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Jesuit Cosmological Textbook in 'the Christian century' Japan: *De sphaera* of Pedro Gomez (Part I)

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Introduction

It is well known that the Jesuit missionaries introduced a considerable amount of European astronomical or cosmological knowledge to late Ming and early Qing China and, by employing it, succeeded in establishing a firm basis for mission endeavour in that country. But less well known is that members of the same Society also introduced European cosmology to contemporary Japan, where they had already established an initial foothold before finding their way into China[1].

As the British historian Charles Boxer called the years 1549-1650 'the Christian century' in Japan[2], the mission began in 1549 when St. Francis Xavier (1506-1552) landed on the southwest shore of Japan. Contrary to the relative success in China, however, this mission ended in the persecutions and executions which began in 1614. From that year on, the Tokugawa shogunate strictly prohibited the diffusion of the Christian religion and Western learning in general. By the middle of the century all the missionaries had been expelled from Japan.

However, a Latin treatise tells us that Aristotelian-Ptolemaic cosmology was introduced to 16th century Japan in a rather systematic way. The treatise is usually called *De sphaera* (the original manuscript has no title) and constitutes the first part of the trilogical *compendium* composed by a Spanish Jesuit Pedro Gomez (1533-1600) in 1593. Sources show that the trilogy was specifically written in textbook form for the benefit of Japanese and European students preparing for the priesthood and was used at Jesuit colleges in Japan as well as in Macao.

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[1] For a concise description of the Jesuits' influence on Japanese astronomy in English, see Shigeru Nakayama, *A History of Japanese Astronomy: Chinese Background and Western Impact*, Cambridge[MA], Harvard Univ. Press, 1969, pp.79-115; Tadashi Yoshida, "A Japanese Reaction to Aristotelian Cosmology" in Luis Saraiva ed., *History of Mathematical Sciences: Portugal and East Asia II, Scientific Practices and the Portuguese Expansion in Asia (1498-1759)*, Emaful, Lisboa, 2001, pp.153-164.

[2] Charles Boxer, *The Christian Century in Japan 1549-1650*, Berkeley and Los Angeles, University of California Press, 1951.

It is this textbook that played a significant role in the introduction of European cosmology into Japan, as it was the origin, or at least one of the sources, of several Japanese books which were all composed at least by the middle of the 17th century. Being similar in contents but different in title and some other peculiar points, they can be classified into at least four types:

(1) *Nigi ryakusetsu*
: 二儀略説 (Brief Discussion on the Celestial and Terrestial Worlds)[3]
(2) *Tenmon biyou*
: 天文備要 (Compendium for Astronomy)[4]
(3) *Kenkon bensetsu*
: 乾坤弁説 (Discussion on the Heaven and the Earth with Critical Commentaries)[5]
(4) *Nanban unkiron*
: 南蛮運気論 (Discussion by the "Southern Barbarians" on the *Yunqi*) [6]

Well known as the first full-scale presentation of Western physical science in Japan, manuscripts of these books had been circulated among Japanese scholars throughout the Edo period (1603-1867) even under persecution.

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[3] For the facsimile reprint of Naikaku Bunko MS, see Kirishitan Bunko Library ed., *Compendium catholicae veritatis (3 vols.), vol.II:Iezusukai nihon colegio no kougi youkou (Compendium, Jesuit college of Japan)*, Tokyo, Ozorasha, 1997. See also Hideo Hirose, "Kobayashi Kentei to nigi ryakusetsu (Kentei Kobayashi and the *nigi ryakusetsu*)", in Hideo Hirose, Shigeru Nakayama and Yoshinori Otsuka eds., *Kinsei kagaku shiso (Nihon shiso taikei 63, 2 vols.)* II, Tokyo, Iwanami shoten, 1971, pp.465-70; Kazutaka Unno, "Edo jidai ni okeru 'Nigi ryakusetsu' no rufu (The circulation of the *Nigi-ryakusetsu* (Outline of the Heaven and Earth) through the Edo period)", *Kagakuhsi kenkyu: Journal of History of Science, Japan, Series II* 38, 1999, pp.93-98.

[4] See Shin'ichi Ohya, "Kenkon bensetsu no ihon (A Variant manuscript of *Kenkon bensetsu*)", *Kagakushi kenkyu: Journal of History of Science, Japan* 17, 1951, pp.25-28; José Miguel Pinto Dos Santos, "As distâncias dos céus aos infernos na cosmologia *Nanban*", *Anais de história de além-mar* 5, 2004, pp.415-479, esp. pp. 467-468.

[5] See Nakayama (n.1), pp.88-98; Henrique Leitao and Jose Miguel Pinto Dos Santos, "O *Kenkon Bensetsu* e a recepcao da cosmologia ocidental no Japao do sec. XVII", *Revista Portuguesa de filosofia* 54, 1998, pp.285-318. For the extant manuscripts of *Kenkon bensetsu*, see Ryuji Hiraoka, "Nanban toraino utyuron (Christian Cosmology in Early Modern Japan) " in Executive committee of 3rd international Symposium on *Edo no monozukuri* (Inventions in the Edo period) ed., *Headwaters of Science and Technology in Pre-Modern Japan –Galileo Leeuwenhoek Ikkansai-*, Kyoto, 2003, pp.173-176; José Miguel Pinto Dos Santos (n.4), pp.466-469.

[6] See Shin'ichi Ohya, "Kenkon bensetsu no ichi ihon: Nanban unkiron (A Variant manuscript of *Kenkon bensetsu*: *Nanban unkiron*)", *Kagakushi kenkyu: Journal of History of Science, Japan* 14, 1950, pp.35-39. As for the extant manuscripts, See Hiraoka (n.5).

This paper provides for the first time an Engligh translation of *De sphaera* with a new edition of the original Latin text. According to the single extant manuscript (Biblioteca Apostolica Vaticana, MS *Reginenses Latini*, 426, fols 1r-38r. Fig.1), it is divided into two main parts: the first part discusses the celestial world, and the second part the sublunary world. Due to limitations of space, the present paper only takes up the first part including the author's preface (1r-20r). Also, since much has been written about the origin, purpose and author of *De sphaera*[7], the following introduction focuses upon some distinctive features seen in the presented text[8].

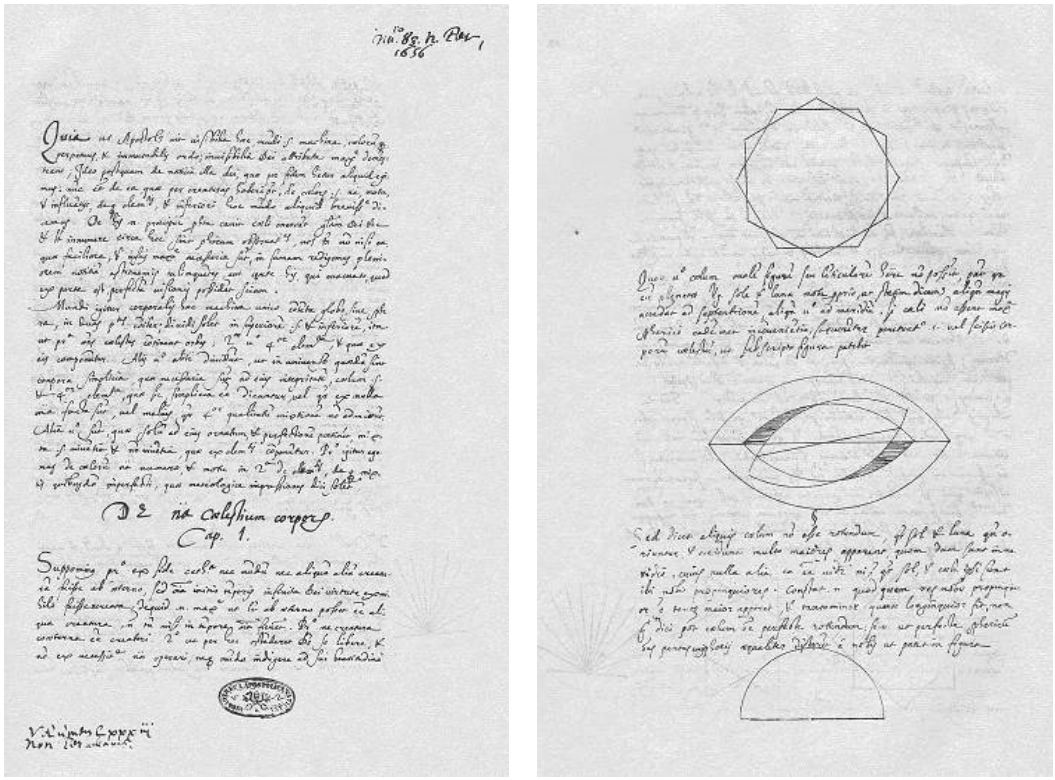

Fig.1 The Vatican manuscript of *De sphaera*: f.1r (left) and f.2v (right)

[7] See Joseph Franz Schütte, "Drei Unterrichtsbücher für japanische Jesuitenprediger aus dem XVI Jahrhundert", *Archivum Historicum Societatis Jesu* 8, 1939, pp.223-256; Satoru Obara, "Kirishitan jidai no kagaku shisou: Pedro Gomez cho 'Tenkyuron' no kenkyu (The scientific knowledge in the Christian Era: A study on 'De sphaera' by Pedro Gomez)", *Kirishitan kenkyu* (Reserches on early Japanese Christianity) 10, 1965, pp.101-273 and (1)-(78); M.Antoni J.Üçerler, "Jesuit Humanist Education in Sixteenth-Century Japan: The Latin and Japanese MSS of Pedro Gomez's '*Compendia*' on Astronomy, Philosophy, and Theology (1593-95)", in Kirishitan Bunko Library ed. (n.3), *vol.III: Commentaries*, pp.11-60.

[8] I am planning to publish the second part successively.

I. Clavius's Commentary as One of the Sources

The order of chapters in the first part of *De sphaera* resembles that of *Libellus de Sphaera* of Joannes de Sacrobosco, but it contains several texts showing that the author had consulted Clavius' *In sphaeram Ioannis de Sacro Bosco commentarius*, as Imai Itaru had claimed[9].

I-1 Dividing the earth into 23 climas

There are many ways of determining the *climas* or *climata*, a zone or region of the earth lying in the same parallel of latitude, in the Western tradition of astronomy and geography. Whereas most treatises written around the late 16th century in Europe adopt a 7 *clima* system, following the tradition of Sacrobosco's *Libellus de Sphaera*, both Gomez and Clavius have one distinctive feature in common: namely that they divide a hemisphere into 23 *climas*. Gomez explains:

> For, as we have said that the same longest day, for example, June 22, would have more or less hours depending on whether some region is nearer to or further from the pole, they [astronomers] conclude that different *climas* of regions should be so assigned that the space, in which the longest day exceeds the length of the day observed in other regions by half an hour, would constitute one *clima.*[10]

Having thus defined the notion of *clima*, the author continues to explain that:

> Therefore those people divide the earth into 23 *climas*, counting from the places which have the latitude of 12 degrees and 43 minutes to that part of 66 and a half degrees or more, […] Thus, for example, the first *clima* is from 12 degrees and 43 minutes to 20 and a half degrees and has 7 degrees and 50 minutes in itself, whereas the 14th *clima* has only 1 degree and 1 minute, as can be seen in the table of the *climas*.

Although the Vatican manuscript lacks the table, we can reproduce it from the above

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[9] My discussion below owes a lot to his Japanese articles: Itaru Imai, "*Nigi ryakusetsu* no 'Jisatai no nikki' ni tsuite (On the tabula climatum in *Nigi ryakusetsu*)", *Nihon tenmon kenkyukai hobun* (Memoirs of the Japan Astronomical Study Association), vol.2, no.1, 1958, pp.9-16 and *idem*, "Gomez no tenkyuron to Clavius (Clavius' *In sphaeram commentarius* and Gomez's *De sphaera*)", *idem*, vol.3, no.3, 1968, pp.13-18. See also Yukari Mori, "Iezusukai nihon korejio no utyuron kogi 1, 2 (Cosmology lectures at the Jesuit college in early modern Japan, part 1-2) ", *Bulletin of Aichi Institute of Technology. Part A* 36, 2001, pp.81-103. In this paper, Mori argues that Gomez's *De sphaera* and the Coimbra commentary of *De caelo* shared some distinct characteristics in common, such as the cubic shape of the empyrean heaven and the angelic intellect as the motive force of the celestial spheres.

[10] *De sphaera*, fol.14r.

texts together with other information seen in the same chapter[11]. In Table 1, I juxtapose the reproduced table (left) with Clavius' 'Table of *climata* according to moderns' in *In sphaeram*[12](right). We find a striking similarity between these two tables.

Gomez's *De sphaera*				**Clavius' *In sphaeram***			
Clima	Longest day	Latitude	Interval	*Clima*	Longest day	Latitude	Interval
	H M	D M	D M		H M	D M	D M
start	12 45	12 43		start	12 45	12 43	
1 middle	13 0		7 50	1 middle	13 0	16 43	7 50
end	13 15	20 30		end	13 15	20 33	
start	13 45			start	13 45	27 36	
3 middle	14 0	ca. 31		3 middle	14 0	30 47	6 9
end	14 15			end	14 15	33 45	
start	14 15			start	14 15	33 45	
4 middle	14 30	36 30		4 middle	14 30	36 30	5 17
end	14 45			end	14 45	39 2	
start	19 15			start	19 15	61 53	
14 middle	19 30		1 1	14 middle	19 30	62 25	1 1
end	19 45			end	19 45	62 54	
start	23 15			start	23 15	66 25	
22 middle	23 30			22 middle	23 30	66 28	0 5
end	23 45	66 30		end	23 45	66 30	
23	24 0	66 30		23	24 0	66 31	0 0

Table 1 23 *climas* in *De sphaera* (reproduced) and *In sphaeram* (some columns abridged)

[11] 'For example, for those for whom the height of the pole is nearly 31 degrees, the longest day will be July 22 having 14 hours; but for those for whom the height of the pole is 36 and a half degrees, the same will be 14 and a half hours, etc.. But for the former, the shortest day will be 10 hours, and the latter, 9 and a half hours.', *De sphaera*, fol.10r.

[12] 'Tabula climatum secundum recentiores', in Clavius, *In sphaeram*, 1593 Lyon ed., pp.496-497.

I-2 Coincidence of false information about the total eclipse of the sun in 1559

In chapter 5, section 2 'On the orbs of the planets', Gomez says:

> […] it has been noticed by experience that the solar and lunar eclipses are unequal very often: for example, the total body of the moon is interposed between the sun and us and it eclipses the whole sun, so that none of its part could be seen and the eclipse continues just a little time, as happened in 1559. Sometimes the total body of the moon interposed cannot eclipse the whole sun, but some crown of light can be seen at the periphery […].[13]

Gomez here mentions the total solar eclipse that happened in 1559. According to Oppolzer's *Canon of Eclipses*, however, the solar eclipses which happened three times in the same year were all partial and unobservable in Europe:

1559	III	9d	5h	6.0m	partial
	IX	1d	20h	0.1m	partial
	X	1d	4h	56.9m	partial[14]

Interestingly, Clavius also mentions in his earlier editions of *In sphaeram* that he observed the total solar eclipse in Coimbra in 1559:

> I will read out two impressive solar eclipses, which happened in our time not long ago, one of which I observed in Coimbra, Lusitania in 1559 around midday, during which the moon was interposed directly between the eye and the sun, so that the total body of the sun was concealed for not a slight interval of time, and it was a bit darker than the night.[15]

Around this period, there was no total solar eclipse visible in Coimbra around midday other than that on 21st August 1560:

Conjunction	12h 23.5m
Maximum at Meridian	W1° N36° [16]

[13] *De sphaera*, fol.17v.

[14] Theodor Oppolzer, *Canon of Eclipses: Canon der Finsternisse*, trans. by Gingerich O., New York, Dover, 1962, pp.264-265.

