diary also represented, as Feingold reminds us, the 'confabulatory life' of the scholar, the diffusion of scientific knowledge through informal discussion with colleagues.[144] Henry Guerlac has commented that 'as historians of ideas we are happiest when we can navigate from the firm ground of one document to the next, and we are prone to forget how great a part travel, gossip and word-of-mouth have played in the diffusion of scientific knowledge, indeed of knowledge of all sorts'.[145] In this manner, the journal of Folkes' scientific peregrination demonstrates to us the parameters of Georgian antiquarian science and Newtonianism.

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[1] Martin Folkes, 'Journey from Venice to Rome', MS Eng. misc. c. 444. Bodleian Library; Martin Folkes Esq. *Memoranda in case he should go abroad again, respecting his Estates, foreighn money & Places*, NRS 20658, Norwich Record Office, f. 18r. The motto also appears on the mezzotint copy of the 1718 portait of Folkes by Jonathan Richardson. See National Portait Gallery, NPG D36990. The exact translation of this phrase is difficult, because the exact phrase would not be used with the pronoun "qui" alone in French, instead beginning with "ce qui". The only modern French phrase that gets as close as possible to this fatalistic meaning would be "Ce qui doit arriver arrivera", which translates "what needs to happen will happen". Used with the verb "être"/to be instead of "arriver"/to happen, an older form of this phrase would be "Ce qui doit être sera" (= what must be, will be). This rendition is very close to Folkes' phrase, where the "ce" in "ce qui" might have been forgotten by the author, in which case it could become "Ce qui sera sera" (= whatever will be, will be). Folkes, however, was a near native speaker of French. See also Lee Hartman, "Que sera sera": The English Roots of a Pseudo-Spanish Proverb ," *Proverbium*, 30 (2013): 51-104. My thanks to Charlotte Marique for this explanation.

[2] Harcourt Brown, 'Madam Geoffrin and Martin Folkes: Six New Letters,' *Modern Language Quarterly* 1,2 (1940), pp. 215-241.

[3] *The Family Memoirs of the Reverend William Stukeley, M.D., and the Antiquarian and other Correspondence,* Publications of the Surtees Society v. 73., Durham, London, and Edinburgh: The Surtees Society, 1882, vol 1, p. 99.

[4] Martin Folkes Esq. *Memoranda in case he should go abroad again,* op. cit. (1), f. 5v. His account book indicates each stage of his journey and how many weeks he stayed in each place.

[5] John Ingamells, *A Dictionary of British and Irish Travellers in Italy, 1701-1800: Compiled from the Brinsley Ford Archive*, New Haven: Yale University Press, 1997, p. 365; William Eisler, "The construction of the image of Martin Folkes (1690-1754) Art, science and Masonic sociability in the age of the Grand Tour," *The Medal* 58 (Spring 2011): 4-29.

[6] David Haycock, *William Stukeley: Science, Religion, and Archaeology in Eighteenth-Century England*, Martlesham: Boydell and Brewer, 2002, p. 52; Journal Book Original (1726-31), JBO/14, f. 147, Royal Society Library, London. As Haycock indicates, 'in spite of the general conviviality of its meetings, ... [the Royal Society] was divided into two factions, broadly defined as the mathematical and the natural historical parties. Their two chief representatives after Newton's death in 1727 — Folkes and Sloane respectively — would come head to head in a heated contest over who should succeed him as President'. (p 52).

[7] *Stukeley*, op. cit. (3), vol. 1, p. 14.

[8] John Byrom, *The private journal and literary remains of John Byrom* (Manchester: Chetham society, 1854-7), vol. 1, part 1, pp. 209-10.

[9] The Correspondence of Henry Baker, Volume 1, ff. 218-19. John Rylands Library, University of Manchester.

