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COPERNICANISM IN ICELAND

Introduction

As you may expect from the geographical position of Iceland it took considerable time for Copernican heliocentrism to become known and to gain support on this remote North–Atlantic island. Probably the first news of this new theory broke on Iceland in the 16th century but we had to wait until the late 18th century for the completion of the Copernican Revolution in Denmark and Iceland[1]. In this paper we will first briefly discuss the Copernican Revolution as a whole and its reception in Europe. Because of the Danish connection some emphasis will be put on Tycho Brahe's role. We will also briefly describe the development in Denmark as a background for the transmission of ideas to Iceland, especially through the University of Copenhagen, which at this time was practically the only university attended by Icelandic students.

The bulk of the paper discusses the cosmological ideas appearing in writings of learned Icelanders of the 17th and the 18th century. The most important sources for this story are disputations in Latin, written during the student years of the authors at the University of Copenhagen and printed there, albeit in small numbers. The subject has not been systematically studied until now, mainly due to the scarcity of combined knowledge of Latin and astronomical cosmology.

The Copernican Revolution

Ptolemaic Geocentrism

The early medieval people of Denmark, Sweden, Norway and Iceland are normally referred to as Vikings or Old Norse. They were seafarers, explorers and settlers, all of which required and promoted the habit of keen observations of nature, both terrestrial and celestial. Thus we know for instance from written sources that they clearly realized that the earth is spherical. We can also see from 12th century Icelandic manuscripts that the Icelanders at that time more or less shared the rough Ptolemaic geocentric system then current

[1] This paper is based on a considerably longer article in Icelandic by the same authors: E. H. Gudmundsson, E. Kolbeins & Th. Vilhjálmsson, *Heimsmyndin í ritum lærðra Íslendinga á sautjándu og átjándu öld.*

on the European continent. We also know that the more refined view transmitted by Sacrobosco (d. ca. 1256) in the 13th century was passed on to Iceland early on, probably through the hands of the Benedictines[1].

We may also mention in passing that 12th–13th century astronomical manuscripts from Iceland contain inserts which seem to be of Icelandic or Old Norse origin, probably meeting the needs of seafarers for knowledge of the Sun, Moon and the fixed stars. The most famous of these inserts is the so–called Oddi's Tale, attributed to Star–Oddi Helgason (fl. ca. 1150)[2].

Copernican Heliocentrism

We presume that the reader knows the main points of Copernican cosmology as well as its gradual dissemination in Europe, with the complicated interplay of computational advantages, novel celestial discoveries on novae, comets, Jovian moons and planetary orbits, discussions on the nature of gravity and inertia, etc. In a sense it is not so strange that the so called revolution took considerable time. Thus, it took 100–150 years to collect the data and ideas which by hindsight seem necessary for the Copernican theory to be completely convincing for people adapting the scientific way of thinking.

For example, from the point of view of the emergent mechanics the problem of the motion of the sun or the earth can be seen as a matter of relative motion. In such a context it may be of only a small consequence which one is really at rest. This ambiguity was not completely resolved until the advent of Newtonian mechanics where the Sun turns out to be by far the heaviest body of the solar system, thus claiming the privileged position of being at least quite close to the center of mass of the system.

Another point of interest here is the question of the diurnal rotation of the Earth versus that of the celestial sphere. The most common Copernican argument on this points out the dimensions of the sphere and the unbelievable speeds, which the fixed stars would have if their sphere were rotating. We can perhaps not blame the sceptic if he does not accept this point at face value. However, if he feels compelled to accept the annual terrestrial motion, lack of diurnal axial rotation might seem difficult to hold. Also, later on, people would observe direct terrestrial consequences of the diurnal rotation through the Coriolis force, but that was not until the 19th century.

So, we may summarize by the well–known fact that the Copernican Revolution really took its time and was not a simple story at all.

The Tychonian Compromise

It is probably well known to the reader how the Danish astronomer Tycho Brahe (1546–1601) came to present a compromise system with the earth at the centre of the solar and lunar orbits but the sun at the centre of the other planetary orbits. Although this cosmology is now considered obsolete, it gained

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[1] The main medieval manuscripts on these subjects have been philologically edited and printed in N. Beckman & Kr. Kålund (ed.), *Alfræði íslenzk: Islandsk encyklopædisk litteratur*, vol. 2: *Rímtöl*.

[2] See Th. Vilhjálmsson, *Time and Travel in Old Norse Society*, Th. Vilhjálmsson, *The Subarctic Horizon as a Sundial* and Th. Vilhjálmsson, *Old Norse Navigation: Hardware or Software*; and references there.

considerable and lasting support in its own time from important members of the scientific community. In view of Tycho's nationality it is not surprising that Danish scholars tended to adhere to this system for almost two centuries.

From the point of view of geometry and kinematics within the solar system, the Tychonian view is completely equivalent to the Copernican one. In such a context, differences between the two views only arise from considerations or observations concerning the fixed stars, like those of the distance of the celestial firmament or of the stellar parallax. This is important to keep in mind when considering the success of the Tychonian view in its time, when observations on this were lacking and when Newtonian mechanics was still not in store.

It is also a peculiarity of history that Tycho Brahe happened to build some of the pillars for Copernican theory by applying his keen observational skills to comets and novae, which were visible in his period of activity. These phenomena were until then normally considered to be sublunary, i. e. terrestrial or atmospheric, since they were so strongly variable and could not belong to the most commonly accepted Aristotelian view of the heavens as immutable. Tycho, however, showed them to be too distant to be sublunary.