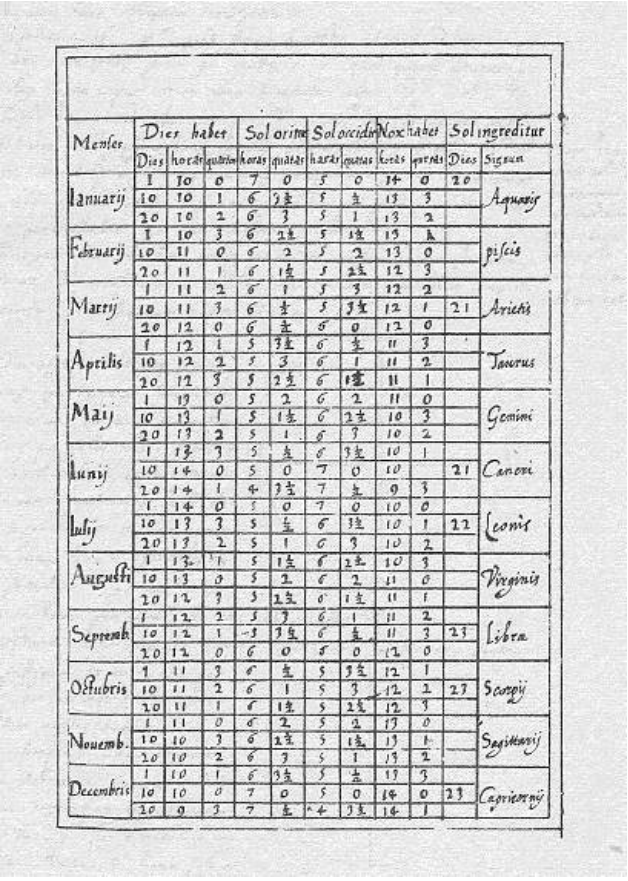
[15] 'recitabo duas insignes Eclipses Solis, quae meo tempore contigerunt non ita pridem, quarum unam anno 1559. Conimbricae in Lusitania circa meridiem observavi, in qua interponebatur Luna directe inter visum, ac Solem, ita ut totum Solem non modico temporis intervallo contegeret, essentque tenebrae quodammodo maiores, quam nocturnae.' I had opportunity to peruse following editions which contain above texts (page number): Lyon,1593 (508); Lyon 1602 (508); Venezia 1603 (441).

[16] Oppolzer, *idem*.

Thus, we can surely assume that Clavius somehow went wrong to say the year was "1559". Later, however, he became aware of this mistake, for we can see the year is corrected into '1560' in the 1611 Mainz edition[17]. In any case, this coincidence of error and other evidence such as shown above indicate that Gomez had consulted an earlier version of Clavius' *In sphaeram*.

II. Supposed readers and their habitation

In part one of *De sphaera*, one astronomical table is inserted between folio 6 and 7 (Fig.2). Each column of this table describes, as to the 1st, 10th and 20th day of each month, (1) the length of day time, (2) the time of sunrise, (3) the time of sunset, (4) the lengh of night time and (5) entrance of the sun into the twelve zodiacal signs.



Menses	Dies habet			Sol oritur		Sol occidit		Nox habet		Sol ingreditur	
	Dies	horas	quartas	horas	quartas	horas	quartas	horas	quartas	Dies	Signum
Ianuarij	1	10	0	7	0	5	0	14	0	20	
	10	10	1	6	3/4	5	1/4	13	3		Aquarius
	20	10	2	6	3	5	1	13	2		
Februarij	1	10	3	6	2/4	5	1/4	13	1/4		
	10	11	0	6	2	5	2	13	0		pisces
	20	11	1	6	1/4	5	2/4	12	3		
Martij	1	11	2	6	1	5	3	12	2		
	10	11	3	6	1/4	5	3/4	12	1	21	Aries
	20	12	0	6	2/4	6	0	12	0		
Aprilis	1	12	1	5	3/4	6	1/4	11	3		
	10	12	2	5	3	6	1	11	2		Taurus
	20	12	3	5	2/4	6	1/4	11	1		
Maij	1	13	0	5	2	6	2	11	0		
	10	13	1	5	1/4	6	2/4	10	3		Gemini
	20	13	2	5	1	6	3	10	2		
Iunij	1	13/4	3	5	1/4	6	3/4	10	1		
	10	14	0	5	0	7	0	10		21	Cancri
	20	14	1	4	3/4	7	1/4	9	3		
Iulij	1	14	0	5	0	7	0	10	0		
	10	13	3	5	1/4	6	3/4	10	1	22	Leonis
	20	13	2	5	1	6	3	10	2		
Augusti	1	13	1	5	1/4	6	2/4	10	3		
	10	13	0	5	2	6	2	11	0		Virginis
	20	12	3	5	2/4	6	1/4	11	1		
Septemb.	1	12	2	5	3	6	1	11	2		
	10	12	1	5	3/4	6	1/4	11	3	23	Libra
	20	12	0	6	0	6	0	12	0		
Octubris	1	11	3	6	1/4	5	3/4	12	1		
	10	11	2	6	1	5	3	12	2	23	Scorpij
	20	11	1	6	1/4	5	2/4	12	3		
	1	11	0	6	2	5	2	13	0		
Nouemb.	10	10	3	6	2/4	5	1/4	13	1		Sagittarij
	20	10	2	6	3	5	1	13	2		
	1	10	1	6	3/4	5	1/4	13	3		
Decembris	10	10	0	7	0	5	0	14	0	23	Capricorni
	20	9	3	7	1/4	4	3/4	14	1		

Fig. 2

[17] Christoph Clavius, *In Sphaeram Ioannis de Sacro Bosco commentarius: Mit einem Vorwort herausgegeben von Eberhard Knobloch*, Hildesheim and Zürich and New York, Olms-Weidmann, 1999 (reprint of Mainz, 1611 edition), p.295.

The longest day in the table is on June 20, around summer solstice, and its value is 14 hours and 15 minutes. If we compare this value with that which is seen in Clavius' 'Table of *climata* according to moderns' mentioned above, we find the region in question is around 33 degrees and 45 minutes north latitude. This indicates that the table was made for the use in that latitude. There is no place of the latitude in Europe, but the parallel passes through or near, for example, Casablanca in Africa, Baghdad in Near East, Xi'an in China and Fukuoka in the northern part of Kyushu Island. At all events, it is very likely and highly probable that this table was made for the use in Funai or Nagasaki.

If we look for other information which relates to the place of origin or use of *De sphaera*, Gomez says in chapter 5, section 3, 'How the solar and lunar eclipses happen', that:

> From the eclipses, especially that of the moon, it is easy to get to know the distance between the regions from east to west for those who are within the same degree. Because, if, for example, we see the moon begin to be eclipsed at midnight, for those who are in India or any other region [the same eclipse would not begin] except at 7 o'clock PM. The distance from that province to us will be 75 degrees, for, as we have said, when elevated 15 degrees above the horizon, then it is said that one hour has been passed. When the distance from that province to us is 5 hours and when it is multiplicated by 15 degrees, 75 degrees would be achieved, and so on for the remaining[18].

In above text, "we" are in 75 degrees east of India, matching the position of Japan by and large. This is how Giulio Aleni (1582-1649) in Macao, Sabbathinus de Ursis (1575-1620) in Beijing and Carlo Spinola (1564-1622) in Nagasaki calculated the longitudinal interval of these places in November 8, 1612[19].

III. Editorial procedure

The Latin text is based on the facsimile reprint edition of the original manuscript[20]. In establishing the text, I have followed the customary procedures. The capitalization, punctuation and paragraphing are all mine. Square brackets [ ] have been employed in the text to enclose my editorial insertions. I have then compared my text with Obara's edition[21], and have noted different readings in footnotes. The following abbreviation and Latin terms have been employed.

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[18] *De sphaera*, fol.19v.

[19] Henri Cordier ed., *De la situation du Japon et de la Corée: manuscrit inédit du Père A.Gaubil S.J.*, (Extrait du *T'oung-pao* 9, no.2), Leiden, E.J.Brill, 1898, pp. 3-4.

[20] Kirishitan Bunko Library ed., *Compendium catholicae veritatis, vol. I: Compendia compiled by Pedro Gomez, Jesuit College of Japan*, Tokyo, Ozorasha, 1997, fol.1r-20r. All figures are reproduced from the edition by kind permission of Ozorasha.

[21] "De SPHAERA Textus Ms. Editus a Satoru Augustino Obara S.J" in Obara (n.7), pp.(1)-(78).

Obara	Obara or Obara's reading
addidit	has added
correxit	has corrected
delevit	has deleted
habet	has
omisit	has omitted
scripsit	has written
addidi	I have added
conieci ex	I have conjectured from
correxi ex	I have corrected from
in margine	in the margin
post	after

[*De sphaera*]

[f.1r]

[Prooemium]

Quia, ut Apostolus ait, visibilia haec, mundi scilicet machina, caelorumque perpetuus et immutabilis ordo, invisibilia Dei attributa maxime demonstrant[1], ideo postquam de notitia illa Dei, quae per fidem habetur, aliquid egimus, nunc etiam de ea, quae per creaturas haberi potest, de caelorum scilicet natura, motu et influentiis, deque elementis et inferiori hoc mundo aliquid brevissime dicemus. De his enim praecipue Propheta canit caeli enarrant gloriam Dei[2] etc.. Et licet innumerae circa hoc sint philosophorum observationes, nos tamen non nisi ea, quae faciliora et usui maxime necessaria sunt, in summam redigemus, pleniorem notitiam astronomis relinquentes, aut certe his, qui evacuato, quod ex parte est, perfectam visionis possident scientiam[3].

Mundi igitur corporalis haec machina unico contenta globo sive sphera, in duas partes communiter dividi solet, in superiorem scilicet et inferiorem, ita ut prima omnes caelestes contineat orbes, secunda vero quatuor elementa, et quae ex eis componuntur. Alii vero aliter dividunt, ut in universo quaedam sint corpora simplicia, quae necessaria sunt ad eius integritatem, caelum scilicet et quatuor elementa, quae sic simplicia etiam dicuntur, vel quia ex nulla materia facta sint, vel melius, quia quatuor qualitatum mixtionem non admittunt. Alia vero sunt, quae solum ad eius ornatum et perfectionem pertinent, mixta scilicet, viventia et non viventia, quae ex elementis componuntur. Primo igitur egemus de caelorum natura, numero et motu; in secunda de elementis deque mixtis quibusdam imperfectis, quae meteorologicae[4] impressiones dici solent.

De natura caelestium corporum
Cap. 1

Supponimus primo ex fide catholica nec mundum nec aliquam aliam creaturam fuisse ab aeterno, sed omnia initio temporis infinita Dei virtute ex nihilo fuisse creata. De quo[5] enim maxime ut, licet ab aeterno posset esse aliqua creatura, non tamen nisi in tempore omnia fierent. Primo ne creatura coaeterna esset[6] creatori, secundo ut per hoc ostenderet Deus se libere et non ex necessitate naturae operari, neque mundo indigere ad sui beatitudinem **[f.1v],** sed potius mundum Deo indigere, tertio ut hoc modo se omnium esse creatorem, suaque divina attributa evidentius hominibus manifestaret, qui scit et potest quando vult omnia libere ex nihilo facere etc..

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[1] *Romanos* 1:20

[2] *Psalmi* 18:2

[3] *1 Corinthios* 13:9-10

[4] *correxi ex* meteologice, *Obara* mete[reo]logicae

[5] De quo] *conieci ex* dequid, *Obara* requiritur

[6] *correxi ex* esse

[*On the Sphere*]

[Preface]

As the Apostle says, these visible things, namely, the machine of the world and the perpetual and immutable order of the heavens, demonstrate invisible attributes of God very clearly. Therefore, after having pursued that knowledge of God, which can be acquired by faith, now we shall also give a very brief account of the knowledge which can be attained through the creatures: that is, the nature, motion and influence of the heavens, and the [four] elements and this inferior world. For with regard to them the Prophet especially says "The heavens declare the glory of God" etc.. And even though there exist innumerable speculations on this issue by the philosophers, we epitomize only those which are easier and indispensable for our use, leaving a more complete account to astronomers or certainly to those who, neglecting that which is partial, have a perfect knowledge of vision.

This corporeal machine of the world, contained in one globe or sphere, is generally divided into two parts, namely, the superior and the inferior worlds: the former is composed of all the heavenly orbs, the latter, of the four elements and the things constituted by them. But some divide it differently as there are some simple bodies, in the universe, which are essential for its integrity: that is, the heaven and four elements. They are called simple on the ground that they are not constituted of any matter, or, better to say, that they do not admit the mixture of four qualities. The others are compounds which merely pertain to the ornament and perfection of the world, that is to say, the living and non-living things, which are composed of the elements. Therefore, in the beginning, we have to inquire into the nature, number and motion of the heavens, and, in the second, into the elements and some imperfect compounds of them, which are usually called meteorological impressions.

Chapter 1
On the nature of the heavenly bodies

First, we suppose that, by the Catholic faith, neither the world nor any other creature has existed from eternity, but everything was created from nothing by the infinite power of God at the beginning of time. For regarding this it is best [to think] that all things were made only in time, even though some creature could have existed from eternity: firstly [because] the creature is not coeternal with the Creator; secondly, by this, God desired to show that he works freely not by necessity of the nature and does not require the world for his felicity, but, rather, the world requires him; thirdly, in this manner he, who knows and can make everything freely out of nothing when he wishes, desired to reveal more evidently his creatorship of everything and his divine attributes to the human beings etc..

Secundo supponimus initium omnium operationum Dei a dextra[1] fuisse caelum et terram, cum dicatur Gen. 1. in principio Deus creavit caelum et terram.

His ergo positis, sit prima conclusio: Caelum est corpus solidissimum, compositum ex materia et forma, non autem ex elementis aut ex illorum qualitatibus. Unde sua essentia a philosophis nominatur, id est, corpus distinctum essentialiter a quatuor elementis. Haec est communis philosophorum et theologorum.

Probatur prima pars, quia ad continuum et velocissimum motum circularem qualem experimur in caelis, requiritur maxima soliditas corporis: res enim fluida sicut aqua constans esse non potest. Secundo ex modo loquendi S.Scripturae. Vocatur enim caelum firmamentum, hoc maximam soliditatem. Et Job. 37 dicitur de coelis, quod solidissimi quasi aere fusi sunt[2].

Quod vero caeli constent ex materia et forma probatur, quia vel caeli sunt sola materia, vel sola forma, vel compositum ex utroque. Non sola materia, quia materia est imperfectissimum ens, nec sola forma, quia alias esset substantia spiritualis. Est ergo compositum ex utroque. Quod vero non sit compositum ex quatuor qualitatibus elementorum probatur, quia qualitates elementorum sunt principium corruptionis, ut experientia patet in elementis et mixtis. Sed caelum incorruptibile et immutabile manet usque modo. Ergo non habet in se contrarietatem qualitatum.

Dices: sol calefacit, ut experientia constat, ergo in se habet calorem? Respondetur calorem solis resultare ex maxima refractione radiorum in terra, unde media luce calorem producit. Et hoc experientia patet in convallis, ubi magis calor sentitur quam in altissimis montibus. Quod non contingeret, si sol esset formaliter calidus. Secundo in speculo et in spicillis, in quibus radii solis compressi ignem producunt.

§

Secunda Conclusio: Caelestia corpora multo nobiliora sunt 4 elementis et mixtis omnibus non viventibus. Excedunt enim omnia haec corporis magnitudine, pulchritudine astrorum, perspicuitate maxima, puritate, luce et summa uniformitate motus. Secundo, incorruptibilitate. Caelum enim solum inter omnia corpora neque alterationi[3] neque corruptioni subiacet. Tertio, quia caelum est quasi pater et universalis causa omnium. Quae generantur, et[4] dependent in fieri et conservari a caelorum influxu, ut infra dicemus.

Tertia conclusio: Natura hominis et animantia omnia saltim perfecta simpliciter habent **[f.2r]** meliorem modum essendi, seu perfectiorem formam, licet secundum aliquas particulares proprietates in particulari possit etiam caelum homines et animantia excellere. Ita Divus Thomas cum Divo Augustino, qui distinguit quattuor genera entium: quaedam

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[1] a dextra] ad extra *Obara*

[2] *Job* 37:18

[3] *conieci ex* arterationi, *Obara* mutationi

[4] *post* et *addidit* ~~ab~~ ~~eo~~

Secondly, we suppose that, by the right hand of God, the first was the heaven and the earth, as the Genesis 1 says "In the beginning, God created the heaven and the earth."

Upon these premises, the first conclusion is that the heaven is the most solid body, and composed of matter and form, not of the elements and their qualities. Thus by the philosophers it is called the body which is essentially different from the four elements after its property. This is a common opinion of philosophers and theologians.

The former part [of the conclusion above] is proved, because the maximam corporeal solidity is required for the kind of continuous and most rapid circular motion, that we see in the heavens: for a liquid thing like water cannot be persistent. Secondly, from the mode of speech in the Holy Scripture. For the heaven is called the firmament, which means the hardest solidity. And regarding the heavens, Job 37 says "They are extremely solid as if cast by metal".

We can prove that the heavens consist of matter and form, seeing that they be made solely from matter, or solely from form, or a composite of both. They are not solely made from matter, because matter is the most imperfect being; nor solely from form, because, otherwise, they would have been a spiritual substance. Therefore the heaven is a composite of both. That it is not a composite of the four qualities of the elements is proved, because the qualities of the elements are the principle of corruption, as is evident empirically in the elements and compounds. The heaven, however, remains incorruptible and immutable until the present time. Therefore it does not intrinsically have contrariety between qualities.