[10] Marc Ratcliff, *The Quest for the Invisible: Microscopy in the Enlightenment*, Aldershot: Ashgate, 2009.
[11] Stukeley MS Eng. misc. e. 126 f. 83. Bodleian Library, Oxford.
[12] George Kolbe, "Godfather to All Monkeys: Martin Folkes and his 1756 Library Sale," *Asylum* (April-June 2014), p. 41. Stukeley also may have been envious of the social position of Folkes, his man and neighbor who indirectly provided him with a living in London as vicar of St. Georges in Queens Square via his uncle William Wake, an antiquarian, numisticist, and as mentioned, Archbishop of Canterbury.
[13] Charles Weld, *A history of the Royal Society, with memoirs of the presidents*, London: J.W. Parker, 1848, 1: 480.
[14] Charles Lennox to Martin Folkes, 31 July 1733, Royal Society MS/865/12.
[15] Charles Lennox to Martin Folkes, 31 July 1733, Royal Society MS/865/12. The letter itself to Pamphili is Royal Society MS/865/13. For the Arcadia and Pamphili's role as host, see Elisabetta Graziosi, 'Women and Academies in Eighteenth-Century Italy', *Italy's Eighteenth Century: Gender and Culture in the Age of the Grand Tour*, ed. Paula Findlen, Wendy Wassyng Roworth, Catherine M. Siena, Stanford: Stanford University Press, 2009, pp. 103-119.
[16] For the letter of introduction, see *The Correspondence of James Jurin (1684-1750), Physician and Secretary to the Royal Society*, ed Andrea Rusnock, Amsterdam: Rodolpi, 1996, p. 391.
[17] Folkes, 'Journey from Venice to Rome', op. cit. (1), f. 25r.
[18] Edward Chaney, *The Evolution of the Grand Tour: Anglo-Italian Cultural Relations since the Renaissance,* London and Portland: Frank Cass, 1998, p. 328.
[19] Mark Greengrass, Daisy Hildyard, Christopher D. Preston, and Paul J. Smith, 'Science on the Move: Francis Willughby's Expeditions,' in Tim Birkhead (ed.), *Virtuoso by Nature: The Scientific World of Francis Willughby FRS* (1635-1672) Leiden: Brill, 2016, pp. 142-226, on p. 145.
[20] Zur Shalev, 'The Travel Notebooks of John Greaves', in Alistair Hamilton, Maurits H. Van Den Boogert, and Bart Westerweel (eds.), The Republic of Letters and the Levant (Leiden: Brill, 2005), pp. 77-103, on p. 85. See *Centres of Medical Excellence? Medical Travel and Education in Europe, 1500-1789*, (eds.), Ole Peter Grell, Andrew Cunningham, Aldershot: Ashgate, 2010.
[21] Greengrass, Hildyard, Preston, and Smith, op. cit. (19), p. 152.
[22] Martin Lister, *A Journey to Paris in the Year 1698*, (ed.) Raymond Phineas Stearns, Urbana, Chicago, and London: University of Illinois Press, 1967, p. 2.
[23] Lister, op. cit. (22), p. 3.
[24] David Boyd Haycock, *William Stukeley: Science, Religion and Archaeology in Eighteenth-Century England,* The Newton Project, http://www.newtonproject.ox.ac.uk/view/texts/normalized/OTHE00017; Betty Jo Teeter Dobbs and Margaret C. Jacob *Newton and the Culture of Newtonianism,* Amherst: Humanity Books, 1995, p. 102.
[25] Garry W. Trompf, 'On Newtonian History', in *The Uses of Antiquity: The Scientific Revolution and the Classical Tradition*, ed. Stephen Gaukroger, New York: Springer, 2013, 213-249, on pp. 234-235
[26] William Eisler, "The construction of the image of Martin Folkes', *The Medal* 58 (2011), pp. 1-29, on p. 5; See also Andreas Önnerfos, 'The Earliest Account of Swedish Freemasonry?: Relation Apologique (1738) revisited', *Ars Quatuor Coronatorum* 127 (2014), pp. 1-34.
[27] Paul Elliot and Stephen Daniels, "The 'school of true, useful and universal science? Free masonry, natural philosophy and scientific culture in eighteenth-century England', *British Journal for the History of Science* 39,2 (June 2006), pp. 2017-229, on p. 213.