The Newtonian Finish

We will not dwell at length with the contributions of Johannes Kepler (1571–1630) and Galileo Galilei (1546–1642) to the Copernican Revolution. Let it suffice to say that we have now come to the stage where the involved scholars felt a strong need for physical considerations in their wrestling with the problems of astronomical cosmology. Kepler's introduction of elliptical instead of circle–based orbits can be seen as a step in this direction, and we also know that he contemplated the problem of gravity. The steps towards the law of inertia taken by Galileo and René Descartes (1596–1650) were also important for the eventual resolution of important mechanical problems deriving from Copernican ideas.

The Cartesian theory of vortices is sometimes underestimated in the history of Copernicanism, probably because it was later completely overthrown by Newtonian mechanics and hence almost forgotten. But it played an important role in the late 17th century and its influence can still be seen far into the 18th century. And it was indeed an honest and intelligent attempt to find a physical although somewhat qualitative basis for the orbital motion of the bodies of the solar system.

We have already mentioned some aspects of the influence of Isaac Newton (1642–1727) on the foundations of the Copernican cosmology. Let us add that in spite of the ingenuity and scope of Newtonian mechanics some of the direct proofs of terrestrial motion (annual stellar parallax, measurements of terrestrial mechanical influence of the diurnal rotation, etc.) were still missing for a long time after *Principia's* appearance in 1687. However, it can be argued that after the acceptance of *Principia* a sceptic wanting to work in the arena of science would not be serving his real interests by continuing to deny the scientific value of Copernicanism. The balance of evidence, empirical and theoretical, had by then finally turned in favour of the ideas of the Polish canon.

The Danish Intermediary

The Lasting Tychonian Influence

As in other European countries of the time 16th century students at the University of Copenhagen would read Sacrobosco's *De Sphaera* in various editions[1]. Later in the studies it might be followed by *Theoricae novae planetarum* by the Viennese astronomer Georg Peurbach (1423–1461)[2]. After the Reformation this would further be complemented by commentaries of Filippus Melanchton (1497–1560) and others.

As to heliocentrism the Copenhagen professor Jørgen Dybvad (d. 1612) had drawn attention to it in his *Commentarii breves in secundum librum Copernici* of 1569[3]. So we can assume that the students of the University from that time onwards had heard about the ideas of Copernicus. In 1590 Anders Kragh (1553–1600) started teaching natural philosophy at the University, introducing the students, among other things, to the writings of the French philosopher Pierre de la Ramée (Ramus: 1515–1572) who was relatively positive towards Copernicus and his work although not accepting it in full[4].

Being of noble birth and a protégé of the king Fredrik II, Tycho Brahe (1546–1601) did not have any permanent association with the University of Copenhagen. However, in 1574–1575 he gave lectures on the heliocentric world system at the University, at the request of the king and the University authorities. This shows clearly that the message of Copernicus had aroused interest in the city.

Tycho Brahe was the best astronomical observer of his times, improving the techniques to the limits of what is possible with the naked eye. One of the most critical problems with Copernicanism was that of the absence of measurable annual parallax of the fixed stars. Tycho applied his skills to this problem but was unable to find any parallax. This was one of the arguments which led him to reject Copernicanism and propose instead his famous compromise system described above. He had finished this about 1583 and published it in 1588 in his book on the comet of 1577.

The Tychonian heritage was well kept at Copenhagen University. Two of Tycho's disciples, Christian Sørensen Lomborg (Longomontanus: 1562–1647) and Kort Aslaksen (1564–1624), became professors at the University in the beginning of the 17th century and shaped new study material in astronomy and natural philosophy which was subsequently used for a long time to come at the University and elsewhere in the learned world.

The real heir of Tycho in Denmark, Longomontanus, came to be the first professor in astronomy at the University of Copenhagen. He published an important textbook, *Astronomia Danica*, in 1622 and again in 1640 and 1663. It contains an extensive report on Brahe's observations and astronomical

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[1] See, for instance, L. Thorndike, *The Sphere of Sacrobosco and its commentators*.

[2] See E. J. Aiton, *Peurbach's Theoricae Novae Planetarum*.

[3] See M. Pihl (ed.), *Københavns Universitet 1479–1979* ... and K. P. Moesgaard, *How Copernicanism Took Root in Denmark and Norway*.

[4] See K. P. Moesgaard, *How Copernicanism Took Root in Denmark and Norway*, S. Ebbesen & C. H. Koch, *Den danske filosofis historie* ... (chap. 3).

theories together with a treatment of all the three main cosmological systems, the Ptolemaic, the Copernican and the Tychonian. The author agrees with Copernicus on the axial rotation of the earth and on precession but is otherwise faithful to his master, Tycho[1].

One of the disciples of Aslaksen was the physician and theologist Caspar Bartholin (1585–1629). He was a prolific and influential writer of textbooks with many descendants among known Danish scientists and scholars in the years to come. In the present context his most important work is *Systema physicum* from 1628, which was the main textbook on natural philosophy at the University until 1690[2].

In 1656 the mathematician and natural philosopher Rasmus Bartholin (1625–1698), son of Caspar, started teaching at the University of Copenhagen. He had been introduced to Cartesian ideas in Leiden and transmitted them in his teaching of astronomy and natural philosophy[3]. The well–known astronomer Ole Rømer (1644–1710) was a disciple and son–in–law of Rasmus Bartholin and adhered to Cartesian theory, including the concomitant heliocentrism.