You may argue "Since the sun evokes heat, as is evident by experience, does it not hold heat in itself ?" We can answer that the heat of the sun results from the maximam bent of rays on the earth, whence the sun produces heat by moderate light. This is empirically evident in the valleys, where we feel more heat than in the higher mountains. This would not happen, if the sun is intrinsically hot. Secondly, in mirrors and lenses, in which the compressed rays of the sun produce fire.

§

Second Conclusion: the celestial bodies are much nobler than the four elements and any other non-living compounds. For they exceed them all in magnitude of body, in beauty of stars, in their highest transparency, purity and light, and in the highest uniformity of their motions. Secondly, in incorruptibility. For, among all bodies, the heaven alone is not subject to change nor to corruption. Thirdly because the heaven is like the father and the universal cause of everything. As we shall see later, creatures owe its generation and preservation to the influence from the heavens.

Third Conclusion: The nature of human beings and all the living things, at least those which are simply perfect, have a better mode of existence or more perfect form, although the heaven can exceed human beings and living things, particularly with regard to some individual properties. Thus St. Thomas, together with St. Augustine, distinguished four genera of beings: those (he says) which exist without life, those which have life without

(inquit) habent esse sine vita; quaedam vitam sine sensu; quaedam sensum sine intellectu; quaedam autem esse, vitam, sensum et intellectum. Et subdit idem Augustinus posteriora esse multo perfectiora prioribus, i.e. ea, quae habent sensum et vitam, multo perfectiora esse secundum suam naturam, quam ea, quae vita et sensu carent. Verum est tamen solem superare hominem in claritate, tamen non simpliciter in natura, sicut aurum aliquando pluris habetur quam homo, et tamen natura hominis et modus operandi multo perfectior est auro.

§

Quarta conclusio: Licet maxime probabile sit caeli empirei superficiem extremam seu convexam esse quadratam, reliqui tamen caeli figuram habent rotundam et sphericam non quadratam. Prima pars patet, quia (ut geometrae dicunt) figura quadrata apta est ad quietem, et difficile mobilis. Empireum autem immobilis est sedes beatorum, cui consonat illud Apocal. 21: et civitas (id est caelestis gloriae locus) posita est in quadro[1].

Sed de reliquis caelis, quod sint rotundi, probatur primo, quia sola figura spherica apta est ad motum velocissimum. Secundo, quia cum plures sint caeli maxime coniuncti, ut capite sequenti dicemus, et unum tardius alio moveatur, si non essent omnes perfecti spherici, sed v.g. quadrangulares, sequeretur manifeste quod quando moventur vel angulus inferioris caeli superiorem dividat, vel habeat se penetrative cum illo. Quorum utrumque rationi repugnat, cum caeli corpora solidissima sint, nec dividi, aut penetrari ab alio possint. Utrumque autem in figuris subscriptis patet manifeste. [Fig. 1, 2, 3]

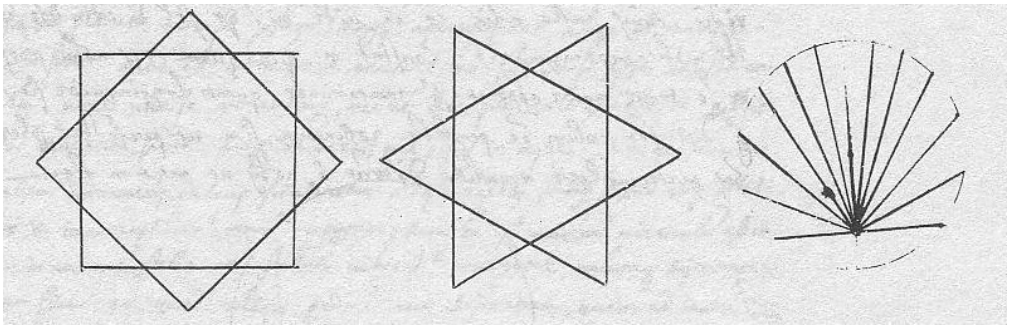

Fig. 1, 2, 3

[f.2v] [Fig. 4] Quod vero caelum ovalem figuram seu lenticularem habere non possit patet, quia cum planetae v.g. sol et luna motu proprio, ut statim dicemus, aliquando magis accedant ad septentrionem, aliquando vero ad meridiem. Si caeli non essent maxime spherici, eademmet inconvenientia sequerentur penetratio id est vel scissio corporum caelestium, ut subscripta figura patebit. [Fig. 5]

[1] *Apocalypsis* 21:16

sense, those which have sense without intellect and those which exist with life, sense and intellect. St. Augustine himself adds that the posteriors are much more perfect than the priors, i.e. those which have sense and life are much more perfect, in their nature, than those which lack life and sense. It is true that the sun exceeds human beings in clarity, but not simply in its nature, just as gold is sometimes thought more valuable than human beings, but, nonetheless, the nature of human beings and its mode of working are much more perfect than gold.

§

Fourth Conclusion: Although it is highly probable that the uttermost or convex surface of the empyrean heaven is square in shape, the remaining heavens have round and spherical shape, not square. The first part [of the conclusion above] is manifest, since (as geometers say) a square shape is fit for quiescency and difficult to move. Surely the empyrean heaven is the immovable seat of the blessed, with which the Revelation 21 accords: "and the city (i.e. the place of celestial glory) is laid out as a square."

But that the remaining heavens are round is proved: first, because only a spherical figure is fit for extremely rapid motion. Secondly because, since many heavens are closely connected, as we shall see in the following chapter, and some move more slowly than the others, if all the heavens are not perfectly spherical, but quadrangular for example, it would naturally follow that, when they are moved, the angle of the lower heaven would either split the higher asunder or penetrate it. But both [of the consequences above] are against reason, since the heavens are the most rigid bodies: they could neither be split by nor be penetrated by each other. Both are made manifest in the figures below.

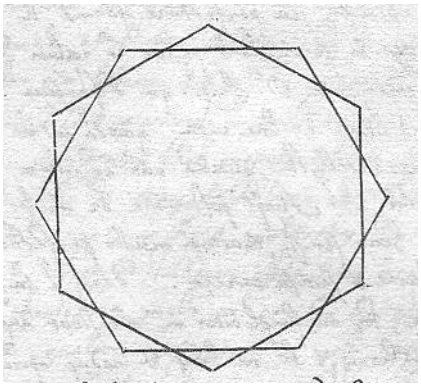

Fig. 4

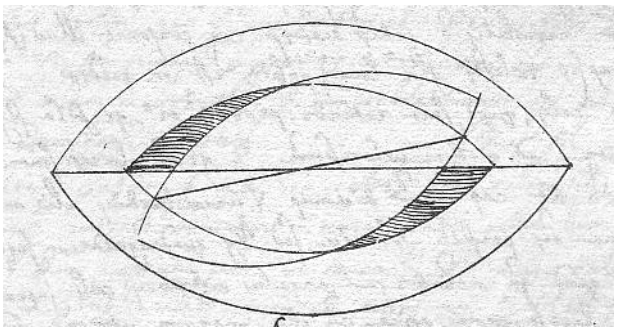

Fig. 5

That the heaven cannot have an oval or lenticular shape is manifest, because the planets like the sun and moon, as we shall see immediately, sometimes come nearer to the north and at other times to the south by their proper motion. If the heavens are not completely spherical, then there would follow the same inconveniences, i.e. the penetration or scission of celestial bodies, as the figure below will show.

§

Sed dicet aliquis caelum non esse rotundum, quia sol et luna, quando oriuntur et occidunt, multo maiores apparent, quam dum sunt in meridie, cuius nulla alia causa esse videtur, nisi quia sol et caeli ipsi sunt ibi nobis propinquiores. Constat enim quod[1] quanto[2] res nobis propinquior est tanto maior apparet, et tanto minor quanto longinquior sit. Non ergo dici potest caelum esse perfecte rotundum: si enim sit[3] perfecte sphericum, omnes partes hemispherii aequaliter distarent a nobis, ut patet in figura. [Fig. 6]

[f.3r] Respondetur solem aut lunam apparere[4] in ortu et occasu maiores, non quia propinquiores nobis fiant, sed quia tunc plures et crassiores elevantur a terra vapores, qui multiplicati inter nos et solem vel lunam ab ipsisque illuminati disgregant[5] visum, et faciunt solem et lunam apparere maiores. Exemplum est in virga aut lapide missis in aquam: apparent enim maiora dum in aqua sunt, praecipue si aqua moveatur.

Secundo caelum versus horizontem videtur a nobis magis distare quam supra caput nostrum, non ergo habet figuram rotundam. Respondetur distantiam alicuius corporis[6] maxime cognosci per spatium, seu corpus interiectum inter videntem et rem visam. Unde quia inter nos et caelum quod est supra caput nostrum, non est aliud corpus solidum, per quod possimus eius distantiam cognoscere, et inter nos et horizontem sint intra posita terra aut mare, propterea magis distare iudicamus caelum versus horizontem, quam[7] versus meridiem. Quod patet ex exemplo montium. Iudicamus enim cacumina montium esse coniuncta, quia vallem intermedium non videmus. Haec de caeli natura, nobilitate, et figura.

De motu et numero et ordine caelorum Cap. 2

Communis philosophorum sententia fuit non unum sed plures esse caelos, quibus etiam consonat modus loquendi S.Scripturarum, in quis[8] de caelis in plurali sit saepe mentio. Hanc autem multitudinem caelorum ex diversitate motuum corporum caelestium colligunt.

Constat enim primo caelestia corpora circulariter moveri ab oriente in occidens. Sol enim et stellae paulatim ascendunt ab oriente in meridiem, et velocissimo motu descendere usque in occidentem etc.. Nec dici potest caelo quiescente terram moveri, de quo suo loco dicemus, tum quia terra ipsa gravissima est nec apta ad motum

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[1] *Obara omisit*

[2] *correxi ex* quam, *Obara* quam

[3] *conieci ex* ut, *Obara* ut (esset?)

[4] *correxi ex* apparerere, *Obara* apparerere

[5] *correxi ex* disgregat

[6] *correxi ex* corpus

[7] *correxi ex* quo

[8] *Obara* quibus

§

However, some will argue that the heaven is not round, because the sun and moon look much bigger when they rise and set than when they are on the meridian. There appears to be no other reason for this than that the sun and the heavens themselves are nearer to us at those points. For it is certain that the nearer a thing is to us, the bigger it looks, and the further away the smaller. Therefore it cannot be said that the heaven is perfectly round, since if they were like a perfect sphere, all the parts of the hemisphere would be equally distant from us, as is shown in the figure.

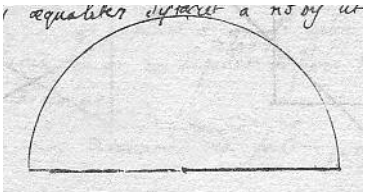

Fig. 6

We can answer that the sun or moon appears bigger while rising and setting, not because they are nearer to us, but because, at that time, profuse and thick vapors rise from the earth: those vapors, multiplied between us and the sun or moon and illluminated by them, confuse the vision and cause the sun and moon to appear bigger. The example is a branch or stone cast in water: for they look bigger when they are in water, especially when the water is stirred up.

Secondly, [you may argue that] "The heaven looks more distant from us toward the horizon than above our head. Therefore it does not have a round figure." We can answer that the distance of a body can be best discerned by the space or the body interposed between an observer and a visible object. Thus, since there is no solid body, by which we can discern its distance, between us and the heaven above our head, and since the earth and the sea are interposed between us and the horizon, we judge that the heaven is more distant when toward the horizon than toward the meridian. This is evident from the example of mountains. For we judge that the peaks of the mountains are connected, since we do not see the intervening valley. The above are the nature, nobility and figure of the heavens.

Chapter 2
On the movement, number and order of the heavens

It has been the common opinion among philosophers that there exist not one but many heavens. This also accords with the mode of speech in the Holy Scripture, in which the referrence to the heavens in the plural is made frequently. They also conclude the multiplicity of the heavens from the diversity of motions of the heavenly bodies.

Firstly, it is evident that the celestial bodies are moved circularly from east to west. For instance, the sun and the stars gradually ascend from east to the meridian, and descend to

velocissimum[1], tum etiam quia stellae ipsae et planetae inter se aliquando magis appropinquant, aliquando vero magis remotae sunt, quod ex motu terrae causari non potest, nisi ipsa caelestia corpora vere inter se moverentur. Nec etiam dici potest caelo quiescente stellas ispas movere, sicut aves in aere, vel pisces in aqua, tum quia hoc modo caelum innumeris in locis scinderetur a discurrentibus stellis, quod eius soliditati, et incorruptibilitati maxime repugnat, tum etiam quia maximum miraculum esset, ut innumerae stellae caeli stellati velocissime moverentur, caelumque disrumperent sine eo, quod aliquando ordinem aut distantiam, quam ad invicem habent **[f.3v]** immutarent sicut quotidie planetae immutant. Tertio item quia via lactea, ut suo loco dicemus pars caeli fixa, lucida est, et plena minutissimis stellis, et tamen[2] illa 24 horarum spatio[3] caelum totum circuit, non ergo stellae sed partes fixae caeli moventur atque ideo[4] totum caelum. Quibus[5] et aliis innumeris rationibus probant astrologi stellas fixae esse in caeli sicut nodus in tabula, nec per se moveri, sed solum ad motum ipsorum caelorum, quibus insunt.

Secundo etiam notandum est corpus unum non posse simul virtute propria moveri duobus motibus contrariis: v.g. lapidem simul ascendere et descendere, vel rotam moveri circulariter a dextra parte in sinistram, et simul a sinistra in dextram. Potest tamen contingere, ut eadem res contrariis simul moveatur motibus, ita tamen ut unus motus sibi naturalis sit, alii vero violenti non naturales; v.g. si navis moveatur ab oriente in occidens[6], et simul homo a prora in puppim discurrat, vel si formica in rota motu velocissimo feratur a dextera parte in sinistram, ipsa tamen econtrario ascendat a sinistra in dextram. Cum ergo in caelis observentur diversi motus stellarum simul fieri in eodem tempore, et ab oriente in occidens, et ab occidente in oriens, fit necessario assignandos esse caelos, quod fuerint diversitates motuum astrorum.

§ 1

His ergo positis sit prima conclusio: Caeli vere moventur motu circulari non virtute propria sibi congenita, sed ab angelo sibi deputato, qui cum voluntate sua movet, ita D. Thomas[7] et D. Augustinus, et communis est etiam inter ipsos philosophos gentiles, qui indignum reputantes, ut auctor naturae immediate per se caelum moveret, secundum numerum caelorum intelligentias seu substantias speciales esse dicebant, quae caelos movebant.

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[1] *correxi ex* verocissimum

[2] *Obara* in

[3] *correxi ex* spassio

[4] *correxi ex* adeo, *Obara* adeo

[5] *correxi ex* quis

[6] *correxi ex* occidns

[7] *correxi ex* Thomae

west by the most rapid motion, etc.. We cannot say that the earth is moved while the heaven stands still, about which we shall speak in its own place, partly because the earth itself is very heavy and hardly fitted for the most rapid motion, and partly because the stars and planets themselves sometimes approach one another and at other times fall apart ~ this cannot be caused by the motion of the earth, unless the celestial bodies themselves actually move among themselves. Nor can we say that the stars themselves move, like a bird in the air or a fish in the water, while the heaven stands still, partly because, if so, the heaven would be torn apart in many places by the stars which run about ~ this conflicts sharply with its solidity and incorruptibility ~, and partly because it would be most surprising that the innumerable stars of the starry heaven should be moved very rapidly and break the heaven into pieces without changing their mutual order or distance, as the planets do every day. Moreover, thirdly because the Milky Way, the fixed part of the heaven as we shall speak in its own place, is luminous and full of the smallest stars, but travels around the whole heaven in 24 hours. Therefore, not the stars but fixed parts of the heavens move, and thus the total heaven moves. On these and other innumerable grounds, astronomers prove that the stars are fixed in the heavens just like a knot in wood, and that they move not by themselves, but only by the motion of their inherent heavens.

Secondly, it should be noted that a single body cannot move by its own power simultaneously in two contrary motions: for instance, a stone cannot simultaneously ascend and descend, nor can a wheel move circularly simultaneously from right to left and from left to right. It can happen, however, that the same body may move by contrary motions at the same time, although one motion is natural to itself and the others are violent, not natural: for instance, if a ship is moving from east to west, a man could run from prow to stern, or if an ant is carried on the wheel by a rapid motion from right to left, it could contrariwise climb up from left to right. Accordingly, since we observe that different motions of the stars are simultaneously made at the same time in the heavens, [that is] from east to west and from west to east, it is necessary to assume the existence of such heavens that would cause the diversity of the motions of the stars.

§ 1

With these things premised, the first conclusion is that the heavens move circularly not by the power proper to them, but by the angel assigned to them, who moves by his own will. Thus St. Thomas and St. Augustine ~ and it is the common [view] among the gentile philosophers ~ pronounced that there exist intelligences or special substances of heavenly movers according to the number of the heavens, since they consider it unworthy that the creator of nature directly moves the heaven by himself.

