Interpreting James Gregory: Mathematician and Astronomer

Leo Doherty

Supervised by Dr Isobel Falconer MBE,

Department of Mathematics and Statistics

Completed for the Laidlaw Research and Leadership Scholarship

July 2022

Word Count: 2593 (exc. bibliography and acknowledgements)

University of St Andrews

Acknowledgements:

I would like to express my gratitude to Lord Laidlaw for providing the opportunity to pursue this research and participate in the leadership scholarship programme and the St Andrews Laidlaw team, who have assisted me throughout the application process and programme. I would also like to thank Dr Isobel Falconer for her expert guidance and Klara Chura from Tufts University, a fellow student who I corresponded with throughout the duration of the research project.

Interpreting James Gregory, Mathematician and Astronomer

Introduction:

When looking at a mathematical or astronomical instrument, it is often easy to see a piece of metal covered in engravings, signatures, and numbers, with its use relegated to a bygone age. Behind each instrument, whether it be a Roman abacus, a 16th century telescope, or a sextant from Elizabethan England, there is a story to tell. These instruments once served a key role in mapping the stars, naval navigation, keeping time, and many other applications. Analysing and interpreting such instruments can provide us with a newfound appreciation for the work of early mathematicians and show that the logic and methods we consider obvious today were at the centre of intellectual debate in the past.

When researching any historical Mathematics, especially that of the 17th century and earlier, a variety of sources is needed to provide a complete and worthwhile interpretation of the material in question. For this research, I have analysed the correspondences between James Gregory and other mathematicians of the era and historians' sources and accounts of the instruments in question. There are many holes and missing information when researching the intricacies of the commissioning of the St Andrews observatory, such as its funding sources, the reasoning behind it, and why Gregory left the university.

This research will take a deeper look at the instruments of James Gregory (1638 – 1675), the first Regius Professor of Mathematics at the University of St Andrews. In particular it will attempt to provide the story of the *Great Astrolabe* and *Universal Instrument* by Humphrey Cole, and the *Knibb split seconds clock* by Joseph Knibb. The essay will contextualise each

of these instruments, where they were bought, for what purpose they were built, how one at the time would have used them, and other relevant questions.

Section 1: James Gregory and the Observatory

James Gregory was born in Drumoak, near Aberdeen in Scotland to John and Janet Gregory (née Anderson). With his father being a university-educated episcopalian minister, and his mother being part of a family with a strong mathematical legacy, one could argue that Gregory grew up in an environment that strongly influenced and nurtured his interest in Mathematics and Astronomy. The maternal side of his family had a flare for Mathematics, especially his uncle Alexander, who was a pupil of the then renowned mathematician Viète (1540 – 1603). His mother could be credited with inspiring James to pursue Mathematics, teaching him Geometry when he was young, at a time in Scotland where women were scarcely educated to a level higher than basic literacy and needlework. After attending Aberdeen Grammar School and graduating alma mater from Marischal College in 1657, he travelled to London in 1663 and became acquainted with the mathematician John Collins (1625 – 1683); this would grow into a lifelong relationship shown in the extensive correspondences that lasted throughout the rest of his career.

Gregory travelled Europe from 1664 – 1668, spending most of his time at the University of Padua, at a time when the '*Scientific Revolution'* was taking place in much of western Europe. Many natural philosophers were beginning to apply an observation and experiment-based approach to accepted theories[1]. Gregory returned to Scotland to take up the post of Regius Professor of Mathematics at St Andrews in 1668, coming back to a Scotland which,

[1] Hakim, Joy. 2005. *The story of science: Newton at the center.* Washington: Smithsonian Books.

under the strong influence of a Calvinist kirk (religious authority), had not seen the same resurgence in scientific culture as that in nations like England, France, and the Netherlands. There would seem to have been a stark contrast between the academic culture in Padua and that of St Andrews. Many Scottish academics had departed for the rest of Europe, which 'left the university in the hands of the clergy and the teaching of science was limited to commentaries on Aristotle.'[2] After the shift in environment from Padua to St Andrews, Gregory was faced with the trouble of both being considered equal amongst the university staff, and the introduction of a more formal teaching and research of Mathematics not yet established at the university.