[28] Ric Berman, *The Foundations of Modern Freemasonry (*Brighton: Sussex University Press, 2012), p. 108.
[29] Charles Lennox to Martin Folkes, 27 June 1725, Royal Society MS/865/1.
[30] Folkes, 'Journey from Venice to Rome', op. cit. (1), f. 24r.
[31] Folkes, 'Journey from Venice to Rome', op. cit. (1), f. 24r.
[32] James E, Force, *William Whiston: Honest Newtonian* (Cambridge: Cambridge University Press, 2002), p. 136.
[33] Byrom, op. cit. (8), vol 2, part one, p. 27, entry for 30 March 1736.
[34] Byrom, op. cit. (8), vol 1, part 1, p. 180, entry for 14 December 1725.
[35] The specification of the cubit was ambiguous: 'in the man's hand a measuring reed six cubits long, of a cubit and a handbreadth each: so he measured the thickness of the building, one reed; and the height, one reed' (Ezekiel 40:5). The Hebrew text reads: 'a measuring reed, six cubits by the cubit and a handbreadth'. ' It was unclear whether the six cubits marked on the reed were particularly large, each outsizing the regular cubit by a handbreadth; or whether the reed as a whole measured six cubits and one extra handbreadth. This was to become one of the key problems of much Temple scholarship'. See Jetze Touber, 'Applying the right Measure: Architecture and Philology in Biblical Schoalrship in the Dutch Early Enlightenment', *The Historical Journal* 58, 4 (2015), pp. 959-985, on p. 964.
[36] Elliot and Daniels, op. cit. (27), p. 220.
[37] Haycock, op. cit (24).
[38] Folkes, 'Journey from Venice to Rome' op. cit. (1), f. 20r.
[39] Folkes referred to Francesco Sansovino, *Venetia, città nobilissima, et singolare : descritta in XIIII. Libri*, Venetia, 1663, p. 365.
[40] Folkes, 'Journey from Venice to Rome' op. cit. (1), f. 20r.
[41] Folkes, 'Journey from Venice to Rome' op. cit. (1), f. 26r. Folkes also routinely complained in his journal that finding exact calculations for traditional Venetian measures was difficult.
[42] Fiona Kisby, *Music and Musicians in Renaisance Cities and Towns,* Cambridge: Cambridge University Press, 2005, p. 31; See also Deborah Howard, *Jacopo Sansovino: Architecture and Patronage in Renaissance Venice*, New Haven and London: Yale University Press, 1975.
[43] For when two palms are taken from the cubit, there is left a foot of four palms, and the palm has four fingers. So it comes that the foot has sixteen fingers, and the bronze denarius as many asses. [*E cubito cum dempti sunt palmi dueo, relinquitur pes quattuor palmorum, palmus autem habet quatuor digitos. Ita efficitur uti pes habeat XVI digitos, et totidem asses aereos denarius*]. Virtruvius, *On Architecture*, in two volumes (trans.), Frank Granger, London: William Heinemann, Ltd, vol. 1, Book III, c. I, pp. 164-165.
[44] John Greaves, *A Discourse of the Romane Foot, and Denarius: from when, as from two principles, the Measures, and Weights, used by the Ancients, may be deduced,* London: M.F, 1647, p. 20.
[45] Greaves, op. cit. (44), pp. 20 and 23.
[46] Martin Folkes, 'An Account of the Standard Measures Preserved in the Capitol at Rome', *Philosophical Transactions* 39 (1735/6), pp. 262-66, on pp. 262-263.
[47] Folkes, op. cit. (46), p. 266. Raphaelis Fabretti, *De Columna Traiani,* Rome: Nicolai Angeli Tinassij, 1693.
[48] G. Boni, "Trajan's Column." *Proceedings of the British Academy* 3: 1-6 (1907a), p. 3.
[49] David Soren and Noelle Soren, *A Roman Villa and a Late Roman Infant Cemetary: Excavation at Poggio Gramignona*, Rome: L' Erma di Bretscheider, 1999, p. 182.
[50] Soren and Soren, op. cit. (47), p. 189.
[51] Francesco Algarotti to Jean Paolucci, 20 May 1763, in *Oeuvres de comte Algarotti traduit de l'italien* (Berlin: G.J. Decker, 1772), vol. VI, pp. 208-214.