Probatur quia duo genera entium moventur ab intrinseco[1] seu virtute propria, animantia scilicet a virtute propria animae, secundo gravia et levia, ut in loco sibi connaturali quiescant, naturaliter ascendunt vel descendunt, v.g. lapis in centrum mundi et ignis in concavum lunae; dum autem in proprio loco sunt, virtutem motivam non habent. Neutro autem istorum modorum caelum moveri potest virtute sua, non[2] primo, quia caelum animam non habet neque vivit, non autem item[3] secundo, quia caelum non movetur, ut in suo loco naturali quiescat, sed ut suo ordinatissimo motu mundum illuminet, omnia producat et conservet. Movetur ergo ab extrinseco[4], impetu[5] scilicet angelorum, qui sibi deputati sunt, ut motores. **[f.4r]** His consonant verba S.Scripturae Job.9. sub quo (i.e. Deo) curvantur qui[6] portant orbem[7] i.e. angeli qui movent caelos humiliantur. Illud etiam Matheus, et virtutes caelorum commovebuntur[8] (i.e. angeli qui caelo virtutem tribuunt, ut ait Origenes[9]). Verum est tamen motum caeli dici connaturalem ipsi caelo, non quia virtute propria moveatur, sed quia maxime conveniens est motus circularis figurae circulari, quam caelum habet.

Secunda conclusio: Tria genera motuum observantur in caelis. Primus diurnus ab oriente in occidens, qui dicitur motus raptus, secundus ab occidente in oriens, qui dicitur naturalis, tertius trepidationis. Primus manifestus est, nam 24 horarum spatio[10] caeli omnes et astra moventur ab oriente in occidens. Secundus etiam experientia constat, videmus enim stellas fixas firmamenti numquam propria loca mutare, neque eam distantiam, quam ad invicem habuerunt ab initio mundi. Septem autem planetas, si cum stellis fixis comparemus, quotidie motu retrogrado magis ac magis ab occidente in orientem revertuntur. Tertium trepidationis motum aliqui ex antiquis philosophis observarunt, sed Alfonsus Hispaniae rex circa annum Domini fere 1200 multis observationibus, quas longum esset referre, confirmavit. Observarunt enim stellas fixas octavae spherae aliquando in austrum tendere, aliquando in septentrionem reverti, et alia hujusmodi, quae non nisi a motu trepidationis causari possent[11].

§ 2

Tertia Conclusio: Praeter caelum empireum, quod sedes immobilis beatorum est, decem

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[1] *correxi ex* intrinceco

[2] *conieci ex* ~~non~~

[3] *Obara* autem

[4] *correxi ex* extrinceco

[5] *conieci ex* imperio, *Obara* imperio

[6] *post* qui *addidit* ~~p~~

[7] *Job* 9:13

[8] *Matthaeus* 24:29

[9] *correxi ex* Origines

[10] *correxi ex* spacio

[11] *conieci ex* posset, *Obara* posse[n]t

We can prove this, because there are two kinds of beings which are moved either intrinsically or by their proper power: namely, animals which are moved by the proper power of the soul; secondly the heavy things and light things, in order to come to rest in their connatural places, ascend or descend naturally ~ for example, a stone toward the center of the world and fire toward the concave [surface] of the moon ~, although they do not have motive force when they are in their proper places. In neither way, however, could the heaven be moved by its power: not in the first way, because the heaven neither has soul nor life; not in the second way, because the heaven does not move in order to come to rest in its natural place, but in order to illuminate the world by its best-ordered motion, and to produce and preserve all things. Consequently, it is moved extrinsically, that is, by the pushing of the angels, who are assigned to the heaven as movers. These things are in agreement with the passages in the Holy Scripture: Job 9 says "Those which carry the heavens prostrate themselves before God", that is, the angels which move the heavens humiliate themselves [before God]. Also Matthew says "and the powers of the heavens will be shaken"(i.e. the angels who bestow the power to the heaven, as Origen says). It is true, however, that the motion of heaven is connatural to heaven itself, not because it is moved by its proper power, but because a circular movement is the most suitable motion for the circular figure of the heaven.

Second Conclusion: Three kinds of motions are observed in the heavens. The first is a daily motion from east to west, which is called the swift motion; the second is from west to east, which is called natural; the third is a motion of trepidation. The first is manifest, for all the heavens and the stars are moved over a period of 24 hours. The second motion is also evident by experience, since we see the fixed stars of the firmament change neither their potisions nor the distance that they have had one from another since the beginning of the world, but the seven planets, when compared with the fixed stars, move daily in retrograde motion, more and more from west to east. Some ancient philosophers have observed a third motion of trepidation, but King Alfonso of Spain confirmed it around 1200 AD by many observations, although it would take too long to refer to them. For they observed that the fixed stars of the eighth sphere sometimes move to the south, at other times move back to the north, and other things of this kind, which can be caused only by the motion of trepidation.

§ 2

Third Conclusion: Except for the empyrean heaven, which is the immovable seat of the

aliae spherae mobiles assignantur ab astrologis. Probatur quia septem planetae non servant ordinem motus aliarum stellarum fixarum, neque etiam inter se; aliquando enim accedunt, aliquando vero recedunt ab invicem. Debent ergo assignari 8 spherae, septem pro planetis et una pro reliquis stellis, quae ordinem et situm non mutant, ut enim diximus, neque stellae moventur per se in caelis, neque unum caelum simul diversis motibus moveri potest. Cum ergo planetarum et aliarum stellarum motus ad invicem differant, immo aliquando contrarii sint, necessum[1] est, ut diversi eis caeli assignentur. Unde saltem erunt 8 caeli.

Sed ultra haec[2] duo alii caeli mobiles non habentes astrum constituuntur. Ratio est, quia multorum observationibus cognitum est caelum stellarum triplici moveri motu, uno ab oriente in occidens, alio tardissimo ab occidente in oriens, sicut et reliquae stellae errantes, seu planetae, tertium trepidationis supra dictum. Cum ergo unum caelum non possit moveri simul tribus motibus contrariis, necessum[3] erit, ut unus solus motus sit proprius octavae spherae, ab occidente scilicet in oriens, **[f.4v]** motum autem trepidationis et motum diurnum ab oriente in occidens habeant[4] motus a duobus caelis superioribus.

§ 3

Quarta Conclusio: Planetarum ordo hic est, ut primo loco nobisque propinquiori ponatur luna, secundo ascendendo Mercurius, tertio Venus, quarto Sol, quinto Mars, sexto Jupiter, septimo Saturnus, octavo firmamentum, seu[5] caelum stellarum. Probatur quia stella quae aliam occultat, ne videri possit, necessario debet esse infra illam. Sed stellae fixae octavae spherae occultantur ab omnibus septem planetis et ipsae nullam planetarum occultarent. Ergo stellae fixae sunt supra omnes planetas. Eadem ratio probat Saturnum esse supra Jovem, Jovem supra Martem, Martem supra Venerem, Venerem supra Mercurium, omniumque infimam esse lunam, quia ad invicem se hoc ordine occultare contingit, et luna a nulla occultatur unquam stella. Secunda ratio, quia, regulariter loquendo, quanto planetae magis distant a primo mobili, eo brevius conficiunt suum motum naturalem ab occidente in oriens, sed Saturnus conficit cursum suum naturalem spatio[6] 30 annorum, Jupiter duodecim fere annis, Mars annis fere 2, Sol diebus 365 et horis prope 6, Venus et Mercurius paulo minori tempori, Lunam 20 et 7 diebus cum 8 ferme horis (licet, ut postea dicemus, mensis lunaris constat 29 diebus cum horis 12). Eum ergo ordinem et situm servabunt inter se huiusmodi caeli.

De sole vero cur quartum obtineat locum specialis solet assignari ratio, quia cum rex sint inter planetas, eiusque motus regula sit motuum omnium planetarum, conveniens erat,

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[1] *sic*. *Obara* necessarium

[2] *correxi ex* hos, *Obara* hos

[3] *sic*. *Obara* necessarium

[4] *correxi ex* habeat, *Obara* habeat

[5] *conieci ex* se

[6] *correxi ex* spacio

Blessed, ten different mobile spheres are assigned by astronomers. This is approved, because the seven planets keep neither the order of motions of the other fixed stars, nor the order of one another, for they sometimes access and at other times recess mutually. Therefore, we should assign 8 spheres: seven for the planets and one for the remaining stars that do not change their order and position, because, as we have said, neither are the stars moved by themselves in the heavens, nor can a single heaven be simultaneously moved by different motions. Consequently, since the motions of the planets and the other stars are different each from the other but rather they are sometimes contrary, it is necessary that different heavens should be assigned to them. Thus there will be at least 8 heavens.

Beyond these, however, two other movable heavens having no stars are placed. The reason is that the starry heaven is recognized by the observations of many people to move in a threefold motion: the first is from east to west; the second slower one is from west to east like the remaining wandering stars or the planets; the third is of trepidation, as is shown above. Therefore, since a single heaven could not be simultaneously moved by three contrary motions, it will be necessary that only one motion should be proper to the eighth sphere, that is, from west to east, whereas the motions of two superior heavens have motion of trepidation and a daily motion from east to west.

§ 3

Fourth Conclusion: The order of the planets is as follows: the moon is placed in the first position, closer to us, and then, in ascending order, the second is Mercury, the third Venus, the fourth the sun, the fifth Mars, the sixth Jupiter, the seventh Saturn and the eighth is the firmament or the heaven of the stars. This is evident, because the star which conceals the other so that it cannot be seen should inevitably be lower than it. But the fixed stars of the eighth sphere are concealed by all the seven planets, and they conceal none of the planets. Therefore the fixed stars are higher than all the planets. By the same reason, it is proved that Saturn is above Jupiter, Jupiter above Mars, Mars above Venus, Venus above Mercury and the moon is the lowest of all, because it happens they conceal eath other in this order, and the moon is never concealed by any stars. The second reason is that, as a general rule, the further the planets are from the *primum mobile*, the shorter period of time they take to complete their natural motion from west to east. But Saturn completes its natural circuit in 30 years, and Jupiter in about 12 years, Mars in about 2 years, the sun in 365 days and nearly 6 hours, Venus and Mercury in a somewhat shorter period of time [than the sun] and the moon in 27 days and about 8 hours (although, as will be said afterwards, the lunar month consists of 29 days and 12 hours). Therefore these heavens will mutually keep this order and position of this kind.

But the particular reason why the sun should occupy the fourth place is generally given, because it would be appropriate that the sun holds a middle place among the planets, since the sun is their king and its motion is the measure of all the planetary motions. If otherwise, in case that the sun be in the lowest heaven, it would burn all the things by its

ut medium teneret locum inter illos. Item ne, si in infimo caelo esset, nimia sua propinquitate omnia combureret aut[1], si nimium distans esset, inefficax redderetur ad influendum in haec inferiora.

Cur autem sol eclipsetur[2] a luna, non autem a Venere et Mercurio, cum infra eum sit, dicetur suo loco. Breviter tamen dicimus quod, cum hi duo planetae minimi sint in conspectu solis eique propinquissimi, eorum umbra non potest usque ad terram pervenire. Luna vero etiam licet minima sit, quia tamen nobis propinquior est magisque[3] a sole distat, facile[4] potest eum nobis occultare, ut in figura patebit infra.

Quinta Conclusio: Immediate post octavam spheram ponitur caelum christallinum[5], quod et aqueum seu glaciale dici solet propter maximam perspicuitatem, et quia astrum non habet. De quo intelligitur, quod dicunt S.Scripturae aquas esse super caelos[6], i.e. caelum quod aquae colorem et naturam refert, licet solidum sit, ut dicimus in secundo tractato Compendii. Caelum hoc cristallinum[7] causa est motus trepidationis **[f.5r]** supradicti. Decimum caelum est primum mobile, quod motu rapidissimo omnes caelos inferiores post se trahit, eiusdemque natura est cum caelo christallino[8] supradicto. Ultimo loco empireum caelum ponitur a theologis, ut sit sedes immobilis beatorum, sic impireum dictum, ab igneo splendore. Est enim lucidissimum, ut ait Basilius, idque colligit ex illo Apoc. 21[9], et civitas, i.e. sedes beatorum. Non eget sole neque luna, quia claritas Dei circumfusit illum[10], et infra dicitur quod est similis auro mundo, vitri et christalli[11] more relucenti[12].

De sphera materiali ad cognoscendos varios motus caelorum inventa Cap. 3

Ut facilius ea, quae in caelestibus orbibus multorum annorum spatio[13] observatae sunt, possent explicari, antiqui philosophi magna industria materialis spherae usu adinvenere, ut in minimi corporis variis circulis, caelorum varii cursus, varietas dierum, eorumque

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[1] *ante* aut *habet* et *quod verbum Obara addidit*

[2] *correxi ex* eclipcetur

[3] *correxi ex* magis quia, *Obara* magis quando

[4] *correxi ex* facileque, *Obara* facileque

[5] *conieci ex* christarinum

[6] *Psalmi* 148:4

[7] *conieci ex* cristarinum

[8] *conieci ex* christario

[9] *Apocalypsis* 21:16

[10] *correxi ex* illam, *Obara* illam

[11] *conieci ex* christari

[12] *Apocalypsis* 21:18

[13] *correxi ex* spacio

excessive proximity to them, or in case it be extremely far, it would not be efficient in influencing the inferior things.

We shall speak in its proper place why the sun is eclipsed by the moon, not by Venus and Mercury, though they are below the sun. But we say briefly that their shadows cannot reach the earth, since these two planets are very small in comparison with the sun and very near to it. Though the moon is also very small, since it is much nearer to us and far from the sun, it can easily conceal the sun from us, as will be evident later in the figure.

Fifth Conclusion. Immediately beyond the eighth sphere, the crystalline heaven is placed: it is usually called watery or icy because of its maximam clarity and containing no stars. Concerning this [heaven], it is known that the Holy Scripture says "the waters exist beyond the heavens", that is, the heaven that resembles the colour and nature of water, although it is solid, as we say in the second treatise of the Compendium. This crystalline heaven is the cause of the above-mentioned motion of trepidation. The tenth heaven is the *primum mobile*, which drags all the lower heavens along with it by the very swift motion, and its nature is of the same as the above-mentioned crystalline heaven. At the remotest position, the empyrean heaven is placed by theologians in order to be the immovable seat of the Blessed; thus called "empyrean" from fiery brightness. For it is brightest as St. Basil says, and he conjectures this from the Revelation 21 "and the city..", that is, the seat of the Blessed. It needs neither the sun nor the moon, since the lucidity of God surrounds it, and we say below that it is similar to pure gold, shining like glass and crystal.

Chapter 3
On the material sphere invented in order to understand the various motions of the heavens

In order to be able to explain more easily those which have been observed in the celestial orbs over many years, ancient philosophers had devised with great assiduity the material sphere, so that the different movements of the heavens, the diversity of days and their

causae facile pro oculis poni possent. Huius spherae primus inventor dicitur fuisse Archimedes, qui in uno minimo globo omnium caelorum motus eorumque periodos assignabat.

Sphera autem corpus solidum est una vel pluribus superficiebus contenta, a cuius centro lineae deductae ad circumferentiam[1] deductae sunt aequales. Est corpus adeo perfecte rotundum, ut omnes eius circumferentiae partes aequaliter[2] differant a centro. Caelestia autem corpora[3], quorum centrum infima pars terrae est, omnino spherica esse iam superius probavimus.

Ut melius autem, quae dicenda sunt, intelligi queant, notandum est omnia caelestia corpora dividi ab astrologis in 360 partes, quas gradus communiter vocari solent; ita tamen quod a linea aequinoctiali usque ad polum 90 sint[4] gradus, iterumque a polo in aequinoctialem 90 sint[5] etiam gradus, qui quater multiplicati 360 conficiunt.

His ergo suppositis dicimus spheram materialem 10 principalibus circulis constare, quorum 6 maiores sunt, totumque caelum in aequales dividunt partes, reliqui autem 4 minores sunt, qui non in aequales, sed in inaequales dividunt partes.

Circuli maiores sunt, primus linea aequinoctialis sic dicta, quia sol ibi existens in universo mundo aequales facit dies ac noctes, ut statim dicemus. Secundus est signifer Zodiacus, tertius et quartus sunt duo coluri, quintus et sextus sunt meridianus et horizon. Circuli vero minores sunt duo tropici Cancri et Capricornii; duo item circuli arcticus, et antarcticus **[f.5v]**, de quibus singillatim[6] dicemus. Illud tamen advertendum est huiusmodi circulos formaliter non inveniri in caelestibus corporibus, sed ab astrologis confingi, ut melius caelorum motus explicari possint.