The commission for the construction of an astronomical observatory at St Andrews was signed 10 June 1673, setting out the supposed reasoning behind it and what purpose the observatory would serve. One would not be wrong to be surprised at this commissioning, particularly at a university with such a nascent culture of mathematical education. There are a multitude of proposed reasons on why the observatory was commissioned, the most obvious being the '…improving of natural philosophy and the Mathematicall sciences…'[3], as stated in the official commission document. Due to the turmoil Scotland faced in the 17th century, from the union of the crowns in 1603, the fallout of Cromwell and the English Civil War, and the constant conflict between religious factions, the 'Scottish Spirit' had been somewhat damaged. The historian Jenny Wormald puts forward the idea that the English national spirit to 'emphasize their superiority over all others'[4] spread to Scotland at this time, and 'created among the Scots the same need to assert their own superiority'[4]. This comment from

[2] Gil, M. Pilar. *Collecting Science in St Andrews. A History in Context.* University of St Andrews, 30 May 2016.

[3] 'Commission', Turnbull, Herbert Westren. *James Gregory: Tercentenary Memorial Volume*. Royal Society of Edinburgh, 1938.

[4] Wormald, Jenny. "Scotland : A History, Edited by Jenny Wormald, Oxford University Press USA - OSO, 2005.

Wormald would align with the line in the commission regarding the 'honour of the kingdom'[3], making a strong case that the observatory was not merely a scientific venture, but one borne of a sense of Scottish pride, and their will to place themselves amongst the powers of Europe.

The funding for this observatory is a subject on which there is a substantial dearth of sources, with only snippets of letters and council records giving us insight into how such a project was paid for. Gregory himself was encouraged to seek funds from 'all whom he knows to be favourers of learning…'[3], a contrast from the Paris Observatory (est. 1667) and the not-yet-commissioned Royal Observatory at Greenwich, which both received most of their money from their nations' respective royal families. Even such humble means as asking for donations 'at the Kirk dores'[5] (at the church doors), as was granted by Aberdeen council in October 1672, were used. Few benefactors' names survive today, with John Steuart of Grandtully donating money[6], and the Duke of Lauderdale giving a two foot radius quadrant.[7] Gregory left St Andrews to take up a position in Edinburgh University in 1674, after feeling prejudice against him and underappreciated, writing to Frazer that some of the scholars '*…did mock at their masters, and deride some of them publicly.*'[8].Gregory died in October 1675 in Edinburgh, with the observatory left unused and to eventually fall into a state of disrepair.

Section 2: The Instruments of James Gregory

[5]Malet, Antoni. *Studies on James Gregorie (1638-1675)*. Princeton University, Oct. 1989, p.80.
[6] Fraser, W. *The red book of Grandtully*. Edinburgh, 1868
[7] Letter from Gregory to Flamsteed 19 July 1673
[8] Gregorie to Frazer, [13 July 1675], (GTMV, p. 312).

Gregory travelled to London in the summer of 1673 in order to purchase instruments and receive advice from other mathematicians on setting up the observatory. In the 17th century, London was the epicentre of scientific instrument making in Britain, with Scotland's own industry being almost non- existent. He corresponded with the astronomer John Flamsteed (1646 – 1716) whilst in London, seeking his advice on the use of the instruments he had purchased.[9] In this letter, he expresses the sheer quantity of instruments bought in a letter to Flamsteed, stating *'It were tedious to write down particularlie all the instruments I have brought home, yea a larger letter wold not contein all ther names & sizes…'*. The quality of the instruments that the university has access to would suggest that the project of the observatory was not half–hearted, as a substantial amount of money would have been needed for such high-quality instruments.

One of the key extant instruments believed to have been purchased on this trip is the Great Astrolabe, manufactured by Humphrey Cole (1530? – 1591). Cole is shown to have been an eminent instrument-maker during the late 16th century, as an 'advertiserment to the reader'[10] in Edward Worsop's 1582 *Discoverie of sundrie errours* begins '…sundry sorts of Geometricall instruments in metal, are to be had in the house of Humfrey Cole…'[10]. The Great Astrolabe was crafted in 1575, long before Gregory was even born, but still stood in Gregory's time as a high-quality mathematical instrument that could be and was used for research. The first glimpse of an astrolabe can often seem intimidating, with a variety of plates, tables, and moving pieces. The basic use of an astrolabe, to discover what constellations will be overhead on a particular day and time, is quite accessible. Knowing the

[9]Malet, Antoni. *Studies on James Gregorie (1638-1675)*. Princeton University, Oct. 1989.