In 1690 *Systema physicum* was replaced by *Specimen philosophiæ naturalis* by Caspar T. Bartholin (1655–1738), a grandson of the author of *Systema physicum.* The *Specimen* rejects the ancient geocentrism and is clearly influenced by Descartes. It does not completely choose between pure heliocentrism and Tychonianism although the author seems more inclined towards the former theory[4].

Both Rømer and his successor, Peder N. Horrebow (1679–1764), made elaborate attempts to measure the stellar parallax. They both thought they had found it but only Horrebow endeavoured to publish his results, in 1727. They were widely noticed but turned out to be erroneous; as we know parallax was not found until 1838. However, in 1728 James Bradley (1693–1762) measured the aberration, which is a consequence of the orbital motion of the earth together with the finite speed of light demonstrated by Ole Rømer in 1676.[5]

In spite of his mistake concerning the parallax Horrebow was an excellent astronomer and quite influential in his university teaching. He took good care of the heritage of his master, Ole Rømer, and compiled it in the form of a textbook in 1735. He and his successor and son, Christian P. Horrebow (1718–1776), were both strongly influenced by the ideas of Descartes[6].

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[1] M. Pihl (ed.), *Københavns Universitet 1479–1979 ...* .

[2] See K. P. Moesgaard, *How Copernicanism Took Root in Denmark and Norway*, S. Ebbesen & C. H. Koch, *Den danske filosofis historie ...* .

[3] M. Pihl (ed.), *Københavns Universitet 1479–1979 ...* . Rasmus Bartholin is best known for discovering double refraction in Iceland spar, see E. H. Guðmundsson, *Gísli Einarsson skólameistari og vísindaáhugi á Íslandi á 17. öld*, pp. 198 sq., L. Kristjánsson, *Silfurberg: Einstæð saga kristallanna frá Helgustöðum.*

[4] S. Ebbesen & C. H. Koch, *Den danske filosofis historie ...* .

[5] M. Pihl, *Ole Rømers videnskabelige liv.*, J. Teuber, *Ole Rømer og den bevægede Jord – en dansk førsteplads?*

[6] M. Pihl (ed.), *Københavns Universitet 1479–1979 ...* .

Newton at Last

Newtonian physics was not transmitted to Denmark until the middle of the 18th century by the mathematician and philosopher Jens Kraft (1720–1765)[1]. He was a teacher at the Academy of Sorø and never worked at the University of Copenhagen. Therefore his influence was both slow in coming and weaker than might be expected. Thus, it was the astronomer and mathematician Thomas Bugge (1740–1815) who first introduced Newton in the teaching of natural philosophy and astronomy at the University, after having succeeded Christian P. Horrebow as a professor in 1777. At the same time he removed Cartesian ideas from the curriculum.

However, the final victory was yet to come. The famous physicist Hans Christian Ørsted (1777–1851) was the most influential Danish scientist in the first half of the 19th century. He was an adherent of Immanuel Kant (1724–1804) and romantic natural philosphy (Naturphilosophie), which nurtured force concepts quite different from that of Newton. He also argued vehemently against emphasizing mathematics in natural science. Thus, Newtonian mechanics did not gain support at the University of Copenhagen until late 19th century. However, it must be mentioned that Ørsted supported heliocentrism and treated both Kepler's laws and Newton's law of gravity in his teaching[2].

Iceland: The 17th century – University of Copenhagen takes over

The settlement of Iceland started about 870 and seems to have taken about 60 years until the country was fully settled[3]. One of the historical prerequisites for this was the ability to sail and navigate to this distant island in an organised way. As we have already mentioned astronomical observations were gradually utilized for this purpose. Also, textual sources show that an indigenous calendar was used and improved until the advent of the Julian calendar of the church in the 11th century[4].

Organized education was also concomitant with the Christianization of year 1000. Icelanders sought education in European schools from 11th century onwards, presumably in the Rhine area, eastern France and elsewhere. Monasteries were established in Iceland from the 11th century and operated as centres of learning and education as well as channels for import of knowledge and ideas from abroad. A school was also established at one of the sees in the beginning of the 12th century.

The rich heritage of medieval manuscripts in the vernacular shows that knowledge of astronomy and related matters was present as might be expected in an isolated society with a need for organized action and depending on seafaring and navigation. This knowledge was partly imported from the continent and partly indigenous, deriving from practical, local needs.

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[1] M. Pihl (ed.), *Københavns Universitet 1479–1979* ... , O. Pedersen, *Det længere perspektiv*, C. H. Koch, *Den danske filosofis historie* ... .

[2] See O. Pedersen, *Det længere perspektiv*.

[3] For Icelandic history in general see G. Karlsson, *Iceland's 1100 Years* ... .

[4] Th. Vilhjálmsson, *Time and Travel in Old Norse Society*, Th. Vilhjálmsson, *The Subarctic Horizon as a Sundial* and Th. Vilhjálmsson, *Old Norse Navigation: Hardware or Software?* and references there.

In the late 13th century Iceland came under Norwegian dominance and later followed Norway when it was integrated in the Kalmar Union under the Danish throne. The literary activity declined in this late medieval period and the historical sources are rather scarce. This, however, changes considerably in the 16th century at the advent of the Reformation with its strengthening of the royal powers in the protestant countries, etc. Thus, for instance, the University of Copenhagen, established in 1479, now became *the* university of Iceland where young Icelanders would go for education in theology and later also in other fields.