De singulis ergo circulis disseremus[7]. Aequinoctialis linea dicitur circulus quidam in primo mobili imaginatus, dividens caelos in aequales partes, aequaliter distans a polis mundi. Dicitur autem aequinoctialis, sive aequator, quia sol sub eo bis in anno existens in principio Arietis et Librae, i.e. 21 die Martii, et 24 septembris, aequales facit dies artificiales cum noctibus in universo mundo, exceptis his regionibus, quae directe sub polo sunt (in his enim, ut postea dicemus, non est varietas dierum ac[8] noctium[9], sed una dies et una nox in toto anno). Ratio huius aequalitatis dierum ac noctium, quia, cum sol est sub aequinoctiali, aequaliter medium mundum illuminat, unde aequales dies cum

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[1] *correxi ex* circunferentiam

[2] *correxi ex* aequalitem

[3] *Obara* omisit

[4] 90 sint] sint 90 *Obara*

[5] *Obara* sunt

[6] *correxi ex* sigilatim, *Obara* sigilatim

[7] *correxi ex* disserentes

[8] p*ost* dierum *addidi* ac, *post* dierum *Obara addidit* [et]

[9] *correxi ex* noctiuum

causes can easily be set before our eyes in the various circles of very small size. It is said that the first inventor of this sphere was Archimedes, who assigned the movements of all the heavens and their periods to one little globe.

The sphere is a solid body, comprised of one or many surfaces, from whose center the lines drawn to the circumference are drawn equal: thus it is a perfectly round body, so that all the parts of its circumference are equally distant from the center. We have already proved above that the celestial bodies, whose center is the lowest part of the earth, are entirely spherical.

For a better understanding of what we ought to say, it should be noted that all the celestial bodies are divided by astronomers into 360 parts, which are accustomed to be called "degrees". Hence, it forms 90 degrees from the equinoctial to the pole and, again, 90 degrees from the pole to the equinoctial line, thus they complete 360 when multiplied four times.

Upon these suppositions, we say that the material sphere consists of 10 principal circles, of which six are great circles that divide the total sphere into equal parts, and remaining 4 are small circles that divide [the total sphere] into not equal but unequal parts.

The great circles are as follows. Firstly, the equinoctial line, thus called because the sun, when staying in it, makes day and night equal all over the world, of which we speak immediately. The second is the zodiac [or] "sign-carrier", the third and fourth are the two colures, the fifth and sixth are the meridian and the horizon.

The small circles are the two tropics of Cancer and Capricorn and, also, the two circles of arctic and antarctic, of which we shall speak one by one. It should be noted, however, that these sorts of circles are not found in the celestial bodies formally, but are so invented by astronomers that the movements of the heavens could be better explained.

Now we shall enquire into individual circles. The equinoctial line is said to be an imaginative circle in the *primum mobile*, which is equally distant from the poles of the world and divides the heavens into equivalent parts. It is called "equinoctial", or "equator", since the sun, which stays beneath it twice in a year at the beginning of Aries and Libre, i.e. on the March 21st and September 24th, makes [the length of] an artificial day equal to [that of] night all over the world, except in the regions directly under the pole (for, as we shall say afterwards, in these regions there exist no varieties of days and nights, but [just] exist one day and one night in a whole year). The reason for this equality of day and night is that the sun, when it is on the equinoctial, illuminates [each] half of

noctibus tunc afficit[1]. Officia huius aequinoctialis sunt distinguere signa, stellas, et partes caeli septentrionalis [2] ab australibus. Deinde aequinoctialis est terminus a quo declinationes solis, sive ad austrum, sive ad meridiem computantur. 90 enim gradus, qui a linea ad polum assignantur, ab ipsa aequinoctiali linea incipiunt computari. Item longitudo diei et noctis artificialis ab aequinoctiali desumitur, ut suo loco dicemus. Aliaeque sunt innumerae aequinoctialis utilitates.

Zodiacus est alius circulus maximus, qui intersecat aequinoctialem circulum, et ab eodem intersecatur in duas partes aequales, quarum una in septentrionem, altera versus austrum declinat. Est autem Zodiacus via solis et omnium aliarum planetarum. Dicitur autem Zodiacus, vel a Zoe i.e. vita, quia scilicet sol et planetae, dum sub eo moventur, influunt vitam in haec inferiora, vel a Zoon, quod est animal, sic dictum propter 12 signa, quae, ut plurimum, sub nominibus animalium describuntur propter aliquas particulares rationes. Zodiacus habet in circuitu 360 gradus, dividit enim caelum in aequales partes. Habet in latitudine 12 gradus, quorum media pars linea ecliptica, sub qua semper sol discurrit, nec ad unam[3] nec ad alteram partem declinans. Aliter etiam Zodiacus dividitur in 12 aequales partes, quae 12 signa appellari solent. Unumquodque autem signum 30 continet gradus, qui duodecies multiplicati 360 gradus constituunt. Horum signorum nomina sunt Aries, Taurus, Gemini, Cancer, Leo, **[f.6r]** Virgo, Libra, Scorpius, Sagittarius, Capricornius, Aquarius, Piscis, quorum 6 priores septentrionales dicuntur, 6 autem posteriores[4] meridionales. Secundum haec signa varietas[5] temporum incidit, cum enim sol est in tribus prioribus, ver est in nostro hemispherio, a principio scilicet Arietis usque ad finem Gemini; cum vero est in tribus sequentibus, qui [*sic*] aestas, a principio scilicet Cancri usque ad finem Virginis; cum vero sol ingreditur principium Librae usque finem Sagittarii, autumnale tempus conficit; a principio vero Capricornii usque ad finem Piscis hiemale.

§ 2

Est autem Zodiacus via, quam sol et reliqui planetae servant in suo cursu naturali, ita tamen ut sol semper sub media ecliptica linea discurrat, nec ad unum aut ad aliam partem declinet. Linea autem haec ecliptica dici solet, quia semper fiunt eclipses[6], quando sol et luna in oppositione vel in coniunctione sub hac ecliptica sunt, ut postea dicemus. Reliqui vero planetae sub eisdem signis Zodiaci aliquando ad septentrionem, aliquando vero ad meridiem per 5 [7] vel 6 gradus declinare solent. Haec autem omnia continua

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[1] *conieci ex* afficiet, Obara efficiet

[2] *Obara* septentrionali

[3] *Obara* unum

[4] *post* posteriores *habet* boreales sive *quae duo verba Obara addidit*

[5] *conieci ex* varies, *Obara* varies

[6] *correxi ex* eclipces

[7] *Obara* 3

the world equally and, therefore, makes [the length of] day equal to [that of] night at that time. The function of this line is to distinguish northern signs, stars and the parts of the heaven from southern ones. Secondly, the equinoctial is the boundary line from which the declinations of the sun toward the south, or on a meridian, are computed. For 90 degrees, which are assigned between the line and the pole, are counted from this equinoctial line. Also, the length of the artificial day and night are picked out by the equinoctial, as we shall say in its proper place. There are many other utilities of the equinoctial.

The Zodiac is another great circle which intersects the equinoctial and is intersected by it into two equal parts, of which one inclines to the north, the other toward the south. The Zodiac is the path of the sun and all the other planets. It is called "Zodiac", either from *zoe*, meaning "life", because it is obvious that the sun and the planets, when moved beneath it, infuse life into these inferior things, or from *Zoon*, which means "animal", being so said because of the 12 signs, most of which are described under the names of the animals for some particular reasons. The Zodiac contains 360 degrees in its circle, for it divides the heaven into equal parts. It has 12 degrees in width, whose central part is the ecliptic line, along which the sun always runs, inclined neither to one nor the other side. In another way, the Zodiac is divided into 12 equal parts, which are usually called 12 signs. Each sign contains 30 degrees, constituting 360 degrees when multiplied 12 times. The names of these signs are Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpius, Sagittarius, Capricorn, Aquarius and Pisces: of which the former 6 are called the septentrional, the latter 6 the meridional. According to these signs, a change of seasons occurs: for when the sun is in the former three, it is spring in our hemisphere, that is, from the beginning of Aries to the end of Gemini; when it is in the succeeding three, it is summer, that is, from the beginning of Cancer to the end of Virgo; when the sun steps into the beginning of Libra to the end of Sagittarius, it brings autumn, and winter from the beginning of Capricorn to the end of Pisces.

§ 2

The Zodiac is the path, to which the sun and other planets keep in their natural course, though the sun always passes through the central part of the ecliptic line, inclining to neither the one nor the other side. This line is generally called "ecliptic", because the eclipses always occur when the sun and the moon are on this line in opposition or conjunction, as we shall say afterward. Under these signs of the Zodiac, however, other planets usually incline to the north at one time and to the south at other times by 5 or 6 degrees. All these things are found by the continuous observation of astronomers: for the

astronomorum observatione comperta sunt: sol enim suo naturali motu vel ad septentrionem ascendit, vel ad meridiem descendit, et hoc regularissimo motu, numquam tamen visus est magis distare ab aequinoctiali, quam per viginti tres gradus cum dimidio; reliqui vero planetae signorum ordinem servantes visi sunt distare per 28 gradus, dum sunt in Cancro vel in Capricornio. Deinde, quod sol numquam extra eclipticam lineam discurrat, experientia patet; posito enim stilo in plano apparebit semper solem, dum est in principio alicuius signi, v.g. Leonis, aut Virginis, omnibus annis facere eandem umbram, dum est in oriente, meridie, et in occidente. Quod quidem non contingeret, si sol sicut et reliqui planetae intra eumdem signum aliquando ad septentrionem, aliquando vero ad meridiem declinaret.

§ 3

Coluri duo sunt circuli maiores, qui transeunt per[1] polos mundi, et per quattuor puncta ecliptica, duo scilicet solstitia, et duo aequinoctia. Horum officium est 4 anni tempora distinguere, solstitia etiam[2] et aequinoctia declarare; unde colurus unus solstitialis, alius vero aequinoctialis dici solet; quia vero aequinoctia duo sunt in anno, primum in principio Arietis, secundum in principio Librae, solstitia item duo, unum quod **[f.6v]** in principio Cancri fit, solstitium scilicet aestivum[3], aliud quod in principio Capricornii fieri solet, et dicitur solstitium hiemale. Propterea hos coluros haec 4 puncta designare et scindere dicimus. Quae ideo 4 puncta cardinalia dici solent, quia ab eis 4 anni incipiunt tempora, ab Ariete ver, a Cancro aestas, a Libra autumnus, a Capricornio hiems.

§

Quintus circulus maior spherae est horizon, qui est linea vel circulus partem caeli visam a non visa dividens: semper enim media caeli pars a nobis conspicitur, et haec superius hemispherium appellatur, media vero pars non visa, inferius dicitur hemispherium. Linea ergo illa seu extremitas hemispherii nostri, quae vel terram vel mare tangens, dividit nostrum hemispherium a non viso, horizon dicitur Graece, Latine vero finitor aspectus, quia terminat ea, quae videntur.

Quod vero in horizonte, non impedito, videatur caeli media pars experientia patet; tum quia semper sex signa Zodiaci nobis apparent, 6 autem occultantur, tum quia in puncto oppositionis simul sol occidit et luna oritur in oriente. Imo, ut Plinius ait, saepe visa est luna eclipsari in puncto orientis sole existente in contrario puncto horizontis. Quod videri non posset, nisi media pars caeli nobis pateret[4], sicut in figura videri potest.

Et licet terra, quia non plana sed spherica est, videatur aliquo modo impedire, ne medium caeli conspicere possimus, quia tamen minima est respectu caelorum ab eisque

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[1] *Obara omisit* per

[2] *conieci ex* est, *Obara* ergo

[3] *correxi ex* vernum, *Obara* vernum

[4] *conieci ex* patere

sun sometimes ascends to the north and at the other times descends to the south by its natural motion, but, by this very regular motion, is never seen to be more than 23 and a half degrees away from the equinoctial, while the remaining planets, keeping the order of the signs, are seen to be 28 degrees away, when they are in Cancer or in Capricorn. Next, it is evident by experience that the sun never deviates from the ecliptic, for if you set up a stake on level ground, it will always appear that the sun, provided that it is at the beginning of some signs like Leo or Virgin, casts the same shadow every year, whether it is in the east, south and east. This would not occur if the sun within the same sign should decline sometimes toward the north and at other times toward the south, as the remaining planets do.

§ 3

The two colures are great circles, which traverse through the poles of the world and, also, the four points on the ecliptic, that is, the two solstices and two equinoxes. The function of these circles is to distinguish the four seasons and to announce the solstices and the equinoxes; thus one is usually called the "solstitial colure" and the other the "equinoctial colure", because there are two equinoxes in a year, the first at the beginning of Aries, the second at the beginning of Libra, while there are two solstices, one at the beginning of Cancer, i.e. the "summer solstice", and the other usually at the beginning of Capricorn, called the "winter solstice". Therefore we say that these colures indicate and divide those four points. Thus they are usually called "the four cardinal points", because with these points the four seasons begin: spring from Aries, summer from Cancer, autumn from Libra and winter from Capricorn.

§

The fifth great circle is the horizon, which is the line or the circle dividing the visible part of the heaven from the invisible part, for half of heaven is always seen from us ~ it is called the "upper hemisphere"~ but the other half is not seen ~ it is called "lower hemisphere"~. Therefore, that line or limit of our hemisphere, which, by touching either the earth or the sea, divides our hemisphere from the invisible one, is called "horizon" in Greek, but in Latin "One who sets a limit of the sight", since it limits those things which are seen.

It is evident by experience that half of heaven should be seen on the horizon unless impeded, because, on the one hand, the six signs of the Zodiac always appear to us while [the other] 6 are concealed, and, on the other hand, the setting of the sun concurs with the rising of the moon in the east [when they are] in opposition. Indeed, as Pliny says, it is frequently seen that the moon is eclipsed at the eastern point of the horizon while the sun stays in the opposite point. This cannot be seen, unless a half part of the heaven appears to us, as can be seen in the figure.

Moreover, although it might appear that the earth, since it is not plane but spherical, in some manner prevents us from seeing half of heaven, it cannot do so, because the earth is

maxime distat, visum medii caeli impedire non potest, ut etiam in figura patet. [Fig.7,8]

[Tabula interposita inter fol. 6 et 7]

Menses	Dies habet			Sol oritur		Sol occidit		Nox habet		Sol ingreditur	
	Dies	Horas	Quartas[1]	Horas	Quartas[2]	Horas[3]	Quartas[4]	Horas	Quartas[5]	Dies	Signum
Januarii	1	10	0	7	0	5	0	14	0	20	Aquarii[6]
	10	10	1	6	3 1/2	5	1/2	13	3		
	20	10	2	6	3	5	1	13	2		
Februarii	1	10	3	6	2 1/2	5	1 1/2	13	1		Piscis
	10	11	0	6	2	5	2	13	0		
	20	11	1	6	1 1/2	5	2 1/2	12	3		
Martii	1	11	2	6	1	5	3	12	2		Arietis
	10	11	3	6	1/2	5	3 1/2	12	1	21	
	20	12	0	6	1/2	5	0	12	0		
Aprilis	1	12	1	5	3 1/2	6	1/2	11	3		Tauri[7]
	10	12	2	5	3	6	1	11	2		
	20	12	3	5	2 1/2	6	1 1/2	11	1		
Maii	1	13	0	5	2	6	2	11	0		Geminorum[8]
	10	13	1	5	1 1/2	6	2 1/2	10	3		
	20	13	2	5	1	6	3	10	2		
Junii	1	13[9]	3	5	1/2	6	3 1/2	10	1		Cancri
	10	14	0	5	0	7	0	10		21	
	20	14	1	4	3 1/2	7	1/2	9	3		
Julii	1	14	0	5	0	7	0	10	0		Leonis
	10	13	3	5	1/2	6	3 1/2	10	1	22	
	20	13	2	5	1	6	3	10	2		

[1] *correxi ex* Quartos

[2] *correxi ex* Quatas

[3] *correxi ex* Haras

[4] *correxi ex* Quatas

[5] *correxi ex* Qurtas

[6] *correxi ex* Aquaris

[7] *correxi ex* Taurus

[8] *correxi ex* Gemini

[9] *correxit ex* 12

very small compared to the heavens and is very far from them, as is also evident in the figure.

