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The Icelandic Copernicans

(1) Introduction

For geographical reasons it took some time for Copernican heliocentrism to become known and gain support in Iceland. Probably the first news of it broke on Iceland in the 16th century but it was not until the late 18th century that the Copernican Revolution was finished in Denmark and Iceland.

This electronic paper is an abridged version of a longer paper to be printed in the Polish journal *Organon.*[1] Here the focus is on the 16th–18th century Icelandic scholars who learned about Copernicanism abroad and imported it to Iceland. We only outline the background, such as the general story of Copernicanism in Europe and in particular at the University of Copenhagen (UC).

The most important sources for the paper are disputations in Latin, written by Icelanders at the UC and printed, 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.

(2) The Copernican revolution

The gradual dissemination of Copernican cosmology in Europe involved the interplay of computational advantages, various novel celestial discoveries, discussions on the nature of gravity and inertia, etc. It is not so strange that this process took time. Thus, it took 100–150 years to collect the data and ideas which by hindsight seem necessary for the new theory to be completely convincing for people thinking in a scientific way.

As a part of this process the Danish astronomer Tycho Brahe (1546–1601) presented 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 now obsolete, this view gained support in its own time. This may seem weird to us but was in fact quite well-argued at the time, due to the scarce evidence for the pure Copernican view. Because of Tycho's nationality Danish scholars tended to adhere to this system for almost two centuries.

We can only mention the work of Johannes Kepler (1571–1630) and Galileo Galilei (1546–1642). The scholars involved at this time felt a strong need for physical considerations in astronomical cosmology. The crowning achievement was the mechanics of Isaac Newton (1642–1727). The balance of evidence, empirical and theoretical, had by then definitely turned in favour of Copernicanism.

(3) The Danish intermediary

As in other European countries 16th century students at the UC would read Sacrobosco's *De Sphaera* in various editions.[2] Later in the studies it might be followed by other authors. Professor Jørgen Dybvad (d. 1612) drew attention to heliocentrism in a work of 1569.[3]

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[1] See *Organon*, vol. 35, 2006, p. 85–103. The printed *Organon* paper is in turn based on a longer article in Icelandic: Gudmundsson, Einar H., Eyjólfur Kolbeins and Thorsteinn Vilhjálmsson, 2006. "Heimsmyndin í ritum lærðra Íslendinga á sautjándu og átjándu öld." In *Brynjólfur biskup: Kirkjuhöfðingi, fræðimaður og skáld*. (eds.) Jón Pálsson, Sigurður Pétursson and Torfi H. Tulinius (Reykjavík: Háskólaútgáfan), pp. 247–291.

[2] See, e.g., Thorndike (1949): *The Sphere of Sacrobosco and its commentators* (Chicago: University of C. Press).

[3] See Pihl, M. (ed.) (1983): *Københavns Universitet 1479–1979. Bind XII: Det matematisk-naturvidenskabelige*

Tycho Brahe gave lectures in 1574–1575 on heliocentrism at the request of the king and the UC authorities. This shows that the new view had aroused interest. Tycho had applied his skills to the problem of the parallax of fixed stars, but in vain. Subsequently he rejected Copernicanism and proposed a compromise system. The Tychonian heritage was well kept at UC. Two of Tycho's disciples became professors there and shaped new study material which was used for a long time.

In 1628 Caspar Bartholin (1585–1629) published a textbook on natural philosophy to be used at UC until 1690.[4] In 1656 Rasmus Bartholin (1625–1698), son of Caspar, started teaching at UC, transmitting Cartesian ideas.[5] Ole Rømer (1644–1710) was his disciple and adhered to Cartesian theory, including heliocentrism. In 1690 a book by Caspar T. Bartholin (1655–1738) replaced that of his grandfather, rejecting ancient geocentrism. He was more inclined towards heliocentrism than Tychonianism.[6] Cartesianism held its stand at the University up to the mid-18th century.[7]

Newtonian physics was not introduced in Denmark until the middle of the 18th century by Jens Kraft (1720–1765) [8] who never worked at UC. Therefore his influence was both slow and weak and it was Thomas Bugge (1740–1815) who first introduced Newton at UC, after gaining a chair in 1777. He also removed Cartesian ideas from the curriculum.