[10] Worsop, Edward. *A Discoverie of Sundrie Errours and Faults Daily Committeed by Landmeters Ignorant of Arithmeticke and Geometrie*. London, 1582.

date, along with using the back of the astrolabe, we can figure out the position of the sun in the Zodiac. This then allows us to move the label until it lines up with the date, showing its the position in the Zodiac. We then would rotate the rule and rete (the ornate network of rings on the front of the astrolabe) as one, pointing to the desired time of day we wish to view the stars, this will then show us a representation of what we would see in the stars at that time on that date, with the rings labelled telling us how high in the sky we should look, and the compass stating in what direction to look. When inspecting the Great Astrolabe, physical aspects of the instrument reveal a lot about the intentions behind the purchase and manufacturing of the instrument. One of the astrolabe plates, made by John Marke, is for a latitude of 52°25', which at the time was the approximate latitude of St Andrews, inferring that the plate was specially made for use at the university. The intended use of the astrolabe can only be inferred, such as the *Quadratum Nauticum* being engraved with two sets of lines for astrological use, and a *tablet of horizons* which was used for calculating sunrise times at different latitudes.

The *Universal Instrument,* or *Armillary Sphere*, is another instrument crafted by Humphrey Cole in 1582 which is thought to have been purchased by Gregory for the observatory. Armillary spheres at the time had varied uses, with smaller ones being used purely for a demonstration of various astronomical models and larger ones such as this being for measurement and observation. A unique feature of this particular instrument is the alidade (a pointer for determining directions or measuring angles in astronomy), which can be rotated on a circular disc. This then can be used for measuring altitudes in a vertical position, and azimuths (the arc length from true north) in a horizontal position. Being far from a mere demonstration-focused instrument, the Universal Instrument's unique features, such as the compass on the base, imply that it was indeed intended to be used for measurement and

observation. The instrument, whilst impressive, has evidently taken inspiration from literature at the time, as R. T. Gunther remarks in *Archaeologia,* the rotatable disc 'had already been described by Cortes (1510 – 1583) in his *Breve compendio de la Sphera y de la arte de Navegar,* published in 1545.'[11]. Gregory would have most likely planned to use this for charting heavenly bodies, using the inner ring of the sphere.

The *Split-seconds Clock*, manufactured by Joseph Knibb in 1673, is an often-misunderstood instrument on which we have many written records from Gregory. The Knibb family was an esteemed family of clockmakers in late 17th century Britain, first established in Oxford in 1662 by Joseph Knibb. The split-seconds clock held by the university is considered the first of its kind, with the ability to measure time to a degree of accuracy of less than a second. The clock was commissioned by Gregory on his 1673 trip to London, which we can assume would have been used to make accurate observations. At the time, the *Longitude Problem*, the question of how to accurately measure longitude, was one of the burning questions amongst navigators, mathematicians, and astronomers. The method of measuring longitude at the time required very accurate timekeeping, which a clock to this degree of accuracy would have been necessary for a worthwhile reading. This particular clock is the subject of much misinterpretation, as Gregory's letter to Flamsteed claimed that he had a clock 'vibratinge 4 times a second…'[7]. In reality, the clock, whilst still splitting the second, only ticked every two-thirds of a second[12], contrasting with every quarter of a second, which Gregory commissioned. Gregory's claim about the clock would suggest he was excited about its use,

---

[11] Guther, R. T. "The Great Astrolabe and Other Scientific Instruments of Humphrey Cole." *Archaelogia; or Miscellaneous Tracts Relating to Antiquity*, vol. 26, 1926, pp. 273–317.

[12] Amson, John Ceres. *THE WORLD'S FIRST-SECOND CLOCK, 1673*. University of St Andrews, 14 Oct. 2014.

as he stated in the letter that he had the clock in his possession, despite the discrepancy in the clock's accuracy, which would have been obvious to a man such as Gregory. Whilst still being impressive for the time, John Ceres Amson remarks that the noticeable downgrade in accuracy from what Gregory originally requested potentially 'added one more nail to the coffin of his earlier Observatory dreams.'[12].

Conclusion

By choosing to focus on three of Gregory's instruments, how they worked, and the background of their purchase, this essay has attempted to bring the stories of these objects to the forefront, and allow the public to truly access and appreciate these pieces of St Andrews' history. The explanations and context within this paper have been used to open up to the public what would be, particularly the Universal Instrument and Great Astrolabe, commendable pieces of work with a complex and obscure purpose. Artefacts in museums are often thought of as objects from the past, without considering the human aspect; understanding the motives for buying them, the politics of the age, what they were used to discover and the craftsmanship behind them can breathe life into these objects, and engage the public with the history of the university at a new level.