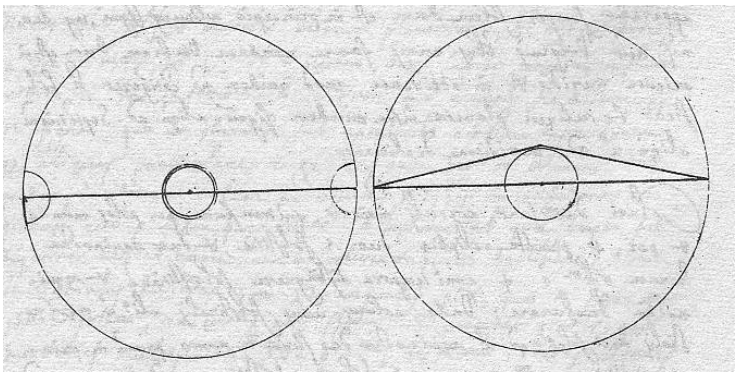

Fig. 7, 8

Month	Day time			The sun rises		The sun sets		Night time		The sun comes in	
	Day	Hours	Quarters	Hour	Quarter	Hour	Quarter	Hours	Quarters	Day	Sign
January	1	10	0	7	0	5	0	14	0	20	Aquarius
	10	10	1	6	3 1/2	5	1/2	13	3		
	20	10	2	6	3	5	1	13	2		
February	1	10	3	6	2 1/2	5	1 1/2	13	1		Pisces
	10	11	0	6	2	5	2	13	0		
	20	11	1	6	1 1/2	5	2 1/2	12	3		
March	1	11	2	6	1	5	3	12	2		Aries
	10	11	3	6	1/2	5	3 1/2	12	1	21	
	20	12	0	6	1/2	5	0	12	0		
April	1	12	1	5	3 1/2	6	1/2	11	3		Taurus
	10	12	2	5	3	6	1	11	2		
	20	12	3	5	2 1/2	6	1 1/2	11	1		
May	1	13	0	5	2	6	2	11	0		Gemini
	10	13	1	5	1 1/2	6	2 1/2	10	3		
	20	13	2	5	1	6	3	10	2		
June	1	13	3	5	1/2	6	3 1/2	10	1		Cancer
	10	14	0	5	0	7	0	10		21	
	20	14	1	4	3 1/2	7	1/2	9	3		
July	1	14	0	5	0	7	0	10	0		Leo
	10	13	3	5	1/2	6	3 1/2	10	1	22	
	20	13	2	5	1	6	3	10	2		

Augusti	1	13	1	5	1 1/2	6	2 1/2	10	3		Virginis
	10	13	0	5	2	6	2	11	0		
	20	12	3	5	2 1/2	6	1 1/2	11	1		
Septemb.	1	12	2	5	3	6	1	11	2		Librae
	10	12	1	5	3 1/2	6	1/2	11	3	23	
	20	12	0	6	0	5	0	12	0		
Octubris	1	11	3	6	1/2	5	3 1/2	12	1		Scorpii
	10	11	2	6	1	5	3	12	2	23	
	20	11	1	6	1 1/2	5	2 1/2	12	3		
Novemb.	1	11	0	6	2	5	2	13	0		Sagittarii
	10	10	3	6	2 1/2	5	1 1/2	13	1		
	20	10	2	6	3	5	1	13	2		
Decembris	1	10	1	6	3 1/2	5	1/2	13	3		Capricornii
	10	10	0	7	0	5	0	14	0	23	
	20	9	3	7	1/2	4	3 1/2	14	1		

[f.7r] Horizon duplex est, alter rectus, obliquus alter. Rectum horizontem habent hi soli, qui lineam habent pro Zenith, i.e.[1] supra caput suum, quia tunc horizon tangens duos polos mundi dividit aequinoctiam ad angulos rectos. Ii vero qui habent elevatum polum aliquem supra suum hemispherium, dicuntur habere obliquum horizontem.

Hinc sequuntur quattuor. Primum quod semper a nostro Zenith ad omnem partem nostri horizontis sunt 90 gradus. Secundum quod, quanto elevatur unus polus supra caput nostrum, tanto deprimitur alter. Tertium quod si v.g. polus supra horizontem elevatur per 23[2] gradus[3] erunt 157 gradus ab ipso polo usque ad horizontem ducti per meridianum, et iidem[4] erunt a contrario polo ad nostrum horizontem ducti per Nadir[5]. Quartum, quod horizon immobilis est, solumque mutatur perceptibiliter, quando homo in quamlibet mundi partem 10[6] et 7 leucas cum dimidia[7] uni gradui caelesti correspondentes[8] perambulat. Quae omnia in figura patebunt.

Officia horizontis sunt ostendere nobis ortum et occasum omnium astrorum, distinguere dies artificiales a noctibus, dierum item et noctium in aequalitates causat, ut in

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[1] *Obara* scilicet

[2] *correxi ex* 33

[3] *post* gradus *delevit* (tot etiam gradus […] ab aequinoctiali versus alium polum, et […]) *quae verba Obara omisit*

[4] *correxi ex* piidem

[5] *in margine habetur* erunt 157…. per Nadir

[6] *correxit ex* 17

[7] *post* dimidia *Obara addidit* [quod]

[8] *conieci ex* correspondet, *Obara* correspondet

August	1	13	1	5	1 1/2	6	2 1/2	10	3		Virgo
	10	13	0	5	2	6	2	11	0		
	20	12	3	5	2 1/2	6	1 1/2	11	1		
September	1	12	2	5	3	6	1	11	2		Libra
	10	12	1	5	3 1/2	6	1/2	11	3	23	
	20	12	0	6	0	5	0	12	0		
October	1	11	3	6	1/2	5	3 1/2	12	1		Scorpius
	10	11	2	6	1	5	3	12	2	23	
	20	11	1	6	1 1/2	5	2 1/2	12	3		
November	1	11	0	6	2	5	2	13	0		Sagittarius
	10	10	3	6	2 1/2	5	1 1/2	13	1		
	20	10	2	6	3	5	1	13	2		
December	1	10	1	6	3 1/2	5	1/2	13	3		Capricorn
	10	10	0	7	0	5	0	14	0	23	
	20	9	3	7	1/2	4	3 1/2	14	1		

The horizon is twofold, right and oblique. Only those who have the [equinoctial] line on the zenith i.e. above their head, have the right horizon, because in this case the horizon, which is touching the two poles of the world, divides the equator at right angles. On the other hand, those who have a pole elevated above their hemisphere are said to have the oblique horizon.

Whence follow the next 4 conclusions. Firstly, there are always 90 degrees from our zenith to every part of our horizon. Secondly, the more one pole is elevated above our head, the more the other is lowered. Thirdly, if, for example, one pole is elevated from the horizon by 23 degrees, there will be 157 degrees from the same pole to the horizon along the meridian, and the same degrees from the other pole to our horizon through the “nadir”. Fourthly, the horizon is immovable, and it is perceptibly moved only when a man walks, in whichever direction, 17 and a half *leucas*, that correspond to one heavenly degree. These all will be evident in the figure.

The functions of the horizon are to show us the rising and setting of all stars, and to distinguish the artificial day from the night. Also it brings about the equalities of day and

sequenti capite dicemus.

§

[Fig. 9[1]] Meridianus est ultimus circulus magnus, qui ex parte dependet ab horizonte. Est autem[2] circulus transiens per polos mundi et per nostrum Zenith, i.e. supra caput nostrum. Vocatur autem[3] meridianus, quia sol elevatus supra horizontem dum pervenit ad hanc lineam, fit nobis meridies. Unde et iis, qui horizontem nostrum habent pro Zenith, fit ortus vel occasus solis, iis vero, qui Nadir nostrum habent pro suo Zenith, est in puncto media nox, sicut patet in figura. Dicitur autem Nadir punctus ille, qui in inferiori hemispherio correspondet nostro Zenith.

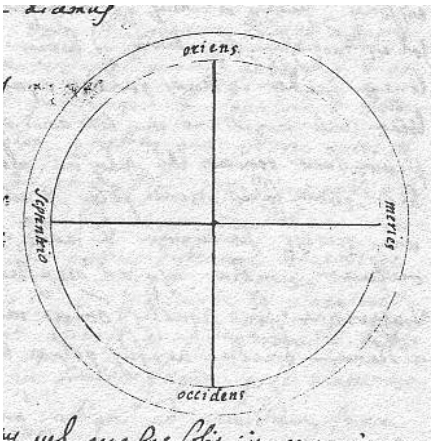

Fig. 9

[Fig. 10] Hinc fit semper, et ubique terrarum, aequale debere esse tempus matutinum cum vespertino, ita ut si dies 14 horarum sit, septem sint a matutino in meridiem, unde quinta hora sol orietur **[f.7v]** et itidem septem horae erunt a meridie in vesperum, quia cum meridianus dividat medium emispherium nostrum tendens a polo in polum per Zenith, fit ut aequaliter distet ab ortu et occasu solis. Unde aequale faciet tempus matutinum cum vespertino.

Dixi meridianum ex parte dependere ab horizonte, quia quicumque mutarit horizontem gradiens ab oriente in occidens, mutabit etiam et meridianum: mutat enim Zenith et lineam illam, quae per ipsum a polo in polum ducitur, quae ut diximus meridianum efficit. Si vero quis directe a septentrione in austrum tenderet, nec ad orientem, vel ad occidentem declinaret, mutaret quidem semper horizontem, numquam tamen meridianum, sicut neque mutat lineam illam, quae a polo in polum ducitur.

Meridianus duobus modis sumi potest pro horologiis conficiendis. Primo fiant in plano plures circuli et in medio elevetur stilus, et observetur, quem circulum tangit extremitas umbrae stili in puncto ortus solis; itemque circulus, quem tangit ultimo eadem umbra, dum sol est in occasu, et spatium, quod fuerit inter haec duo puncta. Dividatur linea quaedam[4] in duas partes aequales versus illum stilum, et haec linea erit meridianus in toto anno. Secundo modo, pro iis, qui extra tropicum sunt, ponatur idem stilus in plano, et observetur extremitas umbrae, quam facit oriente sole, et videbitur umbra paulatim decrescere quousque fit minima et maxime directa versus polum, et iterum crescent

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[1] *in figura habet* oriens; meries [*sic*: meridies], occidens, septentrio

[2] *conieci ex* aut

[3] *correxi ex* aut

[4] *correxi ex* quadam, *Obara* quadam

night, as we shall say in the following chapter.

§

The meridian is the last great circle, which in part depends upon the horizon. It is the circle passing through the poles of the world and through our zenith, i.e. above our head. It is called "meridian", because when the sun, elevated above the horizon, reaches this line, it is noon for us. Consequently, the rising and setting of the sun would occur for those who have our horizon in the zenith; on the other hand, it is exactly midnight for those who have our "nadir" in their zenith, as is evident in the figure. We call that point "nadir" which corresponds to our zenith in the lower hemisphere.

Hence, wherever on earth it may be, it always occurs that the length of the morning should be the same as that of the afternoon, so that if a daytime is of 14 hours, there would be 7 hours from morning to noon, thence the sun would rise at 5 o'clock, and, in the same way, there would be 7 hours from noon to evening, because since the meridian, stretching from one pole to the other through the zenith, divides our hemisphere into two halves, it follows that the line should be equally distant from the rising and setting of the sun, thence it will make the length of the morning equal to that of the afternoon.

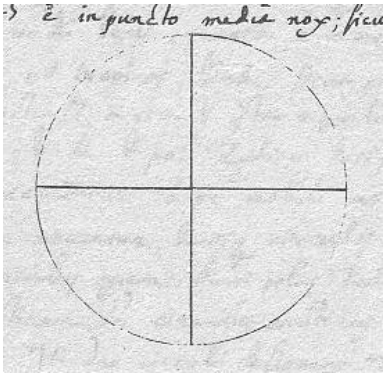

Fig. 10

I said that the meridian in part depends upon the horizon, because whoever shifts the horizon while walking from east to west, would also shift the meridian, for he shifts the zenith and that line which is drawn from one pole to the other through the zenith, and which, as we have said, forms the meridian. If someone marched directly from north to south without inclining toward east or west, he would always shift the horizon, but never the meridian, just as he does not shift the line which is drawn from one pole to the other.

The meridian can be taken in two ways for making sundials. Firstly, draw many circles on the plane and erect a stake at the center, then observe which circle touches the tip of the stake's shadow at the moment of the sun's rising, and also the circle which the same shadow finally touches while the sun is setting, and the length that will exist between these two points. Then divide the length into two equal parts by a line toward the stake, and this line will be the meridian for a whole year. Secondly for those who are outside of the tropics, erect the same stake on the plane, and observe the tip of the shadow which is made while the sun is rising, and you shall see that the shadow gradually decrease untill it becomes the shortest, and precisely directed toward the pole, and again the shadows increase all the way to sun's setting: therefore, the shadows in the morning and evening

umbrae usque ad occasum, ita ut umbrae matutinae et vespertinae sint aequales omnino inter se. Et omnium minima sit meridiana directe versus polum tendens. Utrumque in his figuris patebit[1].

[f.8r] Restat ut de quattuor minoribus circulis agamus, et primo de tropicis. Tropicus idem significat quod reversio, sol enim ascendit ad septentrionem, et dum primum ingreditur signum Cancri, quasi stat, neque ulterius ascendit, unde solstitium dicitur punctus ille, i.e. solis statio, iterumque sol revertitur ad lineam. Via ergo seu circulus, quem conficit sol in principio Cancri, dicitur tropicus Cancri, seu reversio a Cancro. Idem contingit in principio Capricornii, unde alius tropicus Capricornii dicitur. Primus est finis veris et principium aestatis, secundus vero finis autumni, et principium hiemis, et uterque differt a linea per 23 gradus cum dimidio.

Ut de duobus ultimis circulis agamus, notandum est in omni motu circulari regulariter facto in corpore perfecte spherico, debere assignari duo aliqua puncta supra quae fiat motus, quae quasi immobilia sint, ut in sphera materiali patebit: et haec puncta vocantur poli. Cum ergo in caelis tria sint genera motuum iuxta supradicta, raptus scilicet, naturalis et trepidationis, tria etiam genera polorum assignanda sunt. Pro motu raptus[2] assignantur poli mundi, arcticus scilicet et antarticus. Arcticus est ille qui nobis patet, qui et septentrio, et borealis et Aquilonaris [*sic*] pars dici solet. Stella, quae Norte communiter dicitur, vere polus non est, sed nunc differt a polo per 3 gradus cum dimidio aut circa[3]. Alius antarcticus nobis occultatur, nec habet iuxta se stellam aliquam maxime lucidam nisi per 30 gradus distantem. Vocatur ergo pars Australis et meridionalis.

In motu etiam planetarum, quia maxime a motu raptus[4] differt, diversi etiam assignantur poli distantes a polis mundi 23 gradibus cum dimidio. Supra quos planetae aliquando accedentes ad septentrionem, aliquando ad meridiem suum motum naturalem conficiunt ab occidente[5] in orientem[6], tantaque est distantia, quam hi poli a polis mundi habent, quanta est maxima declinatio solis ab aequinoctiali ad tropicos; unde sicut poli mundi aequaliter distant ab aequinoctiali, et ita et isti[7] aequaliter distant a linea ecliptica[8] Zodiaci: unde et poli Zodiaci dici solent. Quia ergo omnes inferiores orbes rapiuntur a primo mobili motu diurno, hi poli Zodiaci motu raptus[9] moventur, duosque circulos motu suo in caelo conficiunt; unde circulus, quem efficit polus Zodiaci, qui est iuxta polum mundi arcticum, dicitur circulus arcticus, et ei oppositus dicitur antarcticus. Hi duo circuli

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[1] *desunt figurae in textu*

[2] *correxi ex* raptu*, Obara* raptu

[3] *Obara dixit de* aut circa "duo verba intelligibilia"

[4] *correxi ex* raptu*, Obara* raptu

[5] *correxi ex* oriente *quia in margine habet* -2-, *Obara* oriente

[6] *correxi ex* occidens *quia in margine habet* -1-, *Obara* occidens

[7] *correxi ex* ista, *Obara* istae

[8] *correxi ex* hacliptica

[9] *correxi ex* raptu*, Obara* raptu

are entirely equal to one another. And now the shortest of all is the meridian stretching directly toward the pole. Both will be evident in these figures.

It remains for us to discuss the four small circles: firstly, the tropics. "Tropic" means the same thing as "turning back", for the sun ascends to the north and when it first enters the sign of Cancer, it does not ascend any more as if standing still ~ whence that point is called the solstice, i.e. a stationary position of the sun ~ and the sun turns back again to the [equinoctial] line. Therefore, the path or circle, which the sun makes at the beginning of Cancer, is called the "tropic of Cancer", or the "turning-back in Cancer". In the same manner, the sun reaches the beginning of Capricorn, whence the other circle is called the "tropic of Capricorn". The first is the end of the spring and the beginning of the summer, and the second is the end of the autumn and the beginning of the winter, and both are distant from the [equinoctial] line by 23 and a half degrees.

In order to discuss the last two circles, it should be noted that, to every circular motion regularly performed in a perfectly spherical body, two other points, on which occurs the motion, and which are, as it were, immovable, have to be assigned, as will be evident in the material sphere: these points are called poles. Therefore, since there are three kinds of motion in the heavens according to what has been said, that is, swift motion, natural motion and trepidation, three kinds of pole ought to be assigned. For swift motion, the poles of the world, that is, the northern and the southern, are assigned. That which is visible to us is the northern one, and it is accustomed to be called "septentrion", the "boreal" and "Aquilon" part. The star which is commonly called "North [star]" is indeed not the pole, but nowadays is distant from the pole by 3 and a half degrees. Another south pole is hidden from us, and does not have a star nearby which is very bright, except for the one which is 30 degrees away. Thus, the pole is called the "austral" and "meridional" part.