Hans Christian Ørsted (1777–1851) was the most influential Danish scientist in the early 19th century. He adhered to Kantian ideas and romantic natural philosphy (Naturphilosophie) with force concepts different from that of Newton. He also disliked too much math in natural science. Thus, Newtonian mechanics did not finally enter UC until late 19th century. However, Ørsted supported heliocentrism and treated both Kepler's laws and Newton's law of gravity in his teaching.[9]

(4) Iceland: The 16th and 17th century

The settlement of Iceland started about 870.[10] One of its prerequisites was the ability to sail and navigate, which induced the use of astronomy.[11] Later, organized education followed the Christianization of year 1000. Icelanders sought education on the Euoropean continent and monasteries were established in Iceland from the 11th century. They operated as centres of learning and education as well as channels for import of knowledge and ideas. A school was also established at one of the sees in the early 12th century. — Medieval manuscripts in the vernacular show knowledge of astronomy and related matters as might be expected in an isolated society with a need for organized action, seafaring and navigation. This knowledge was partly imported and partly indigenous, deriving from practical, local needs. — In the late 13th century Iceland came under Norwegian dominance and later the Danish throne. The literary activity declined in the late Middle Ages. This, however, changes in the 16th century with the Reformation and its strengthening of royal power, etc. Thus UC, started in 1479, now became *the* University of Iceland, giving education in theology and other fields.

In the 16th–18th centuries students at European universities often gave public lectures, so-called disputations. The texts would be printed in small numbers at the cost of the author or his patrons. Most

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Fakultet - 1. del. Copenhagen 1983; Moesgaard, K.P. (1972): "How Copernicanism Took Root in Denmark and Norway." *Études sur l'audience de la théorie héliocentrique,* (ed.) J. Dobrzycki (= *Studia Copernicana* 5 (1972), pp. 117–151.

4 See Moesgaard K.P., *op. cit.*; Ebbesen S. and Koch C. H. (2003), *Den danske filosofis historie: Dansk filosofi i renæssancen, 1537–1700* (Copenhagen).

5 Pihl, *op. cit.*

6 Ebbesen and Koch, *op.cit.*

7 Pihl, *op. cit.*.

8 Pihl, *op. cit.*; Pedersen, Olaf (1987): "Det længere perspektiv", in: *Hans Christian Ørsted*. Eds. F. J. Billeskov Jansen, E. Snorrason and C. Lauritz-Jensen (IFV-energi i/s (Isefjordværket)), pp. 142–166; Koch, C. H. (2003): *Den danske filosofis historie: Dansk oplysningsfilosofi, 1700–1800* (Copenhagen).

9 See Pedersen, *op.cit*.

10 For Icelandic history in general see Karlsson, Gunnar (2000), *Iceland's 1100 Years: The History of a Marginal Society* (London: Hurst & Co.).

11 See Vilhjálmsson, Thorsteinn, (2006): "Old Norse Navigation: Hardware or Software?", in: *Viewing the Sky: Through Past and Present Cultures*, eds. T.W. Bostwick and B. Bates, p. 63–376 (Phoenix: Pueblo Grande Museum) and references there.

of these were unimportant although more essential works can be found in between. Among the latter are disputations in Latin by Icelandic students on astronomy, cosmology and natural philosophy.

The first Icelandic student of the UC who was culturally active on his return back home was Gudbrandur Thorláksson (c. 1542–1627). He studied at at the University in 1561–1564, at a similar time as Tycho Brahe. Returning home he started as a schoolmaster at Hólar but soon became a bishop there 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.