In the 16th–18th centuries it was quite common in European universities that the students gave lectures in public, so–called disputations, on various fields of study. The texts were often printed in small numbers at the cost of the author or his patrons. Most of these writings were unimportant although more essential works can be found in between. Among the latter are the disputations by Icelandic students on astronomy, cosmology and natural philosophy to be discussed in the following. These disputations are all in Latin, which has until recently hampered their accessibility to Icelandic scholars, since combined knowledge of Latin and natural science is not very common nowadays.

Powerful Bishops

The first Icelandic student of the University of Copenhagen who was culturally active on his return back home was Gudbrandur Thorláksson (c. 1542–1627). He first studied at the gymnasium of the Hólar see and then at the University of Copenhagen in 1561–1564, at a similar time as Tycho Brahe. After his return he started as a schoolmaster at Hólar but soon became a bishop for the rest of his life. He was quite skilled in mathematical arts, published books on calendar matters and was involved in geodesic measurements of the latitude of Hólar, laying the foundations for maps of Iceland for the next century or so.

We can safely assume that Thorláksson adhered to Ptolemaic geocentrism although he presumably heard about Copernican theory and Tycho Brahe's geocentric view, both through Danish contacts and from his student and collaborator Oddur Einarsson (1559–1630). Einarsson first studied at Hólar and then in Copenhagen in 1580–1584. In 1585 he stayed for a while with Tycho at Hven and visited him again in 1589. After the first visit he became schoolmaster at Hólar and after the second visit he was installed as a bishop at the other Icelandic see at Skálholt. He must have known the theories of Copernicus and Tycho although we have no direct sources to that effect.

The third bishop to be mentioned was not the least influential one. Brynjólfur Sveinsson (1605–1675) started his education at the school of Skálholt and then studied at the University of Copenhagen in 1624–1629. He was conrector at the gymnasium in Roskilde in 1632–1638 but then the king called upon him to be installed as a bishop at Skálholt.

Sveinsson's tutor (præceptor privatus) in Copenhagen was Caspar Bartholin the older (see above). Sveinsson was also influenced by the teachings of Ramus. He seems generally to have been quite well informed on most of the arts of learning and had an excellent library of books in Greek and Latin.

However, he did not have any books by Copernicus or Brahe although he must have known about their theories. But following the pietist spirit of the time it is not likely that he has treated such topics in his sermons.

As an example of Sveinsson's contacts we can mention that in 1633 Hans Nansen (1598–1667), a vigorous Iceland merchant, later a major of Copenhagen and a friend of Sveinsson, published a book called *Compendium cosmographicum*, treating, among other things, the Tychonian system. This book is known to have been in Iceland and a translation is extant in manuscript.

Enthusiastic Students

In the years around and after 1640 there were several Icelandic students in Copenhagen who took great interest in natural philosophy and mathematical arts of learning, although they had other main fields of study.

A member of this group was the first Icelander who studied mathematics and astronomy at the University beyond obligatory classes, Gísli Einarsson (c. 1621–1688)[1]. In 1649 he became the first royally appointed teacher of these subjects in Iceland, at the Skálholt School under the auspices of bishop Brynjólfur Sveinsson. Before leaving Copenhagen he calculated the Danish almanac for 1650. At the end of the book we find a chapter on the history of astronomy which mentions *the very intelligent man, Nicolas Copernicus* who has put forward the ancient view of the motion of the Earth. The reception of Copernicus' work is reported without taking a stand on his theories. At the end Tycho Brahe is also mentioned. The identity of the author of this almanac chapter is not known but probably many Icelanders have read the almanac which was used in the country at this time.

The only one of the group who had the opportunity of really applying his interest to mathematics in Iceland was Runólfur Jónsson (c.1620–1654). He became schoolmaster at Hólar in 1645 and occupied himself with mathematics, measured the local latitude and made an attempt to determine the longitude, which of course is much more difficult. In 1649 he moved again to Denmark and settled there. He ran a school of natural philosophy in Copenhagen in 1649–1651 and twelve of his pupils delivered disputations in 1652. There are reports that no less than 10 of these were Icelanders. The disputations were probably printed in a book of which we only know the name, since it is not extant. There are indications that they were based on *Systema physicum* by Caspar Bartholin the elder.

Jónsson's teaching may have been somehow related to another informal school run at the same time in Copenhagen by Jens Jensen Bircherod (1623–1686) who later became a professor at the University. In 1650–1651 disputations by students of Bircherod were published by him, all of them extant. The eighth of them is by Gísli Thorláksson (1631–1684), son of the bishop at Hólar and later to succeed his father. The disputation is titled *De stellis fixis et errantibus*[2]. It is the oldest printed work on astronomy by an Icelandic author

[1] E. H. Guðmundsson, *Gísli Einarsson skólameistari og vísindaáhugi á Íslandi á 17. öld.*

[2] G. Thorláksson, *Collegii Physici Disputatio Octava De Stellis Fixis et Errantibus.*

and gives a high quality introduction to the astronomy being taught at this time at the University of Copenhagen.

The disputation is 9 pages (quarto), divided into 32 sections or theses. In the introduction the author states that the luminous army of the stars seems to be created in order to sharpen and form human intelligence. Sections 2–24 contain a fairly thorough discussion of astronomy and cosmology, mainly following Caspar Bartholin's *Systema Physicum.* However, the emphasis is often different and Thorláksson may also have used the main work of Longomontanus, *Astronomia Danica.* The text of these 23 sections is exceptionally clear and concise whereas the remaining 8 sections, 25–32, treat astrology and related medicine and are less informative from a modern point of view.