Also, for the motion of the planets, since it is quite different from swift motion, different poles which are away from the pole of the world by 23 and a half degrees are assigned. The planets, sometimes ascending to the north and at other times to the south toward these poles, complete their natural motion from west to east, and these poles are distant from the poles of the world as much as the maximam declination of the sun from the equator to the tropics. Consequently, just as the poles of the world are equally distant from the equator, so are these poles equally distant from the ecliptic line of the Zodiac; whence it is called the "poles of the Zodiac". Therefore, since all the lower orbs are carried off by a daily motion of the *primum mobile*, these poles of the Zodiac are [also] moved by swift motion, and make two circles in the heaven by their proper motion; whence the circle, which the pole of the Zodiac near the northern pole of the world makes, is called the "Northern circle", and the opposite one is called "Southern circle". These

designant zonam **[f.8v]** frigidam, ut statim dicemus. Pro motu etiam trepidationis, qui tardissime fit a septentrione in meridiem, alii etiam poli assignantur, puncta scilicet aequinoctialia, ut est principium Arietis et principium Librae.

Haec de circulis spherae, et secundum hos varietas motuum caelestium facile dignoscitur. Solent etiam astrologi mundum dividere in quinque zonas seu in quinque plagas. Zona autem est regio ab uno aut duobus circulis minoribus circumscripta. Inter has zonas duae dicuntur zonae frigidae, duae temperatae, et una torrida. Zonae frigidae sunt partes illae terrae, quae sunt sub circulo arctico et antarctico. Zonae temperatae sunt illae terrae, quae sunt a circulo arctico usque ad tropicum Cancri et a circulo antarctico ad tropicum Capricornii. Sub zona vero torrida sunt terrae illae, quae sunt a tropico Cancri usque ad tropicum Capricornii. Antiquiores philosophi solam zonam temperatam habitari existimabant, nam torrida prae nimia caliditate et vicinitate solis, frigida prae nimia frigiditate et absentia solis, inhabitabiles esse videbantur. Sed nunc experientia constat omnes esse habitabiles, imo magna ex parte habitari.

Ex his patet modus conficiendi spheram: in plano fiat circulus et hic duabus lineis in quattuor aequales partes dividatur, ita ut 90 gradus seu partes in uniuscuiusque circumferentia sint, et tunc una linea harum duarum erit aequinoctialis, alia vero erit axis polos designans. Deinde ab aequinoctiali versus unumquemque polorum duae item lineae ducantur, quarum distantia ab aequinoctiali 23 gradus cum dimidio non excedat, ulterius circa utrumque polum aliae lineae ducantur, quarum extremitates a polo per 23 gradus cum dimidio distent. Deinde a puncto unius tropici usque ad alterum linea altera deducatur, quae centrum spherae pertranseat, et haec[1] linea ecliptica. Deinde iuxta hanc duae etiam lineae, una a parte septentrionis, altera a parte meridiei ducantur, quae a dicta linea ecliptica per 6 gradus semper differat, et hae tres lineae Zodiacum significant[2], qui, in 6 partes divisus, 6 signa quae in dimidio caelo semper apparent, designabit.

De dierum et mensium[3] et annorum periodis eorumque varietate Cap. 4[4]

Ad rerum omnium tempora et durationes dignoscendas, maxime necessarium erat regularissimum et indeficientem aliquem motum statuere, cuius motus duratio omnium aliarum durationum esset regula et mensura, **[f.9r]** tempusque communiter vocaretur[5]. Quia vero caelestes motus omnium regularissimi sunt, ideo Aristoteles tempus mensuram esse dixit durationis motus caelestis corporis[6]. Atque hinc factum est, ut omnes nationes solis et lunae motus, qui notiores sunt, observantes iuxta eorum varietatem tempus etiam

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[1] *post* haec *Obara addidit* [est]

[2] *correxi ex* significat, *Obara* significa[n]t

[3] c*orrexi ex* mentium

[4] *hinc a manu alia scriptum est*

[5] communiter vocaretur] cognosceretur *Obara*

[6] *Physica* lib.4, cap.14, 223b10-224a10; *De caelo* lib.2, cap.4, 287a20

two circles define the frigid zone, as we shall discuss immediately. For the motion of trepidation which is made from north to south exceedingly slowly, other poles are assigned, that is, the "equinoctial points", as they are in the beginning of Aries and in the beginning of Libra.

So much concerning the circles of the sphere, and the variety of celestial motions is easily discerned by them. Now, astronomers usually divide the world into 5 zones or into 5 regions. A zone is the region which is circumscribed by one or two small circles. Among these zones, two are called the frigid zones, two are temperate and one is torrid. The frigid zones are the parts of the earth which are under the northern and southern circle. The temperate zones are the parts of the earth which are from the northern circle to the tropic of Cancer and from the southern circle to the tropic of Capricorn. And the torrid zone is the part of the world which is from the tropic of Cancer to the tropic of Capricorn. Ancient philosophers thought that only the temperate zone was inhabited, for they thought that the torrid and the frigid zones were inhabitable; the former because of too much heat and the vicinity of the sun, the latter because of too much cold and the distance of the sun. But nowadays it is evident by experience that all zones are habitable and surely inhabited for the most part.

From the above it is clear how to make the [material] sphere. Describe the circle on the plane and divide it into 4 equal parts by two lines so that each circumference has 90 degrees or parts; then one of these two lines will be the equator, the other will be the axis depicting the poles. Next, from the equator toward each pole, draw a further two lines whose distance from the equator does not exceed 23 and a half degrees, and around each pole draw an other [two] lines, whose extremity from the pole is 23 and a half degrees. Next draw another line from a point on one tropic to another, which penetrate the center of the sphere, then it is the ecliptic. Next draw two lines along the ecliptic, one in the northern part and the other in the southern part, [both of] which are drawn always 6 degrees away from the ecliptic, then these three line indicate the Zodiac which, divided into 6 parts, would show the 6 signs that always appear in the half of the heaven.

Chapter 4
The periods of days, months and years, and their variety

In order to discern the times and durations of all things, it was highly important to fix that unfailing and most regular motion, whose duration would be the standard and measure of all the other durations of motions, and it is generally called "time". Since the celestial motions are the most regular of all, Aristotle said that "time is the measure of the duration of the heavenly body". For this reason it has been the case that all races, observing the well-known motions of the sun and moon, divided natural time in conformity with their

naturale in dies, menses, annos, et saecula dividerent. Neque incongrue, ideo enim Deus optimus et maximus (ut habetur Genesis 1) in illorum creatione dixit: fiant luminaria in firmamento caeli, et dividant diem ac noctem, et sint in[1] signa et tempora et dies et annos; et rursum fecitque Deus luminare maius, ut praeesset diei, et luminare minus, ut praeesset nocti[2] etc.. Sed quia anni ex mensibus, menses vero ex diebus componuntur, prius de diebus, deinde de reliquis suo ordine disseremus[3].

§ 1
De die naturali et artificiali

Dies ab astronomis dupliciter usurpatur. Naturalis enim et artificialis dicitur. Naturalis dies est unica et integra revolutio equinoctialis supra totam terram cum tanta ulterius parte, quanta interim sol motu suo proprio contra motum primi mobilis conficit, quae fere unius gradus est; seu clarius, dies naturalis est integra revolutio solis, quam supra totam terram semel conficit, et tunc dies noctem simul et diem comprehendit. Artificialis vero est mora, seu cursus, quem idem sol supra nostrum hemispherium[4] ab oriente in occidentem conficit, et sic contra noctem dies distinguitur. Itemque[5] artificialis dies dicitur, quia eius magnitudo aut parvitas non semper est eadem, sed iuxta varietatem regionum aut temporum immutatur, ut statim dicemus. Dies vero naturalis econtra. Ideo naturalis dicitur, quia ex nulla varietate regionum crescit aut decrescit. Diem hunc naturalem in 24 partes aequales (quae horae dicuntur) communiter dividimus hoc ordine, ut quando simul cum motu solis 15 gradus equinoctialis supra horizontem oriuntur, tunc[6] unam horam transactam esse dicamus. Cumque[7] equinoctialis, ut diximus, 360 contineat gradus, si per 15 dividantur, 24 aequales constituent horas.

De puncto autem, a quo hae horae seu dies naturales[8] incipiant computari, maxima fuit nationum varietas. Babilonii ab ortu solis diem naturalem incipiebant, Itali ab occasu, astronomi omnes a meridie usque ad alterius diei meridiem, et hoc propter usum astrolabii. Sed Egiptii, quos et Romana semper secuta[9] est Ecclesia, a media nocte ad alteram mediam usque noctem, **[f.9v]** diem integrum naturalem connumerant. Nec incongrue. Sol enim a media nocte incipit ascendere in nostrum hemispherium, eiusque maxima ascensio fit in meridiano supra caput nostrum, et iterum a meridie incipit declinare usque ad mediae noctis punctum. Unde congrue dies naturalis a media nocte

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[1] *Obara omisit*

[2] *Genesis* 1:14-16

[3] *conieci ex* disceremus

[4] *correxi ex* haemispherium

[5] *conieci ex* idemque, *Obara* idemque

[6] *correxi ex* tamen

[7] *Obara* itemque

[8] *Obara* naturalis

[9] *correxi ex* sequuta, *Obara* sequuta

variety into days, months, years and centuries. This is not inappropriate, because the most excellent and almighty God said at the creation of them (as described in Genesis 1) “Let there be lights in the firmament of heaven, and let them separate day from night, and let them be for signs, times, days and years”; and furthermore, “And God made the greater light to rule the day, and the lesser light to rule the night” etc.. However, since years consist of months, and months of days, we will discuss days first, then go on to the remaining according to its order.

§ 1
On the natural and artificial day

“Day” is employed by astronomers in two ways. For it is called “natural” and “artificial”. The natural day is the one and entire revolution of the equator above the whole world, together with that part which the sun moves by its proper motion against the motion of the *primum mobile*, which is about one degree; or, to say it more clearly, the natural day is the entire revolution of the sun, which is completed a single time over the whole world, and then the day cotains the night-time together with the day-time. On the other hand, the artificial day is the lapse or the course of time, which the same sun completes above our hemisphere from east to west, and thus the day-time is distinguished from the night-time. Likewise the day is called “artificial”, because its length, or brevity, is not always the same, but variable according to the variety of regions or times, as we shall speak of immediately; but the natural day is to the contrary. The reason why it is called “natural”, is that it never increases nor diminishes according to the variety of the regions. We generally divide this natural day into 24 equal parts (they are called “hours”) in such a way that when 15 degrees of the equator rise above the horizon together with the motion of the sun, then we would say that one hour has passed. And since, as we have said, the equator has 360 degrees, if they are divided by 15, they will constitute 24 equal hours.

About the point, however, where these hours or natural days should begin to be reckoned from, there has been a great variety among races. Babylonians began to reckon the natural day from the rising of the sun, Italians from the setting and all astronomers from noon to the next noon, and this is because of the use of the Astrolabe. But Egyptians, whom the Roman Church has always followed, count a whole natural day from midnight to the next midnight. This is not inappropriate. Because the sun begins to rise from midnight in our hemisphere and comes to its highest altitude at noon above our head, and again begins to decline from noon to the point of midnight. Thence, it is appropriate that

incipiet, et in media nocte finietur.

§ 2
De dierum inaequalitate

De die artificiali maior est difficultas. Is enim incipit in puncto orientis et deficit in puncto occidentis, sed omnino irregularis est. Nec enim in eadem terra omnes dies anni sunt aequales, immo idemmet dies in diversis provinciis maior et minor esse recipitur.

Pro cuius explicatione notandum solem motu raptus, seu ad motum primi mobilis, 182 circulationes seu spiras cum dimidia conficere sub ecliptica, dum ascendit in principio Capricornii usque ad principium Cancri, totidemque conficere, dum revertitur a Cancro ad Capricornium. Unusquisque autem horum arcuum seu harum circulationum diem unum naturalem constituit; mediae autem eorum partes, quae supra horizontem elevantur, dies artificiales designant, mediae vero quae occultantur noctes. Fingamus ergo in caelo hos 182 arculos seu circulos intra duos tropicos, et tunc manifeste patebit, quod in his regionibus, in quibus medietas omnium illorum semper apparet et media pars semper occultatur, dies semper erunt aequales cum noctibus; in his vero, in quibus inaequaliter apparent, dies etiam erunt inaequales.

His suppositis, sit prima conclusio: Habitantibus sub equinoctiali, vel prope usque ad tertium vel quartum gradum, in toto anno dies sunt aequales cum noctibus. Patet quia hi habent spheram rectam, eorumque horizon caelum per polos mundi in duas partes aequales dividit. Atque adeo eis medietas horum arcuum diurnorum semper apparebit, medietas vero semper occultabitur. Erunt ergo eis dies semper aequales cum noctibus.

Secunda conclusio: Qui per aliquot gradus ab equinoctiali distant, solum habent dies aequales cum noctibus, cum sol sub equinoctiali est, in principio scilicet Arietis et Librae, reliquos vero dies habent inaequales. Patet quia, ut superius diximus, hi habent horizontem obliquum. Horizon autem obliquus semper equinoctialem ad angulos obliquos, sed in partes aequales debet dividere, reliquos autem circulos in partes inaequales. **[f.10r]** Unde fit ut, quando sol fuerit in equinoctiali, aequales faciat dies, non autem dum alios circulos seu spiras conficit. Quod manifeste in sphera patebit.

Tertia[1] conclusio: Habitantibus alibi[2] versus septentrionem semper dies crescunt imperceptibiliter, cum sol ingreditur Capricornii signum; sunt aequales dum ingreditur Arietem; maximam habent diem in principio Cancri; et iterum dies decrescentes in principio Librae fiunt aequales, minima vero dies est in fine Sagittarii, et principio Capricornii; contrarie vero accidit iis, qui partes australes inhabitant.

Quarta conclusio: Quo aliqua regio septentrionalior est, dies maxima[3] complures habet horas, dies vero minima[4] pauciores. V.g. eis, qui habent 30 et prope unius graduum[1]

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[1] *Obara* 3[m]

[2] *conieci ex* aliam, *Obara* aliam

[3] *correxi ex* maximae

[4] *correxi ex* minimae

the natural day begins from midnight and ends in midnight.

§ 2
On the inequality of days

We have greater difficulty about the artificial day. For it begins at the eastern point and ends at the western point, but is totally irregular. And all the days of the year are not equal in the same region, but rather, the very same day is known to be longer and shorter in the various provinces.

For the explanation of this phenomenon, it should be noted that the sun accomplishes 182 and a half circular movements or spirals on the ecliptic by the swift motion, or by the motion of the *primum mobile*, while it ascends from the beginning of Capricorn to the beginning of Cancer, and also accomplishes the same number [of circular movements or spirals] while returning from Cancer to Capricorn. Each one of these arcs or these circular movements constitutes one natural day; the half parts of the arcs which are above the horizon designate the artificial days, and the other half parts which are concealed designate the nights. Therefore if we assume in the heaven these 182 arcs or circles between two tropics, then it will be plainly evident that, in those regions where the half these arcs always appear and the [other] half are always concealed, the days will be always equal to the nights, whereas in those regions where they appear unequally, the days will be unequal.

From these suppositions comes the first conclusion: For those who live on the equator, or within the range of three or four degrees, the days are equal to the nights for a whole year. This is evident because they have the right sphere, and their horizon divides the heaven into two equal parts through the pole of the world. And, indeed, half those diurnal arcs will always appear to them, while the [other] half will always be concealed. Therefore the days will always be equal to the nights.

Second conclusion: Those who are several degrees distant from the equator, have the days equal to the nights only when the sun is on the equator, that is, at the beginning of Aries and Libra, but they have the remaining days unequal to the nights. This is evident because, as we have said above, they have the oblique horizon. The oblique horizon always has to divide the equator at oblique angles but into equal parts, and the remaining circles into unequal parts. Thence it happens that, if the sun is on the equator, it makes the days equal to the nights; but it does not, while it accomplishes the other circles or spirals. This will be plainly evident in the [material] sphere.

Third conclusion: For those who live somewhere to the north, the days always increase imperceptibly when the sun enters the sign of Capricorn, they are equal to the nights while it enters Aries, and those people have the longest day at the beginning of Cancer; and likewise, the diminishing days become equal to the nights at the beginning of Libra, but the day is shortest at the end of Sagittarius and the beginning of Capricorn; but the contrary happens for those who live in the southern part.

Fourth conclusion: The more to the north some region is, the more hours the longest

altitudinem poli, erit dies maxima 22 Junii, habebitque 14 horas; eis vero, qui habent altitudinem 36 graduum cum dimidio, erit eadem dies 14 horarum cum dimidia et caet. Dies vero minima prioribus erit 10 horarum, secundis vero 9 cum dimidia.