Thorláksson must have adhered to Ptolemaic geocentrism although he probably heard about Copernicanism and Tycho Brahe's geocentrism, through Danish contacts and from his collaborator Oddur Einarsson (1559–1630). Einarsson first studied at UC in 1580–1584. In 1585 he stayed with Tycho at Hven and visited him again in 1589. Later he became a schoolmaster and a bishop at Skálholt. He must have known the theories of Copernicus and Tycho even if sources for it are missing.

Brynjólfur Sveinsson (1605–1675), studied at UC in 1624–1629. He was conrector at the gymnasium in Roskilde in 1632–1638. Then the king wanted him to become bishop at Skálholt. Sveinsson's tutor (præceptor privatus) in Copenhagen was Caspar Bartholin the older (see above). Sveinsson seems generally to have been quite well informed on most of the arts of learning and he had an excellent library. He must have known about Copernicanism and Tychonianism, but following the pietist spirit of the time he is not likely to have treated such topics in his sermons.

In the years around and after 1640 several Icelandic students at UC took great interest in natural philosophy and mathematical arts of learning, although they had other main fields of study. One of them was the first Icelander who studied mathematics and astronomy at UC beyond obligatory classes, Gísli Einarsson (c. 1621–1688).[12] In 1649 he became the first royally appointed teacher of these subjects in Iceland. Before leaving Copenhagen he calculated the Danish almanac for 1650. The book contains a chapter on the history of astronomy mentioning "the very intelligent man, Nicolas Copernicus". The reception of Copernicanism is reported without taking a stand. The identity of the author of this chapter is not known but probably many Icelanders have read the almanac.

The only one of the group applying his interest to mathematics in Iceland was Runólfur Jónsson (c.1620–1654). He became schoolmaster at Hólar in 1645 and measured the local latitude and made an attempt to determine the longitude. In 1649 he moved again to Denmark and settled there. He ran a school of natural philosophy in Copenhagen in 1649–1651 and no less than 10 of his Icelandic pupils delivered disputations in 1652. The disputations were probably printed in a book which is not extant.

In 1650–1651 a disputation by Gísli Thorláksson (1631–1684) was published with the title *De stellis fixis et errantibus*.[13] It is the oldest extant printed work on astronomy by an Icelander and gives a high quality introduction to the classes of the time at UC. It is 9 pages (quarto), divided into 32 sections or theses.[14] Sections 2–24 contain a discussion of astronomy and cosmology, mainly following Caspar Bartholin. However, the emphasis is often different and Thorláksson may also have used other works. 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 the 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. He also treats the Cartesian theory of vortices and seems to be the first author to discuss this in print in Denmark.[15] Then he turns to the diurnal motion of the fixed stars and its explanation. The author clearly adheres to geocentrism like Bartholin but follows Longomontanus and Copernicus on the axial rotation of the Earth. He follows Brahe in taking the stellar sphere to be at the distance of 14.000 Earth radii. He also assumes the Earth radius to be 860

[12] Guðmundsson, Einar H. (1998): "Gísli Einarsson skólameistari og vísindaáhugi á Íslandi á 17. öld", *Saga*, 36, p. 185–231.

[13] Thorláksson, Gísli (1651): *Collegii Physici Disputatio Octava De Stellis Fixis et Errantibus* (Hafniæ).

[14] *Ibid.*, sec. 1: [T]um maxime ad ingenium hominum acuendum informandumq; factus esse videtur splendidissimus ille cælestium Syderum exercitus.