[52] Massimo Mazzotti, 'Newton for Ladies: gentility, gender and radical culture', *British Journal for the History of Science* (June 2004), pp. 119-146, on p. 143.
[53] Francesco Algarotti, 'Dialoghi Sopra l'Ottica Neutoniana', in *Opere Varie Del Conte Francesco Algarotti*, Venice: Giambiatista Pasquali, 1757, vol. 1, p. 317.
[54] Martin Folkes, "On the Trajan and Antonine Pillars at Rome," Read 5 Feburary 1735-6, *Archaeologia* 1, 2 (January 1779), pp. 117-21, on p. 120. Contrary to Folkes, the bas relief figures actually do slightly increase from 60 to 80 cm in height.
[55] Charles Perrault, *Paralelle Des Anciens et Les Modernes En Ce Qui Regarde L'Eloquence* ,(Paris: J. B. Coignard, 1688-97), vol. 1, p. 190 and pp. 193-4: 'Il n'y a aucune perspective ny aucune degradation . . .Les figures sont presque toutes sur a mesme ligne; s'il y en a quelques-unes sur le dierriere, ells sont aussi grandes et marquees que celles qui sont sur le devant; en sorte qu'elles semblent este montées sur des Gradins pour se faire voir les unes au dessus des autres'. See also Larry F. Norman, *The Shock of the Ancient: Literature and History in Early Modern France,* Chicago: University of Chicago, 2011, p. 235, note 10 and Anne Betty Weinshanker, *Falconet, His Writings and His Friend Diderot,* Geneva: Librairie Droz, 1966, p. 89.
[56] Tina Bawden, Dominik Bonatz, Nikolaus Dietrich, Johanna Fabricius, Karin Gludovatz, Susanne Muth. Thomas Poiss and Daniel A. Werning, 'Early Visual Cultures and Panofsky's Perspektive als 'symoblische Form', *eTopoi: Journal for Ancient Studies* 6 (2016), pp. 525-570, on p. 551.
[57] Journal Book Original 14 (1726-31), JBO 14, 19 January 1726, p. 37, Royal Society Library, London; Harold Samuel Stone, *Vico's Cultural History: The Production and Transmission of Ideas in Naples,* Leiden: Brill, 1997, pp. 278-80.
[58] Journal Book Original 14 (1726-31), JBO 14, 21 March 1727, p. 199, Royal Society Library, London.
[59] Paolo Casini, 'The reception of Newton's Opticks in Italy,' in J.V. Field and Frank A.J.L. James (eds.), *Renaissance and Revolution: Humanists, Scholars, Craftsmen and Natural Philosophers in Early Modern Europe*, Cambridge: Cambridge University Press, 1997, pp. 215-229, on p. 217.
[60] Folkes, 'Journey from Venice to Rome' op. cit. (1), f. 37r.
[61] Casini, op. cit. (59), p. 217.
[62] 'Folkes to Stirling, 10 June 1747', in C. Tweedie, *James Stirling: a Sketch of this Life and Works along with this Scientific Correspondence,* Oxford: Oxford University Press, 1922, p. 192.
[63] Journal Book Original 14 (1726-31), JBO/14, 21 March 1727, 10 April 1728, 27 June 1728, and 31 October 1728, pp. 191, p. 235, pp. 249-250, Royal Society Library, London.
[64] Sir Isaac Newton, *The Correspondence of Isaac Newton*, 7 vols, H.W. Turnbull, J.F. Scott, A.R. Hall and L. Tilling (eds.), Cambridge: Cambridge Unviersity Press, 1959-1977, Vol. 1, p. 96.
[65] Aberration occurs as lenses have a different refractive index for each different wavelength of light.
[66] A. Rupert Hall, *All Was Light: An introduction to Newton's Opticks* (Oxford: Clarendon Press, 1993), p. 96.
[67] Hall, op. cit (66), pp. 96-97. See also Kirsten Walsh, 'Newton's Epistemic Triad', PhD Dissertation, University of Otago, 2014, p. 104.
[68] Sir Isaac Newton, *Opticks*, New York: Dover, 1952, p. 26; Hall, op. cit (66), p. 97.
[69] J.T. Desaguliers, 'Optical Experiments made in the beginning of August 1728, before the President and Several Members of the Royal Society, and Other Gentlemen of Several Nations, upon Occasion of Signior Rizzetti's Opticks . . .', *Philosophical Transactions* 35 (1727-8), pp. 596-629, on pp. 598-99.