The author starts by describing the difference between fixed stars and planets. He then discusses the number of visible fixed stars and how they are organized in constellations. He also mentions the huge multitude of stars, which can be seen in a telescope. He describes the classification of stars according to magnitude and lists their sizes, using data from Tycho Brahe. In section 5 the author discusses the Cartesian theory of vortices, referring to Descartes' recently published *Principia philosophiae* from 1644. Thorláksson seems to be the first author to discuss this theory in print in Denmark[1].

The next two sections treat the diurnal circular motion of the fixed stars and its explanation. The author clearly adheres to geocentrism like Bartholin but he prefers to follow Longomontanus and Copernicus as to the axial rotation of the earth. He follows Brahe in taking the stellar sphere to be at the distance of 14.000 earth radii from the centre of the earth. He also assumes the earth radius to be 860 German miles or 6400 km, which is quite close to the modern value. He then finds the speed of the fixed stars to be 6500 km/s in modern units, which he finds unlikely and says:

This has caused others to prefer to attribute motion to the Earth, although not the annual motion which the Bible openly ascribes to the Sun (Psalms, 19:6–7), but rather the daily motion, which, however, seems also to contradict the Scripture since it also attributes daily motion to the stars (Joshua 10:13; Eucharist 1:5).

Then the author briefly discusses the nature of the stars, which he predicts to be impossible to determine exactly. This is followed by a discussion of *the lower or nearer parts of the sky*, including the question of planetary parallax. He states that such measurements show beyond doubt that the planets are much closer to us than the fixed stars. The reason must be that the Earth is itself the centre relative to the heavens of the stars, and therefore there can only be a tiny apparent difference if the firmament is viewed from the surface of the Earth rather than its centre.

The next subject is the order of the planets as seen from the Earth. The author tells us that various authors have suggested an order different from that of traditional ancient geocentrism. Still, nobody has turned the Ptolemaic system as radically around as the renowned Copernicus ... who completely fol-

[1] K. P. Moesgaard, *How Copernicanism Took Root in Denmark and Norway.*

lowed the order proposed by Aristarchos of Samos 400 years before Ptolemy and put the Sun motionless at the centre of the world. ... By this theory Copernicus gave an ingenuous account of the celestial phenomena. Hence, in his times and in the next generations many and important people came to support his theory.

Then Thorláksson describes the Tychonian geocentric system and discusses the criticism of the Copernicans to the effect that neither Ptolemy nor Brahe have given solid arguments for the Earth being at the centre of the Universe. But their tenacity is obvious since they have themselves not yet shown that the Sun should be put at the centre of the world. Why do they demand from others what they have not accomplished themselves?

The author also rejects the heliocentric argument that it is in discordance with nature that the world should have two centres as in the Tychonian system. There he finds them *killing themselves with their own sword* because the heliocentric universe has at least two centres, the Sun and the Earth, which is the centre of the lunar orbit.

In the last sections of the disputation Gísli discusses several subjects related to natural philosophy. He tells us that the Sun is the only planet actively radiating light and also informs the reader on sunspots and on the apparent seas and mountains seen on the moon through a telescope.

This summary shows that the author is well versed in the arguments of the dispute between the geocentric and heliocentric systems. He reports on these arguments in a clear and concise way although he indirectly supports the Tychonian geocentric compromise. He is milder in his judgment of Copernicanism than earlier Danish authors, cf. e. g. *Systema physicum* by Caspar Bartholin. He is clearly well informed on his subject and has a talent for a clear exposition of ideas, which are not particularly simple.

As far as we know Gísli Thorláksson did not occupy himself markedly with astronomy or natural philosophy after his return to Iceland. However, in 1671 he published *Calendarium*, a handbook with a perpetual calendar, popularly called *Gíslarím*,[1] but its author was in fact his brother Thórdur Thorláksson (1637–1697) who had just returned from his studies in Copenhagen and later in various universities of northern Europe. He was at this time already preparing himself for taking over the see of Skálholt from Brynjólfur Sveinsson, which he did in 1674.

Thórdur Thorláksson was a gifted scholar besides being quite skilled manually. He wrote a remarkable *Description of Iceland*, published many books, measured the geographical position of Skálholt and made maps of Iceland and the Nordic countries. In 1692 he published a second edition of *Calendarium* under a different name[2]. Appended to the book were chapters on time reckoning, the lunar phases, the planets, the zodiac and other subjects. Rather surprisingly, the cosmology presented is deliberately that of late medieval geocentrism. This is probably due to the pietism and orthodoxy of

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[1] Th. Thorláksson, *Calendarium: Edur Islendskt Rijm ...* .

[2] Th. Thorláksson, *Calendarium Perpetuum Ævarande Tijmatal ...* .

the day, since the author's education at several of the most important universities of Europe surely must have brought to his knowledge both Copernican, Tychonian and Cartesian ideas.

The Early 18th Century

Two Bright Students

In the year 1700 the Gregorian calendar was established in the Danish kingdom, the transition being directed by Ole Rømer. The first Icelandic calendar of the new style, *Calendarium Gregorianum*, was published in 1707, written by bishop Jón Árnason (1665–1743)[1]. This publication contained no material on the world system.

In the first decade of the 18th century two bright Icelandic students were studying at the University of Copenhagen, both of them giving several disputations that are extant. Thorleifur Halldórsson (c. 1683–1713) was the more philosophically minded of the two, whereas Magnús Arason (c. 1683–1728) was more inclined towards the mathematical arts. Both of them were good linguists and wrote poetry in Latin as was customary for such people at this time.