[15] Moesgaard, *op. cit.*

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).[16]

A brief and inconclusive discussion of the nature of the stars is followed by a discussion of "the lower or nearer parts of the sky", including 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.[17]

The next subject is the order of the planets as seen from the Earth. 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 followed the system proposed by Aristarchos of Samos 400 years before Ptolemy and put the Sun motionless at the centre of the world. ... By this hypothesis 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.[18]

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 unfairness is obvious for all 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? [19]

The author rejects the heliocentric argument that the world can not have two centres as in Tycho's system. He finds the Copernicans "killing themselves with their own sword" [20] 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 Thorláksson 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. We see that the author is well versed in the arguments on the geocentric and heliocentric systems. He indirectly supports the Tychonian compromise but is milder in his judgment of Copernicanism than earlier Danish authors. He shows a talent for a clear exposition of ideas, which are not very 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

[16] Thorláksson, *op. cit.*, sec. VII: ... [Q]vod alios movit, ut potius terræ motum asscriberent, at non qvidem annuum, qvem Soli aperte tribuit scriptura, Psalm. 19.v.6.7. Sed saltem diurnuum, qvi tamen cum Scriptura etiam pugnare videtur, cum illa Stellis etiam motum diurnum assignet Jos. 10.13. Eccl. I.V.5.

[17] *Ibid*, sec. X: [C]um terra respectu cæli stellati ipsum centrum sit: ideoqve aut nulla aut perexigua fieri possit aspectuum diversitas, sive ex centro terræ, sive ex superficie ad stellas firmamenti visus dirigatur.

[18] *Ibid*, sec. XIII: Nemo fuit omnium qvi Ptolemaicum Systema magis inverteret, qvam celeberrimus Copernicus. Hic enim ordinem ab Aristarcho annis 400 ante Ptolemæi tempora propugnatum per omnia secutus, Solem immobilem in centro mundi constituit, ... Ex qva hypothesi phænomena cælestia Copernicus ingeniose demonstravit. Qvo factum, ut plurimos suo seculo pariter ac subseqventibus habuerit habeatq; etiam num magni nominis sectatores.

[19] *Ibid*, sec. XV: [Qvod] neq; Tycho neq; Ptolemæus firmiter demonstratum reliqverint, terram in centro universi sitam esse. Id qvod qvam iniqve faciant, neminem latere potest, cum ipsi nondum solide demonstratum dederint, qvod Sol in medio mundi collocari debeat. Cur igitur ab aliis postulant qvod ipsi præstare neqveunt?

[20] *Ibid*, sec. XVI: In eo proprio se jugulant gladio.

perpetual calendar, popularly called *Gíslarím*,[21] but its author was in fact his brother Thórdur Thorláksson (1637–1697) who had just returned from his studies in Copenhagen and other European cities and who later became bishop at Skálholt. 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,[22] with chapters on time reckoning, 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 the day, since the educated author must have known about both Copernican, Tychonian and Cartesian ideas.

(5) The early 18th century

In the year 1700 the Gregorian calendar was established in Denmark, under the direction of Rømer. The first Icelandic calendar of the new style, *Calendarium Gregorianum*, appeared in 1707, written by bishop Jón Árnason (1665–1743).[23] This publication contained no material on the world system.

In the first decade of the 18th century two bright Icelandic students were studying at UC, 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 mathematics. Both of them were good linguists and wrote poetry in Latin as was customary at this time. — The curriculum in natural philosophy at UC was quite influenced by Descartes, the main textbook being that of 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.[24] Both of the two students finished their studies in 1710 and Halldórsson returned home soon after. However, he died 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.

In his Copenhagen years Halldórsson gave 5 disputations, all of them printed and 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 need not concern us here. 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 shortly, while the other two treat subjects related to geodesy and will not be further discussed here. From these works the author emerges as quite skilled in the mathematical arts and he 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.

The disputation of Halldórsson on the fixed stars is 10 pages in quarto and has the title *De aplane (On the Firmament).*[25] It is quite different from the disputation by Gísli Thorláksson. The approach is much more philosophical with arguments for and against various ideas. The third section treats the difference between the planets and the fixed stars. Here the author clearly supports the Copernican view. In the fourth section he disputes the addition of a 9th and a 10th sphere in order to get the 11th sphere, solely for theological purposes. In discussing the distances to the fixed stars Halldórsson points out the surprising disagreement among scholars on the subject. He considers himself unable to resolve the dispute. However, he cannot accept Bruno's infinite universe although it might be without limits

[21] Thorláksson, Thórdur (1671): *Calendarium: Edur Islendskt Rijm, so Meñ meige vita huad Tijmum Arsins lijdur, med thui hier eru ecke Arleg Almanøc*. Holar. [*Gíslarím* also publ. as a part of a larger vol., *Enchiridion*].