[70] Simon Schaffer, 'Glass Works: Newton's Prisms and the Uses of Experiment', in David Gooding, Trevor Pinch, and Simon Schaffer (eds.), *The Uses of Experiment: Studies in the Natural Sciences*, Cambridge: Cambridge University Press, 1989, pp. 67-104, *passim*; Casini, op. cit. (57), p. 222.
[71] To be fair, Schaffer does acknowledge the controversy over the nature of Newton's genius and his posthumous legacy in his 'Fontanelle's Newton and the Uses of Genius,' *L'Esprit Createur* 55, 2 (Summer 2015), pp. 48-61.
[72] Vincenzo Ferrone, *Intellectual Roots of the Italian Enlightenment* (Atlantic Highlands, New Jersey: Humanities Press, 1995), p. 95.
[73] Schaffer, op. cit. (70), pp. 72, 99.
[74] Letter from Antonio Conti to Martin Folkes, 9 July 1733, MS 790/28, Correspondence of Martin Folkes, Royal Society Library, London
[75] T. E. Jessop, *A Bibliography of George Berkeley,* 2d. ed, International Archives of the History of Ideas, vol. 66, New York, Springer, 1973, p. 9. Pisenti's was the first translation of Berkeley's work on vision into any language: George Berkeley, *Saggio d'una nuova teoria sopra la visione ... ed un discorso preliminare al Trattato della cognizione* (tr. Giovanni Pisenti), Venice: Francesco Storti, 1732. Pisenti also translated Berkeley's work on cognition.
[76] Don Gasparo Leonarducci, *La Provvidenza, cantica seconda,* Venice: dalla tipograia di alvisopoli, 1828, p. 5. This is a history of the Somasco congregation.
[77] Giovanni Antonio Moschini, *Della letteratura veneziana del secolo XVIII fino a' nostri giorni,* Venice: Dalla Stamperia Palese, 1806, vol. 1, p. 169.
[78] Casini, op. cit. (59), p. 217; Antonella Barzazi, *Gli Affanni dell'erudizione: studi e organizzazione culturale degli ordini religiosi a Venezia tra Sei e Settecento*, Venice: Istituto Veneto di scienze, lettere ed arti, 2004, p. 181.
[79] Daniel E. Flage, 'George Berkeley (1685-1753)', *Internet Encyclopedia of Philosophy*, http://www.iep.utm.edu/berkeley [Accessed 3 December 2016]. This is a peer reviewed, and scholarly encyclopedia.
[80] Flage, op. cit (79). The moon illusion is that the moon when just above the horizon appears much larger than when it is overhead.
[81] Geoffrey Cantor, *Optics after Newton: Theories of LIght in Britain and Ireland, 1704-1840,* Manchester: Manchester University Press, 1983, p. 19.
[82] John Nichols, *Literary Anecdotes of the Eighteenth Century*, London: Nichols, Son and Bentley, 1812, p. 538.
[83] Mazzotti, op.cit. (52), p. 143.
[84] *Dialoghi Sopra l'Ottica Neutoniana* in *Opere Varie Del Conte Francesco Algarotti* (Venice: Giambiatista Pasquali, 1757), vol. 1, p. 317.
[85] George Berkeley, *Essay towards a New Theory of Vision*, in the *Works of George Berkeley,* ed. A.A. Luce and T.E. Jessop (London, 1948), section 41, p. 186; John W Davis, 'The Molyneux Problem', *Journal of the History of Ideas* 21, 3 (July-September 1960), pp. 392-408, on p. 396
[86] Nicholas Saunderson, *The Elements of Algebra, in Ten Books,* Volume 1, Cambridge: Cambridge University Press, 1741, vol. 1, p. vi.
[87] Denis Diderot, "Letter on the Blind," in M.J. Morgan, *Molyneux's Question,* Cambridge: Cambridge University Press, 1977, p. 33.
[88] Saunderson, "Index of Subscribers, " op.cit (84).
[89] Conti, op. cit. (74), MS 790/28.
[90] Conti, op. cit. (74), MS 790/28.
[91] Cantor, op. cit, (81), p. 26.
[92] Cantor, op. cit, (81), p. 31.