The curriculum in natural philosophy at the University was very much influenced by Descartes at this time, the main textbook being *Specimen philosophiæ naturalis* by Caspar Bartholin the younger. However, both Halldórsson and Arason also read other works and the latter took a special interest in astronomy and mathematics, being tutored by Ole Rømer. He expressed his gratitude to Rømer in a long extant eulogy in verse from 1710[2].

Both of the two students finished their studies in 1710 and Halldórsson returned home soon after to work as a schoolmaster at the school of Hólar. However, he died very prematurely from tuberculosis in 1713, only 30 years old. Arason, on the other hand, entered the Danish army as a captain of the engineering team. He was sent to Iceland in 1721 for geodetical work and managed to send some maps back to Denmark before he drowned in 1728 at the age of 45.

Halldórsson is now best known in Iceland for his book called *Lof lyginnar* [*In praise of lying*] which he originally wrote in Latin but translated to Icelandic in 1711. The book was first published in 1915 and then in 1988[3] in a popular and well known series of books on philosophy and related matters. There the author briefly discusses the *art of astronomy* and makes it clear that he adheres to heliocentrism.

In his Copenhagen years Halldórsson gave 5 disputations. All of them were printed and are extant. The first one is on the origin of astronomy among the Babylonians, the second on the fixed stars and the third on the Pythagorean theory of celestial harmony. The last two are on theology and philosophy

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[1] J. Árnason, *Calendarium Gregorianum* ... .

[2] M. Arason, *Tristissimum obitum Viri Inter Mortales* ... .

[3] Th. Halldórsson, *Lof lýginnar*.

and need not concern us here[1].

Magnús Arason also gave 5 disputations. Three of them form a coherent series on the phases of the Moon and related matters and will be described in the following, while the other two treat subjects related to geodesy and will not be further discussed here. From these disputations it emerges that the author is quite skilled in the mathematical arts and does not hesitate to show his calculations when he finds it appropriate. He also clearly shows that he supports the heliocentric theory in the Keplerian version.

Interesting Disputations

The disputation of Halldórsson which is most interesting in the present context is 10 pages in quarto and has the title *De aplane* [*On the Firmament*][2]. It is quite different from the previously described disputation by Gísli Thorláksson. The approach is much more philosophical with the author striving to give arguments for and against various ideas on the firmament. For instance, in the first two sections on the names of the firmament and the number of spheres he mentions the views and theories of Christoph Scheiner (1573–1650), Galileo, Descartes, van Lansberge, Anaximander (c. 610 – c. 545 BC), Hipparchus (fl. c. 150 BC), Ptolemy, Peurbach, Brahe and Descartes.

The third section treats the difference between the planets and the fixed stars. Here the author's support for the Copernican view is very clear. In the fourth section Thorleifur disputes the addition of a ninth and a tenth sphere in order to get the eleventh sphere, solely for theological purposes.

In discussing the distances to the fixed stars Halldórsson points out the surprising disagreement among scholars on that subject. He does not consider himself to be able to resolve the dispute. However, he can not accept Bruno's idea of an infinite universe although it might be without limits *as Descartes and his followers have phrased it so succinctly.*

When the author comes to the subject of the speed of the fixed stars, he gives, among others, the same figures as previously mentioned in the description of Gísli's treatment. But he also quotes much higher values derived by other authors and other considerations. He concludes by the statement that the huge size implied by Copernicus is more trustworthy than the absurd speed obtained by the Ptolemaic theory.

At the end of the seventh chapter the author quotes Galileo's discussion in *Dialogo* on the extension of the space of the fixed stars, and declares his support for the view given in Galileo's text, that the stellar universe is embedded between two spheres of different radii.

The disputation is well written and shows the comprehensive knowledge of the author. However, it can be seen from the presentation that the author does not have much training in the mathematical arts, beyond what was given in the first year at the University of Copenhagen. Thorleifur Halldórsson did not receive the tutorship of Ole Rømer like his countryman Magnús Arason.

[1] Library cards for all of the disputations of Halldórsson and Arason can easily be found by entering their names at the Icelandic library catalogue website gegnir.is.

[2] Th. Halldórsson, *Schediasma Mathematicum de Aplane*, Hafniæ 1707.

Magnús Arason's disputations on the phases of the moon form a series in three parts which were published in 1708–1710[1]. In total, there are 15 chapters on 22 pages in quarto. The author is clearly well read and has a good knowledge of his subject.

The first disputation is historically oriented and treats an ancient object of dispute: *Whether the Moon emits light on its own or borrows the light from the Sun.* The author quotes several of the ancient Greek writers who thought that the Moon emits light by itself. Then he states that this is contradicted by experience and that most well–informed contemporary authors adhere to the opposite view, that the moon is illuminated by the Sun. For support of this he quotes Kepler's work, *Astronomia Pars Optica*, from 1604.

Arason refers to more recent authors, like Reinhold in his comments on Peurbach's book on the planets, who have stated that the moon emits some kind of a special, dim light and its nature is easily observed in a total lunar eclipse when the total lunar disk faces us in sombre and horrible colours. He says that authors disagree on the cause of this but he agrees with Kepler who gives the correct explanation that during a new moon and a solar eclipse the moon is dimly illuminated be light reflected from the earth (earthshine).

Then Arason discusses various ideas on how the sunlight is reflected from the surface of the Moon. As before he refers to various ancient, medieval and more moderns scholars, such as Scheiner, Giuseppe Biancani (1566–1624), Galileo and Kepler.

After this comprehensive introduction on moonlight the author comes to the main subject, that of the phases. He discusses the origin of the word and gives a detailed description of the variable appearance of the moon depending on its position relative to the Sun. He briefly discusses the relevance of the phases for the various calendars, referring to al–Battani (c.855–929), Giovanni Riccioli (1598–1671) and Joseph Scaliger (1540–1609).