[22] Thorláksson, Thórdur (1692): *Calendarium Perpetuum Ævarande Tijmatal: Edur Rijm Iislendskt til að vita hvad Arsins Tijdum lijdur* (Skálholt). [Thórdarrím].

[23] Árnason, Jón (1707): *Calendarium Gregorianum: Edur Sa Nie Still, Vppa hvørn Gregorius, 13de Pave i Rom, fañ Año 1582. fyrer Hialp og Lidveitslu Aloysii Lilii Stiørnumeistara.* (Hólar).

[24] Arason, Magnús (1710): *Tristissimum obitum Viri Inter Mortales qvondam Perillvstris et Generosi Dn. Olai Römeri S. R. M. Dan* (Hafniæ).

[25] Halldórsson, Thorleifur (1707): *Schediasma Mathematicum de Aplane* (Hafniæ).

"as Descartes and his followers have phrased it so succinctly".[26] For the speed of the fixed stars the author gives, among others, the same figures as Gísli Thorláksson, see above. But he also quotes much higher values derived by other considerations. He concludes that the size implied by Copernicus is more trustworthy than the speed obtained by the Ptolemaic theory.[27] At the end of the seventh section 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 attributed to Simplicio, that the stellar universe is embedded between two spheres of different radii.[28] The disputation is well written and shows comprehensive knowledge. However, it can be seen that the author lacks training in the mathematical arts, beyond the first year at UC. Halldórsson did not receive the tutorship of Ole Rømer like Arason.

Magnús Arason's disputations on the phases of the moon form a series in three parts which were published in 1708–1710.[29] In total, there are 15 chapters on 22 pages in quarto.

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".[30] The author quotes several ancient Greek writers who thought that the Moon emits light by itself. He states that this is contradicted by experience and that most well-informed contemporary authors take the moon to be illuminated by the Sun. For this he quotes Kepler, Astronomiæ Pars Optica, from 1604.[31] — Then he refers to more recent authors who think that the moon emits some kind of a special, dim light visible in a total lunar eclipse when the lunar disk faces us in sombre and horrible colours. He says that authors disagree on the cause of this but he agrees with Kepler in that at new moon and a solar eclipse the moon is dimly illuminated by light reflected from the Earth (earthshine).[32] The main subject, however, is that of the phases. The author gives a detailed description of the appearance of the moon varying with its position relative to the Sun. He briefly discusses the relevance of the phases for the various calendars, referring to previous authors. Finally Arason mentions that the phases do not divide the lunar month into equal parts. "This is prevented by some anomalous, uneven oscillation of the Moon, because it moves a little faster at new moon and full moon than at other quarters." [33] He quotes Kepler in the Rudolphine Tables complaining about this irregularity, saying that "this stubborn and disobedient star still deviates every now and then from its orbit." [34]

The second and shortest disputation of Magnús Arason is from 1709 and treats old and new ideas about 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

[26] *Ibid*, p. 8, sec. 6: Non est ergo *Aplane*, vel qvoad distantiam a nobis, vel qvoad sui ipsius qvantitatem *infinita*, bene tamen (respectu scilicet nostri) esse potest *indefinita*, ut aptissime cum suis *Cartesius* loqvitur.

[27] *Ibid*, p. 9, end of sec. 6: Amplitudinem Copernicanam qvam velocitatem Ptolemaicam plus fidei merituram.