[93] Nicolas Gauger, "Lettre à M. l'abbé Conti, juillet 1727," *Continuation des Mémoires de Littérature et d'Histoire*, 5, pt. 1 (March 1728),10-51.
[94] Conti, op. cit. (74), MS 790/28.
[95] Folkes, 'Journey from Venice to Rome' op. cit. (1), f. 30r
[96] Ferrone, op. cit (72), pp. 98-99.
[97] Ferrone, op. cit (72), p. 99.
[98] Ferrone, op. cit (72), p. 99.
[99] Folkes, 'Journey from Venice to Rome' op. cit. (1), f. 39r.
[100] Folkes, 'Journey from Venice to Rome' op. cit. (1), f. 39r.
[101] Folkes, 'Journey from Venice to Rome' op. cit. (1), f. 39r.
[102] Folkes, 'Journey from Venice to Rome' op. cit. (1), f. 39r.
[103] Folkes, 'Journey from Venice to Rome' op. cit. (1), ff 39r-40r.
[104] Pietro Antonio Michelotti to John Machin, 6 October 1733, EL/M3/32, Royal Society Library. Michelotti noted, 'I have often understood from that most noble and intelligent gentleman Mr. Martin Folkes, a man furnished with every kind of virtue, who is still staying with me, that you have the most clear-sighted opinions in respect of the disciplines of mathematics and physics (in which I too take enormous delight)'. Folkes appended a letter of introduction for Michelotti to Machin to this piece of correspondence.
[105] Folkes nominated Riva by letter on 1 October 1733 to be a Fellow of the Royal Society, as a 'Person of great Modesty and knowledge in his way and Author of Several Works, which he hath given me to be presented to the Society, one of which is a dissertation on certain fiery Meteors, that have lately appeared and done a pretty deal of Mischief. He is likewise strongly recommended by the Marquis Poleni and Dr Michaelotty.' Riva was elected on 24 January 1733/4. See EC/1733/07, The Royal Society, London. The dissertation that was mentioned was 'an account of some surprizing Meteors appearing from time to time in the Province or Trevegiana (in the dominions of Venice) described and explained by Signor Ludovico Riva in his Miscellanies in Latin', Read to the Royal Society on 5 December 1734, see Register Book Original, RBO/19/5, The Royal Society, London.
[106] U1590_C21_6a. Stanhope Papers, Kent County Archives.
[107] For a comprehensive biography of Cocchi, see Luigi Guerrini, *Antonio Cocchi naturalista e filosofo*, Florence: Polistampa, 2002; Cocchi and Folkes also were both freemasons, and Cocchi later became Master of the Florentine Lodge. See Nicholas Hans, 'The masonic lodge in Florence in the eighteenth century', *Ars Quatuor Coronatorum* 61(1958), pp. 109-12. Folkes' son also would attend several meetings at the Royal Society when he returned from England, as a means of furthering his education.
[108] In a letter to Walpole, Mann recalled speaking with Folkes, and the editor speculated that Mann and Folkes may have met in Italy. Indeed they did. Horace Mann to Horace Walpole, H*orace Walpole's Correspondence*, New Haven, Yale University Press, online edition, 19 April 1777, vol. 24, pp. 289-90, note 3.
http://images.library.yale.edu/hwcorrespondence/default.asp [Accessed 2 November 2016].
[109] Casini, op. cit. (59), p. 220. See also Paolo Cassini, *Hypotheses Non Fingo: Tra Newton E Kant* (Edizioni di storia e letteratura, 2006), p. 108.
[110] Cocchi to Folkes, 3 March 1736, MS/790/26 Royal Society Library.
[111] Folkes had a pervasive interest in games of chance and was presented with a probability calculations about the game of whist from George Lewis Scott, 25 April 1744, MS 250/26, Royal Society Library.
[112] Folkes, 'Journey from Venice to Rome' op. cit. (1), f. 39r. Martinelli owned a Hauksbee-type air pump which was bought by the Republic of Venice in 1738-9 for the new chair of experimental philosophy at the University; the pump was used by Giovanni Poleni for his lectures on experimental philosophy. See Terje Brundtland, 'Francis Hauksbee and his Air Pump', *Notes and Records of the Royal Society* (2012), pp. 1-20, on p. 15. The pump is still