Through referencing of multiple sources and my comments on their proposed theories on the reasoning behind the commissioning and failure of the observatory, the paper has given the reader the opportunity to ponder on these, and think about the past as one full of people, with motives, ambitions, dreams, and failures. This essay has sought to encourage readers to take a more human-centred approach to the artefacts and buildings we see around us, as behind even the most mundane-appearing objects, there is often a story to tell.

Bibliography

- Amson, John Ceres. *THE WORLD'S FIRST-SECOND CLOCK, 1673*. University of St Andrews, 14 Oct. 2014.
- Gil, M. Pilar. *Collecting Science in St Andrews. A History in Context.* University of St Andrews, 30 May 2016.
- Guther, R. T. "The Great Astrolabe and Other Scientific Instruments of Humphrey Cole." *Archaelogia; or Miscellaneous Tracts Relating to Antiquity*, vol. 26, 1926, pp. 273–317.
- Jardine, Boris. "Instruments of Statecraft: Humphrey Cole, Elizabethan Economic Policy and the Rise of Practical Mathematics." *Annals of Science*, vol. 75, no. 4, Oct. 2018, pp. 304–29, https://doi.org/10.1080/00033790.2018.1528510.
- Jardine, Boris. "'Neere unto the North Dore of Paules': New Light on the Life and Times of Humphrey Cole." *Bulletin of the Scientifc Instrument Society*, vol. 142, no. September, Sept. 2019, pp. 1–5, https://scientificinstrumentsociety.org/BulletinArticles_public/Bulletin142_Jardine,B.,Humphrey-Cole.pdf.
- Lee, Ronald A. *The Knibb Family Clockmakers or: Automatopaei Knibb Familiaei*. 1st ed., vol. 1, Manor House Press, 1964, pp. 154–57.
- Malet, Antoni. *Studies on James Gregorie (1638-1675)*. Princeton University, Oct. 1989.
- O'Connor, J. J., and E. F. Robertson. "James Gregory." *Mactutor*, Sept. 2000, https://mathshistory.st-andrews.ac.uk/Biographies/Gregory/.
- Parkin, Chris. "Armillary Sphere." *History of Science Museum*.
- Rawson, Helen C. "James Gregory, the University Observatory and the Early Acquisition of Scientific Instruments at the University of St Andrews." *Notes and Records: The Royal Society Journal of the History of Science*, vol. 69, no. 2, Feb. 2015, pp. 109–33, https://doi.org/10.1098/rsnr.2014.0026.
- Turnbull, Herbert Westren. *James Gregory: Tercentenary Memorial Volume*. Royal Society of Edinburgh, 1938.
- Wormald, Jenny. "Scotland : A History, Edited by Jenny Wormald, Oxford University Press USA - OSO, 2005. ProQuest Ebook Central, Https://Ebookcentral.Proquest.Com/Lib/St-Andrews/Detail.Action?DocID=422796." *Scotland: A History*, Oxford University Press, 2005, pp. 123–49, https://ebookcentral.proquest.com/lib/st-andrews/detail.action?docID=422796.
- "How to Use Your Astrolabe: What's in the Sky Tonight?" *The Way to the Stars: Build Your Own Astrolabe*, https://www.joh.cam.ac.uk/library/library_exhibitions/schoolresources/astrolabe/use. Accessed 20 June 2022.

Appendix 1: The instruments in question which are assumed to have been in the possession of Gregory, held in the St Andrews Museums collections.

Images obtained from:

St Andrews University Museums Collections: https://collections.st-andrews.ac.uk

- The Great Astrolabe (Humphrey Cole, 1575), held in St Andrews Museums collection, ID – PH201. https://collections.st-andrews.ac.uk/item/great-astrolabe/1000988

- The Universal Instrument (Humphrey Cole, 1582), held in St Andrews Museums collection, ID – PH203. https://collections.st-andrews.ac.uk/item/universal-instrument/1000990

- The Knibb split seconds clock (Joseph Knibb, 1673), held in St Andrews Museums collection, ID – PH208. https://collections.st-andrews.ac.uk/item/knibb-split-seconds-clock/1001103