[28] *Ibid*, p. 9, end of sec. 7: [A]ssignandum orbem (non orbes) descriptum circa determinatum aliqvod centrum, duabus sphæricis superficiebus comprehensum, una scil: altissima concava, et altera inferiore convexa, inter qvas constituendam innumerabilem stellarum multitudinem, sed diversis altitudinibus, ut hæc possit appellari sphæra (non sphæræ) universi; qvibus subscribimus.

[29] Arason, Magnús (1708): *Phases Lunœ Dissertatione Mathematica I Adumbratœ*. Hafniæ; Arason, Magnús, 1709. *Phases Lunœ, Disputatione Mathematica II Adumbratœ* (Copenhagen); Arason, Magnús (1710): *Phases Lunœ Thesibus Mathematicis Loco Disputationis III Adumbratœ* (Hafniæ).

[30] *Ibid.*, p. 3, sec. 1: An luna proprio, an vero mutuato a sole splendeat Lumine?

[31] *Ibid.*, pp. 3–5, sec. 2.

[32] *Ibid.*, p. 6, sec 3: Nos cum Celeberr: *Keplero Epit. Astron. pag. 832* radiis solaribus non penetrantibus lunam, sed a terra reflexis lumen istud qvantum qvantum est deberi afferere audemus; lunæqve non majus splendoris nativi inesse qvam telluri nostræ a luce astrorum penitus vacuæ. — From the modern point of view, this explanation is of course the correct one.

[33] *Ibid*, p. 11, sec. 7: Obstat enim lunæ anomala maxime et inæqvalis vibratio ac motus, qvum aliqvanto celerius in novilunio et plenilunio qvam in aliis ejus phasibus moveatur.

[34] *Ibid*, p. 11, sec. 7: [A]dhuc contumax sydus, legesqve respuens, passim exorbitat minutule.

and appear again and are clearly seen in a telescope close to the lunar edge.[35] Then the author discusses the fact that at any time except for a lunar eclipse more than half of the moon is illuminated by the Sun, the reason being that the Sun is larger than the Moon. For this he quotes Arabic and late medieval European scholars.[36] 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 on astronomical calculations and cosmology. Arason applies the method of Aristarchos for finding the sun's distance to be 25.800 Earth radii [37] which is not too far from Christiaan Huygens' (1629–1695) result from 1659. For the calculation Arason uses logarithms and the sine rule. Using Kepler's third law he can then find the orbital radii of all the other planets. The third disputation ends with the problem of geographical longitude which was so important for navigation at the time. He says that normally longitude is found by observing celestial events which can be timed at various places. For instance, lunar and solar eclipses can be used for this purpose, and the eclipses of the Jovian moons. He also points out the usefulness of the phases of the Moon and the timing of light falling on easily recognizable places or landmarks on its surface.[38]

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*, Newton's ideas had not yet reached UC.

(6) The Enlightenment

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 first studied theology at UC.[39] He became schoolmaster at Hólar but due to personal conflicts he returned to UC to study natural philosophy and mathematics. He subsequently worked for a long time on geodesy, especially on data processing, for the Royal Danish Academy of Science. He published a noteworthy book on quadrangles in 1780 [40] and was the first Icelander to earn the Golden Medal for Mathematics at UC in 1793. In 1780 he edited the first scholarly edition of Rímbegla, a well known medieval Icelandic manuscript on calendar, computus and astronomy,[41] with his own translation 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 enlightenment society Lærdómslistafélag.

Björnsson published four disputations at UC, all of them extant. Two are on philosophical subjects, influenced by G.W. Leibniz (1646–1716). Two other disputations of Stefán Björnsson discuss astronomy

[35] Arason (1709), p. 4, sec. 1: [I]d quod jam dudum compertum est, ex occultatione stellarum, qvæ prius qvam Lunam subeunt, et postqvam iterum emergunt, valde exiguo spatio a limbo Lunæ satis clare beneficio tubi optici cernuntur.