extant at the Museo di Storia della Fisica in Padua. For Stanhope and Folkes, see David Bellhouse, 'Lord Stanhope's papers on the Doctrine of Chances', *History of Mathematics* 34 (2007), pp. 173-186.
[113] Folkes, 'Journey from Venice to Rome' op. cit. (1), f. 42r.
[114] Record of the reading of Celsius's book is in the Register Book Original, RBO/16/57, Royal Society Library; See also Anders Celsius, 'Observations of the Aurora Borealis Made in England by Andr. Celsius, F. R. S. and Secr. R. S. of Upsal in Sweden', *Philosophical Transactions* 39, 441 (1735), pp. 241-244.
[115] Mike Lockwood and Luke Barnard, 'An arch in the UK: Aurora Catalogue', *A & G: News and Reviews in Astronomy and Geophysics* 56 (August 2015), pp. 4.25-4.30, on p. 4.26.
[116] See also N.V.E. Nordenmark*, Anders Celsius: Professor I Uppsala 1701-44*, Luleå, 1926.
[117] Mary Terrall, *The Man who Flattened the Earth: Maupertuis and the Sciences in the Enlightenment,* Chicago: University of Chicago Press, 2002, p. 102. See also Rob Iliffe, "Aplatisseur du Monde et de Cassini"; Maupertuis, Precision Measurement, and the Shape of the Earth in the 1730s', *History of Science,* xxxi (1993), pp. 335-375.
[118] This explanation is adapted from Richard Sorrenson, 'George Graham: Visible Technician', *British Journal for the History of Science* 32 (1999), pp. 203-21, on pp. 210-11.
[119] Sorenson, op. cit. (118), p. 211.
[120] Terrall, op. cit. (117), p. 137; In his letter to Celsius, Maupertuis indicated he wished for a model of James Bradley's instrument for observing the transits of fixed stars as well as Graham's astronomical pendulum clock. See Extract of a letter from Pierre Maupertuis, dated at Paris, to Andreas Celsius, 22 November 1735, EL/M3/24, Royal Society Library, London.
[121] James Bradley, 'A Letter from the Reverent Mr. James Bradley Savilian Professor of Astronomy at Oxford, and F.R.S. to Dr Edmond Halley Astonom. Reg. &c. giving an Account of a new discovered Motion of the Fix'd Stars', *Philosophical Transactions* 35 (1727-8), pp. 637-661.
[122] Journal Book Original 13 (1720-26), 8 December 1720, JB0/13/18, Royal Society Library, London.
[123] Byrom, op. cit. (8), vol. 1, p. 109: 1725. 'Tuesday, 6th April ... to Paul's Church Yard, where Mr. Leycester and I went, Mr. Graham, Foulkes, Sloan, Glover, Montagu ... There was a Lodge of Freemasons in the room over us, where Mr. Foulkes, who is Deputy Grand Master, was till he came to us'.
[124] Anders Celsius, ''Lapis Maltadensis'. Transcription and translation of a runic inscription on the Malsta stone in Rogsta, Há/lsingland, Sweden by Prof. Anders Celsius, Hon. FSA ', Society of Antiquaries of London Minute Book (SAL), SAL/MS/264 B, Vol. 2, p. 309, Society of Antiquaries Library, London. See also S. Jansson, *The Runes of Sweden*, London: Phoneix House, 1962, 79-80.
[125] Anders Celsius, "An Explanation of the Runic Characters of Helsingland," *Philosophical Transactions* 40, 7-13 (1737/8), pp. 7-13, on p. 13. Celsius wrote, 'if we suppose Frumunt (the creator of the monument) to have been thirty years of Age when he erected this Monument for his Father, and, with Sir Isaac Newton, allow thirty Years for each Generation, we shall find three hundred and thirty Years from the Death of Fifiulsi to the Birth of Fidrasiv, who is the Stock of these Generations'.
[126] SAL Minute Book, SAL/MS/264 B, volume 2, pp. 164-5, Society of Antiquaries Library, London
[127] MS 790/21 Letter from Celsius to Folkes, 3 December 1736, Royal Society Library, London
[128] Sorrenson, op. cit. (118), p. 214.
[129] A star's declination change sgradually due to precession of the equinoxes and annual parallax.