Finally Arason mentions that the phases do not divide the lunar month into equal parts. *This is prevented by some uneven motion of the Moon, because it moves a little faster at new moon and full moon than at other quarters.* He quotes Kepler in the Rudolphine Tables complaining about this irregularity, saying that *this arrogant and disobedient star still deviates every now and then from its orbit.*

The second and shortest disputation of Magnús Arason is from 1709 and treats old and new ideas concerning an atmosphere on the Moon. The author reports that both Galileo and Mästlin think that the moon is surrounded by air which is quite suitable for reflecting the sun's rays. Arason maintains on the contrary that the Moon has no atmosphere as we can see when fixed stars disappear behind the Moon and appear again and are clearly seen in a telescope close to the lunar edge.

Then the author discusses in some detail the fact that at any time except for a lunar eclipse more than half of the moon is illuminated by the Sun, the

[1] M. Arason, *Phases Lunæ Dissertatione Mathematica I Adumbratæ*, M. Arason, *Phases Lunæ, Disputatione Mathematica II Adumbratæ* and M. Arason, *Phases Lunæ Thesibus Mathematicis Loco Disputationis III Adumbratæ*.

reason being that the Sun is larger than the Moon. For this he quotes Arabic and late medieval European scholars.

The second disputation ends with a discussion on popular beliefs on the supposed connection between lunar phases and weather. He rejects such a causal connection with good arguments.

In the third disputation we find subjects which have to do with astronomical calculations and cosmology. Arason applies the method of Aristarchos of Samos for finding the sun's distance. He finds it to be 25.800 Earth radii which is not too far from Christiaan Huygens' (1629–1695) result from 1659. For the calculation he uses logarithms and the sine rule of trigonometry. By using Kepler's third law he is subsequently able to find the orbital radii of all the other planets.

Arason ends the third disputation by discussing the determination of geographical longitude which was of such predominant importance for navigation at the time. He says that normally longitude is found by following celestial events which can be timed at various places. For instance, it is possible to use lunar and solar eclipses for this purpose, and also the eclipses of the Jovian moons. He then states that it should also be possible to use the phases of the Moon and the timing of light falling on to easily recognizable places or landmarks on its surface.

Thorleifur Halldórsson and Magnús Arason are the first Icelanders to treat the works of Galileo and Kepler, while a search for Newton's ideas in their writings will be in vain. Although some 20 years had passed since the publication of *Principia*, it seems that Newton's ideas had not yet reached the University of Copenhagen.

The Enlightenment

A Diligent Mathematical Scholar

The Enlightenment in Iceland started a little after the middle of the 18th century when we see the first writings unambiguously reflecting the ideas of this new movement. Among the leaders of the movement were several scholars who were well–versed in astronomy and natural philosophy and wrote on such subjects. This holds for Stefán Björnsson (c. 1721–1798), applied mathematician in Copenhagen, Hannes Finnsson (1739–1796), bishop in Skálholt, and Magnús Stephensen (1762–1833), chief of justice in Reykjavík.

Stefán Björnsson started his education at the gymnasium of Hólar and then studied theology at the University of Copenhagen[1]. After finishing his degree he became schoolmaster at Hólar but soon came into conflict with powerful people. He then returned to the University to study natural philosophy and mathematics. He subsequently worked for a long period on geodesy, especially on data processing, for the Royal Danish Academy of Science. He published a noteworthy book on quadrangles in 1780[2] and was the first Icelander to earn the Golden Medal for Mathematics at the University

[1] One of the present authors has recently written two papers on Stefán: E. H. Guðmundsson, *Stefán Björnsson reiknimeistari* and E. H. Guðmundsson, *Ferhyrningar, halastjörnur og grunnmaskínur* ... .

[2] S. Björnsson, *Introductio in Tetragonometriam ad Mentem V. C. Lambert.*

of Copenhagen in 1793. In 1780, he edited the first scholarly edition of *Rímbegla*, a well known medieval Icelandic manuscript on calendar, computus and astronomy[1]. The edition includes his translation of the text into Latin. In the period 1782–1794 he wrote various educational articles in the spirit of the Enlightenment on the subjects of mechanics, geodesy and meteorology. They were in Icelandic and were published in the Journal of the Lærdómslistafélag (see below).

Before he started his work for the Academy Björnsson published four disputations in Copenhagen, all of which are extant. Two of them are on philosophical subjects, influenced by G. W. Leibniz (1646–1716) and his follower Christian Wolff (1679–1754).

Two other disputations of Stefán Björnsson discuss astronomy and natural philosophy. In the first one[2] it is clear that the author knows Newtonian mechanics quite well and quotes *Principia* among other writings. He writes extensively on the law of gravitation and describes how comets move under the gravitational influence of the Sun. He also discusses the effect of comets on the motion of the Sun and the planets and on the tides. The treatment is thoroughly based on Newtonian natural philosophy and cosmology. As far as Stefán Björnsson is concerned the Copernican Revolution is already over.

The title of the second disputation on natural philosophy refers, strangely enough, to medicine, which is not treated at all, but it refers also to the influence of the bodies of the solar system on the Earth through magnetism and light[3]. As Descartes and Aristotle had done before him, Björnsson thinks that vacuum does not exist and consequently opts for the ether to carry the gravitational forces from one body to another. He mentions that Leibniz and his supporters defend the ether theory whereas the Newtonians adhere to the existence of the vacuum. In this context he refers to a textbook by one of Newton's most influential continental supporters, W. J. 'sGravesande (1688–1742) in Leiden. Then Björnsson discusses extensively the properties of sunlight and its influence on the Earth, quoting Newton's *Opticks* of 1704 and his posthumous *Opuscula* of 1744, together with works by Hermann Boerhaave (1688–1738) and Robert Hooke (1635–1703).