[36] *Ibid*, p. 4, sec. 1: Solem corpus sphæricum et undiq luminosum, insigniter magnitudine sua Lunam, etiam sphæricum, sed opacum, corpus superare, radiisq; suis eam illuminare, nemo facile negabit. Qvo concesso, necessario seqvitur, Majorem partem Lunæ, utpote sphæræ minoris et opacæ, illuminari.

[37] Arason (1710), p. 4.

[38] *Ibid*, p. 8: Et, qvod scopus est hujus dissertationis, non contemnendum usum præstabunt Phases Lunæ et illuminationes insignium punctorum in ejus superficie.

[39] Guðmundsson, Einar H. (1995): "Stefán Björnsson reiknimeistari." *Fréttabréf Íslenzka stærðfræðafélagsins*, Júli 1995, 1, pp. 8–27; Guðmundsson, Einar H. (1998a): "Ferhyrningar, halastjörnur og grunnmaskínur: Tveggja alda ártíð Stefáns Björnssonar." *Lesbók Morgunblaðsins*, 17. október, pp. 8–9.

[40] Björnsson, Stefán (1780): *Introductio in Tetragonometriam ad Mentem V.C. Lambert* (Havniae).

[41] Björnsson, Stefán (ed.) (1780): *Rímbegla: Rymbegla sive Rudimentum Computi Ecclesiastici* (Havniæ).

and natural philosophy. In the first one [42] it is clear that the author knows Newtonian mechanics quite well and quotes *Principia*. He writes extensively on the law of gravitation and how comets move under the 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 work is thoroughly based on Newtonian views. As far as Björnsson is concerned the Copernican Revolution is already over.

The second disputation on natural philosophy treats the influence of the bodies of the solar system on the Earth through magnetism and light.[43] As Descartes and Aristotle had done before him, Björnsson thinks that vacuum does not exist and 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 vacuum. In this context he refers to a textbook by one of Newton's most influential continental supporters, W.J. 's Gravesande (1688–1742) in Leiden.[44] 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 other authors.[45]

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 UC. Thomas Bugge, his later chief, had not started his teaching at UC when Björnsson gave his disputations.

Hannes Finnsson started his studies at UC in 1755, 16 years old. He studied math and astronomy with Christian Horrebow who held him in high esteem. His lecture notes 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 relation continued. He was a student at UC in 1781–1788, leaving various extant notes. On returning home he became a top official, prolific in publishing as well as writing all kinds of works for public education.

Among the media used by the Enlightenment movement were societies, journals and books for educating the public. Iceland was no exception in this respect. The first society started in 1779 with the agenda of promoting science, improving the taste of the people and increasing reading activity. The society published a journal, which in general appeared annually with informative articles on various subjects, including natural science and cosmology. This first society was followed by another one started in 1794 with similar agenda, led by Stephensen and supported by Finnson.

(7) Conclusions

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

Public and published communication on the world system seems to have been dominated by Icelandic students at UC, which at this time was the university of Iceland. The discussion was closely related to studies and is available to posterity mainly through extant disputations in Latin. The students are mainly in the role of commentators and we do not know any example of them stepping forward as public proponents of heliocentrism at a critical stage, neither during the student years at UC nor afterwards in Iceland. Also, after the students turned into officials at home 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 Tychonian theory, which was the predominant world system

[42] Björnsson, Stefán (1758): *Dissertatio de Effectu Cometarum Descendentium in Systema Nostrum Planetarium* (Havniæ).

[43] Björnsson, Stefán (1759): *Dissertatio de Usu Astronomiæ in Medicina, Cujus Præliminaria de Influxu Corporum Cælestium Systematis Nostri Solaris in Tellurem Nostram Mediante Vi Luminaria et Magnetica.* (Hafniæ).

[44] *Ibid*, p. 3–4, sec. 3.

[45] *Ibid*, especially p. 5, sec. 6.

in the teaching at UC up to the late 17th century. However, the general public in Iceland has nonetheless 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 the Enlightenment societies in 1780–1798 we can safely say that the Copernican revolution in Iceland was complete.