[130] MS 790/21, Letter from Celsius to Folkes, 3 December 1736, Royal Society Library, London
[131] *Obligeante lettre*, that is to say, a letter that was helpful and pleasant to the reader, Maupertuis.
[132] The French word *ouvrage* is generally a 'work' but it could be also a book, a work of art, architecture or any sort of work that was undertaken.
[133] I read *et de périls* in the letter, where *périls* would rather mean 'risks' instead of the general translation into 'peril' because Maupertuis in his letter is generally referring to difficulties and trouble regarding his discoveries.
[134] 'Astronomer' is written with a capital A in French in the original letter.
[135] Letter from Pierre Maupertuis to Martin Folkes, 26 July 1738, MS 790/42, Royal Society Library.
[136] MS 790/42, op. cit. (135).
[137] Folkes, 'Journey from Venice to Rome' op. cit. (1), f. 98v. This was noted by Kristen Lippincott, 'A chapter in the Nachleben of the Farnese Atlas: Martin Folkes' Globe', *Journal of the Warburg and Courtauld Institutes*, lxxiv (2011), pp. 281-299, on p. 287; Society of Antiquaries Minute Book, vol 2, pp. 201-02.
[138] B. E. Schaefer, 'The epoch of the constellations on the Farnese atlas and their origin in Hipparchus' lost catalogue', *Journal for the History of Astronomy*, xxxvi (2005), pp. 167–196. on p. 196.
[139] Royal Society Journal Book, Copy, xx, p 184). This comment about genius was from the address Folkes gave when presenting the Copley Medal to Harrison. See Jim Bennett, 'James Short and John Harrison: personal genius and public knowledge,' *Science Museum Journal* 2 (Autumn 2014), http://dx.doi.org/10.15180/140209
[140]Martin Folkes, Letters and Papers, Decade 1, Volume 10A, 5-December 1745 to 1 May 1746, MS no. 479, Royal Society Library, pp. 1-33. For an approachable treatment of Ulloa's voyage, see Larrie D. Ferreiro, *Measure of the Earth: The Enlightenment Expedition that Reshaped Our World*, New York: Basic Books, 2013; See also Francisco de Solano, *Don Antonio de Ulloa, Paradigma del Marino Cientifico de la Ilustacion Española*, Coimbra, Universidade de Coimbra, 1990, which has a nice description of Ulloa's mineralogical work and discovery of platinum.
[141] Folkes, Letters and Papers, op. cit. (140), pp. 30-31.
[142] Folkes, Letters and Papers, op. cit. (140), p. 1. Ulloa published his account in his *Relación histórica del viaje a la América Meridional*, Madrid, 1748, 4 vols. See de Solano, op. cit. (140), pp. 335-336 for a discussion of Ulloa's editions.
[143] Sorenson, op. cit. (118); See also George Rousseau, *The Notorious John Hill: A Man Destroyed by Ambition in the Age of Celebrity,* Bethlehem, PA: Lehigh University Press, 2012.
[144] Mordechai Feingold, 'Confabulatory life', in P.D. Omodeo and K. Freidrich (eds.), *Duncan Liddel (1561– 1613): Networks of polymathy and the Northern European Renaissance*, Leiden: Brill, 2016, pp. 22–34.
[145] Henry Guerlac, *Newton on the Continent*, Ithaca: Cornell University Press, 1981, p. 46.