Stefán Björnsson was the first Icelander who studied the works of Isaac Newton in some detail. It is not clear whether he was influenced by Jens Kraft in Sorø but he was without doubt one of the first scholars who openly discussed Newton's theory at the University of Copenhagen. Thomas Bugge, his later chief, had not started his teaching at the University when Björnsson gave his disputations.

Heavyweight Men of Learning

After matriculation from the school of Skálholt Hannes Finnsson continued his studies at the University of Copenhagen in 1755, when he was

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[1] S. Björnsson (ed.), *Rímbegla: Rymbegla sive Rudimentum Computi Ecclesiastici ...* .

[2] S. Björnsson, *Dissertatio de Effectu Cometarum Descendentium in Systema Nostrum Planetarium.*

[3] S. Björnsson, *Dissertatio de Usu Astronomiæ in Medicina, Cujus Præliminaria ...* .

16 years old. He studied mathematics and astronomy with Christian Horrebow who held him in high esteem. For instance, Horrebow recommended him as a teacher of mathematics at the Danish court in 1766, but he could not accept because he was going to Iceland. However, he returned to Copenhagen and stayed there until 1775. His lecture notes on natural philosophy and astronomy from the Copenhagen years are extant in manuscript. He succeeded his father as a bishop of Skálholt in 1785 and died in 1796.

Magnús Stephensen was a student of Finnsson before entering the Skálholt school where their relationship continued. He was a student in Copenhagen in 1781–1788, leaving various extant lecture notes. On returning to Iceland he became a top official and was prolific in publishing as well as writing all kinds of works for public education.

Societies of Learning

Among the media used by the Enlightenment movement were societies, journals and books for educating the public. Iceland was no exception in this respect. Thus, in 1779 twelve Icelanders gathered in Copenhagen to start the Icelandic Society for the Learned Arts (Hid íslenska lærdómslistafélag). It had on its agenda the promotion of science in the country, improving the taste of the people and increasing the interest in reading. In the years 1780–1794 the society published a journal, *Rit Lærdómslistafélagsins*, which in general appeared annually. It contained informative articles on various subjects, either original or translated.

Among other things the journal contained a translation from Danish of a quite readable book, *Undirvísan í náttúruhistoríunni* [*Teaching of Natural History*], by the German geographer Anton Friedrich Büsching (1724–1793). The work originally appeared in Berlin in 1776. Its subject is natural science, including astronomical world system. The presentation shows clearly that by this time heliocentrism has completely replaced geocentrism.

In 1794 a new society inspired by the Enlightenment was started at the Althingi [the Parliament], called Hid íslenska landsuppfrædingarfélag [The Icelandic Society for Education of the People]. Magnús Stephensen was the main instigator for this new society, supported by Hannes Finnsson and others. The society published journals, theological works, *Schönlitteratur,* children's books, and various educational writings.

Among the latter were several books by Magnús, including a good overview of contemporary cosmology in two papers from 1797. The society also published a collection of enlightening papers by Hannes Finnsson but the only paper on our subjects there was on comets. In 1798 the society published a translation of *An Essay on Man* by Alexander Pope. The English original text reflects the heliocentric theory although the Icelandic translation for some reason does not convey it in an appropriate way. Finally, in the same year, the society published a translation of a work by the Danish historian Peter Frederik Suhm (1728–1898) giving a fairly good overview of natural science in the late 18th century.

Conclusions

In the 17th and 18th century the ideas of informed Icelanders on cosmology and related matters seem generally to have been the same as those of their contemporaries in other countries, especially in Denmark. However, the smallness and isolation of the country, together with the canalization of the flow of ideas through Copenhagen, seem to have caused a considerable time lag relative to the centres of activity in this field.

Public and published communication on the world system among Icelanders seems to have been dominated by Icelandic students at the University of Copenhagen, which at this time was *the* university of Iceland. The discussion was closely related to studies in natural philosophy and astronomy and is available to posterity mainly through extant disputations in Latin. The students are predominantly in the role of commentators and we do not know any example of an Icelandic student stepping forward as a public proponent of heliocentrism at a critical stage, neither during the student years in Copenhagen nor afterwards in Iceland. Also, after the students turned into officials in their home country they tended to do almost nothing visible in order to present to their countrymen the ideas they had savoured during their studies.

Although learned Icelanders knew about the heliocentrism of Copernicus already in the beginning of the 17th century, and perhaps earlier, they did not support it, and geocentric theories were quite predominant in the country during the 17th century and most of the 18th. The majority of the learned men have probably supported the subtle geocentric theory of Tycho Brahe, which was the predominant world system in the teaching at the University of Copenhagen up to the late 17th century. However, the general public in Iceland will nonetheless have adhered to the late medieval geocentrism with amendments from the Reformation. Such ideas were presented to people through influential writings like *Gíslarím* and *Thórdarrím*.

It is not until the advent of the Enlightenment that we see things clearly changing. Then readable books in the vernacular on contemporary astronomy, natural philosophy and cosmology became accessible to the general reader. With the publications of Lærdómslistafélag and Landsuppfrædingarfélag in 1780–1798 we can safely say that the Copernican revolution in Iceland was complete.

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