Notandum est enim quod, quanto dies maximi in aliquo loco crescunt supra 12 horas, tanto postea dies minimi erunt minores 12, vel clarius, quanta fuit nox maximi diei, tanta erit dies minimi diei, et quanta fuit dies maximi diei, tanta erit nox minimi diei.

Nomine autem diei intelligimus solum spatium, quo sol est supra hemispherium, non autem crepusculum, nomine vero noctis tempus[2], quo sol occultatur sub horizonte, etiam si sit crepusculum. V.g. hi, qui 22 die Junii habent diem 14, noctem vero 10 horarum, habebunt 22 die Decembris diem 10 horarum, noctem vero 14 horarum.

Ratio omnium horum est obliquitas horizontis in maiori accessu et recessu solis. In horizonte enim recto, ut diximus, aequaliter apparet[3] medietas omnium arcuum diurnorum. Quanto[4] vero polus v.g. arcticus elevatur, iam arcus diurni aequaliter apparent, hoc tamen ordine, ut quanto magis elevatur[5] polus supra horizontem, tanto v.g. circulus tropici Cancri maior appareat, circulus vero Capricornii minor, et sic de reliquis proportionaliter. Imo quanto pars Cancri apparet, tanta in Capricornio semper occultatur sub horizonte, et quanta pars Cancri occultatur, tanta in Capricornio apparet, ut in sphera materiali videri est. Unde fit ut, cum sol dictos circulos conficit, eam proportionem maximi **[f.10v]** diei ad minimum faciat, quam diximus in conclusione.

Quinta conclusio[6]: Qui habitant intra circulum arcticum, dies habent continuos et noctes continuas plures vel pauciores secundum quod magis aut minus ad polum accedunt. V.g. his qui directe sub polo sunt, 187 diebus plus minusve sol continuo lucebit, ii vero, qui in gradibus 67 sunt, non nisi 22 dies continuos sine nocte habent plus minusve. Ratio huius est quia, ut superius diximus, media semper caeli pars elevatur supra omnem horizontem ita ut a Zenith in omnem partem horizontis debeant esse 90 gradus. Unde fiet, ut illis, qui sub polo arctico fuerint, numquam 6 signa borealia occultentur, australia vero numquam appareant, sed linea aequinoctialis sit eorum horizon, cum a polo ad lineam sint 90 gradus. Atque ideo[7] quamdiu sol lustrat signa borealia, sol semper eis lucebit, cum vero australia discurrit, semper eis occultabitur, eritque nox. Eadem ratio est de reliquis, qui non sub polo, tamen intra circulum habitant. Qui enim habuerit v.g. altitudinem poli 69 graduum cum duobus tertiis, habebunt semper intra suum horizontem totos fere Geminos et Cancrum, sibique occultabuntur Sagittarius et Capricornius prope integri. Reliqui vero signorum arcus diurni secundum partes inaequales maiores vel

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[1] *conieci ex* gradus, *Obara* gradus

[2] *Obara omisit* tempus

[3] *conieci ex* apparent, *Obara* apparent

[4] *correxit ex* quando, *Obara* quando

[5] *Obara* elevetur

[6] *correxi ex* conclusia

[7] *conieci ex* adeo, *Obara* adeo

day has, but the less hours the shortest day has. For example, for those for whom the height of the pole is nearly 31 degrees, the longest day will be July 22nd having 14 hours; but for those for whom the height of the pole is 36 and a half degrees, the same will be 14 and a half hours, etc.. But for the former, the shortest day will be 10 hours, and the latter, 9 and a half hours.

It should be noted that in any place the more the longest days increase over 12 hours, the more the shortest days will decrease less than 12, or in clearer terms, the night of the longest day will be as long as the day of the shortest day, and the day of the longest day will be as long as the night of the shortest day.

Under the name of "day", we understand solely the interval when the sun is above the hemisphere, not the twilight; under the name of "night", on the other hand, we understand the time when the sun is concealed under the horizon, even though it is twilight. For example, those who have a 14 hour day and a 10 hour night on June 22nd, will have a 10 hour day and a 14 hour night on December 22nd.

The reason for all these things is the obliquity of the horizon involving the greater access and recess of the sun. Because, as we have said, half the diurnal arcs appear equally in the right horizon. But the more the north pole, for example, is elevated, the same extant the diurnal arcs appear, but in such a way that the more the pole is elevated from the horizon, the more the tropic circle of Cancer, for example, appears, while the less the tropic of Capricorn does, and so on proportionally for the remaining. In reality, the more the part of Cancer appears, the more the part in Capricorn is always concealed under the horizon, and also the more the part of Cancer is concealed, the more the part in Capricorn appears, as is seen in the material sphere. Thence it follows that, when the sun accomplishes the above-mentioned circles, it forms that proportion of the longest day to the shortest, which we have spoken of in the conclusion.

Fifth conclusion: those who live within the arctic circle have continuous days and nights, more or less according as they are nearer or further to the pole. For example, for those who are directly under the pole, the sun will continuously shine for 187 days more or less, while those who are in the 67 degree, have only approximately 22 continuous days without night. The reason for this is that, as we have said above, the half part of the heaven is always elevated above all the horizon such that it is 90 degrees from the zenith to all parts of the horizon. Thence, it will happen that for those who are under the north pole, the 6 boreal signs will never be concealed, while the austral ones will never appear. But their horizon is the equator, since it is 90 degrees from the pole to the line. And, therefore, as long as the sun illuminates the boreal signs, it will always shine upon them, but when it runs through the austral ones, the sun will always be concealed from them and it will be night. The same reason is applied to the remaining people who live not under the pole but within the circle. Because those who have, for example, the pole of 69 and two third degrees high, will always have almost the whole of Gemini and Cancer within their horizon, and almost the whole of Sagittarius and Capricorn are concealed. But the remaining diurnal arcs of the signs will always appear to them according to

minores semper eis apparebunt. Unde cum sol Geminos et Cancrum lustrat, semper eis lucebit, eritque dies, quando vero Sagittarium et Capricornium, semper eis occultabitur, eritque nox. Reliquo autem anni tempore habebunt dies et noctes inaequales maiores vel minores iuxta supradicta. Idem proportionaliter dicendum est de reliquis.

Notandum tamen non esse regulam certam ut, quot fuerint dies continui in vere iis, qui sub polo arctico sunt, tot sint postea in hieme futurae noctes[1] continuae eisdem, quia sol velocius pertransit Sagittarium et Capricornium quam Geminos et Cancrum, ut capite sequenti dicemus. Notandum praeterea, quod licet illis, qui sub polo sunt, sol semper luceat 187 dierum spatio, eisque occultetur per 178 plus minusve, non tamen ideo tot dierum spatio noctem obscuram eos habere intelligendum est. Cum enim sol non multum ab illorum horizonte discedat, multum temporis durat crepusculum, ita ut postquam sol discessit ab eorum hemispherio per 40 vel 50 dies continuos duret crepusculum, et iterum antequam elevetur supra eorum horizontem, **[f.11r]** per totidem dies sentiatur crepusculum, sicut et nobis contingit in aurora et vespere. Sol enim aliquando per 14 vel 15 gradus occultatur infra horizontem, et tamen eius claritas sentitur in aere.

§ 3
De anno solario

Licet in dierum mensura una fuerit omnium sententia, ut a solis cursu desumatur, in mensium autem et annorum computatione maior fuit nationum varietas: quidam enim et annum et menses lunares conficiunt, quia lunae motus et varietates facile negotio cognoscuntur. Alii vero licet lunarem[2] mensuram non rejiciant, mensium tamen temporum, et annorum periodos non nisi a motu solis describunt, quod quidem melius est. Sol enim rex et mensura omnium astrorum est. Prius ergo de solari, deinde de lunari anno aliquid dicemus.

Solaris igitur annus est una et integra latio, quam motu proprio contra motum primi mobilis conficit sub toto Zodiaco. Sol enim, sicut et reliqui planetae, a primo mobili velocissime[3] trahitur, et 24 horarum spatio integram quandam spiram seu circulationem ab oriente in occidens conficit, interim tamen quotidie gradum ferme unum proprio motu ab occidente in oriens sub ecliptica discurrit. Unde fit, ut licet Zodiacus, ut supra diximus, vel[4] etiam ecliptica, quae via solis est, 360 tantum contineat gradus, quia tamen sol quotidie unum integrum gradum non conficit motu proprio sub ecliptica, 365 integros dies et quinque horas cum 49 minutis consumat, antequam integram unam circulationem sub Zodiaco conficiat, et ad eum punctum, a quo egressus est, revertatur. Haec ergo mora annus solaris ab astronomicis vocatur, dividique solet in quattuor partes aequales, quae quattuor tempora communiter dicuntur, ver scilicet, aestas, autumnus, et hiems.

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[1] *correxi ex* noctis

[2] *correxi ex* lunares, *Obara* lunares

[3] *correxi ex* velocissimi, *Obara* velocissimi

[4] *Obara* et

unequal, longer or shorter, parts. Thence, when the sun illuminates Gemini and Cancer, it will always shine upon them, and it will be day, while when it illuminates Sagittarius and Capricorn, the sun will always be concealed, and it will be night. For the rest of the time in a year they will have unequal, longer or shorter, days and nights as have shown above. The same should be maintained proportionally for the remaining.

It should be noted, however, that there is no definite rule like "for those who are under the north pole, there would be as many continuous days in spring as continuous nights to come in winter", for the sun traverses faster through Sagittarius and Capricorn than through Gemini and Cancer, as we shall speak of in the following chapter. Moreover, it should be noted that, although the sun will always shine for 187 days and be concealed for around 178 days for those who are under the pole, we mush understand that they do not have as many dark nights for this reason. Because, when the sun does not depart from their horizon so much, twilight lasts very long, so that it lasts for 40 or 50 continuous days after the sun has departed from their hemisphere, and for as many days before it rises above their horizon, just as also happens to us in the dawn and evening. For when the sun is concealed under the horizon by 14 or 15 degrees, its brightness is perceived in the air.

§ 3
On the solar year

Although there had been a single opinion among all the people about the measure of the day, as it is derived from the movement of the sun, there have been, on the other hand, great national varieties about the computation of the months and years: for some take the lunar year and months, because the movement and varieties of the moon are understood easily. But others, though not rejecting lunar measure, describe the periods of months, seasons and years only by the motion of the sun. This is surely better, for the sun is the king and measure of all the stars. Therefore we shall say something about the solar year first, then about the lunar year.

The solar year is a single complete course, which the sun makes by its proper motion on the whole Zodiac against the motion of the *primum mobile*. For the sun, like the other planets, is dragged by the very swift *primum mobile* and makes a sort of total spiral or circulation from east to west in 24 hours, but, meanwhile, it moves nearly one degree from west to east every day by its proper motion on the ecliptic. Thence it follows that, although the Zodiac, as we have said above, or the ecliptic, which is the path of the sun, contains only 360 degrees, since the sun does not move one whole degree every day by its proper motion on the ecliptic, it spends whole 365 days, 5 hours and 49 minutes before it completes one whole circulation on the Zodiac and returns to that point from which it started. Therefore, this interval is called the solar year by astronomers and is accustomed to be divided into 4 equal parts, which are usually called 4 seasons, that is, spring, summer, autumn and winter. On the other hand, it is subdivided into 12 parts or months, but in such a way that 3 single months constitute one of the above-mentioned 4 seasons,

Rursusque subdividitur in 12 partes, seu menses, hoc tamen ordine, ut singuli 3 menses unum ex dictis quattuor temporibus constituant, et ex omnibus unus annus solaris resultet.

Sed in assignandis his mensibus annique principio, est aliqua varietas. Julius enim Caesar, primus Romanorum Imperator, annum solarem antiquum sic ordinavit, ut 365 dies cum 6 horis haberet, **[f.11v]** et ne 6 istae horae relinquerentur, cum sint quarta pars[1] diei naturalis, qui ex 24 constat horis, iussit ut quarto quoque anno dies unus intercalaris post diem 24 Februarii adderetur. Et quia dies ille[2] 6 a Kalendis Martii erat, bisque in Kalendario quarto quoque anno 6 Kalendis Martii repetebatur, ideo annus ille bissextus, seu bissextilis nuncupatus est.

Menses praeterea 12 taliter divisit[3], ut 7 ex illis 31 tribueret dies, Januario scilicet, Martio, Maio, Julio, Augusto, Octobri, et Decembro; quattuor vero aliis 30 tantum, Aprili[4] scilicet, Junio, Septembro, et Novembro; uni solo Februario 28 dies solos tribuebat, praeterquam[5] in anno bissextili, in quo 29 continebat dies; qui omnes, ut diximus, 365 dierum constituunt annum. Et licet in hac mensium divisione Julius Caesar motum solis sub singulis signis Zodiaci non attenderit, ut statim dicemus, hunc tamen ordinem, quia congruus et antiquus erat, usque modo servavit Ecclesia Romana, primumque anni diem Kal. Januarii cum antiquis constituit, et hoc quidem congruenter.

Conveniens enim erat, sicut de die naturali diximus, ut ab eo tempore annus numerari inciperet, quo sol incipit ad nos accedere diesque incipiunt paulatim maiores fieri[6], et tunc annus deficeret, quando sol ultimo a nobis discedit minimique fiunt dies, prout in solstitio brumali seu Capricornii, quod prope Kal. Januarii, 20 scilicet secunda dies Decembris incidit, contingit. Ex eo enim tempore sol ad nostrum revertitur hemispherium diesque paulatim conficiunt[7] maiores, ut diximus. Cui etiam accedit alia religionis ratio. Eo enim tempore Christus Dominus Salvator noster in carni mortali natus est, primumque Januarii diem, et mirifico Salvatoris Nomine et suo pretioso sanguine in circumcisione effuso mirabiliter insignivit, principiumque dedit reparationis operi, et ideo iure optimo dies haec primum in anno obtinet locum.

Verum astrologi longe aliter procedunt. Cum enim annus solaris via sit solis sub Zodiaco, et Zodiacus supradictas[8] in 12 divisus sit partes, sive signa, menses nihil aliud esse dicunt, quam spatium illud, quod sol consumit in unoquoque illorum signorum discurrendo ita, ut 6 signa sex menses, 12 vero 12 etiam menses constituant. Ut sciamus, quo tempore praedicti menses astronomici incipiant, notandum est communi omnium

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[1] *correxi ex* parte, *Obara* parte

[2] *Obara* illa

[3] *conieci ex* divisi, *Obara* divisi[t]

[4] *correxi ex* Apliri

[5] *conieci ex* praeterque, *Obara* praeterque

[6] *addidi*

[7] *correxi ex* conficit, *Obara* conficit

[8] *conieci ex* supra dicta, *Obara* supradicta

and from all these results one solar year.

However, there is some variation of setting these months and the beginning of the year. For Julius Caesar, the first imperator of the Romans, had so arranged the solar year of ancient times that it had 365 days and 6 hours, and, in order to prevent those 6 hours from being left over, as they are one fourth of the natural day which is composed of 24 hours, had ordered one intercalary day to be added after February 24th every four years. Also, because that day was the 6th day counting from March 1st, and the 6th day before March 1st was repeated twice every four years in the calendar, that year has been called "bissextus", or "bissextile".

Moreover, he divided 12 months such that he assigned 31 days to 7 of them, that is, January, March, May, July, August, October and December; only 30 days to 4 others, that is, April, June, September and November; just 28 days solely to February other than in the bissextile year, in which February contained 29 days; all of which constitute a year of 365 days, as have been said. Although Julius Caesar did not direct his attention to the motion of the sun under each sign of Zodiac, as we will speak immediately, the Roman church has preserved this order up to the present, because it was ancient and suitable, and has set the first day of the year on January 1st together with the ancients, and this is in congruity.

For it was suitable that, as we have spoken about the natural day, we begin to count a year from that time when the sun starts coming closer to us and the days begin to be longer gradually and, then, we finish a year when the sun goes away from us and the days become shortest, as happens in the solstice of winter or Capricorn which is around January 1st, that is, December 22nd. For, from that time, the sun turns back to our hemisphere and the days get longer gradually, as we have said. Also, another religious reason is added to this. For Christ, our Lord and the Savior, was born around that time in mortal flesh, and he made January 1st special by the wonderful name of the Savior and his valuable bloodshed poured out in the Circumcision, and he bestowed the beginning of the work of reparation, and therefore, it is best that the day obtains the first place in a year .

However, astronomers employ a quite different procedure. For, since the solar year is the path of the sun on the Zodiac, and the Zodiac, as said above, has been divided into 12 parts or signs, they say that the months are nothing but that interval which the sun spends in passing each of those signs, so that 6 signs constitute 6 months, but also 12 signs 12 months. In order to know when the above-mentioned astronomical months begin, it should be noted that all astronomers have accepted by common observation that the sun

astrologorum observatione esse receptum solem hoc ordine signa intrare Zodiaci, **[f.12r]** ut primum gradum Arietis 21 die Martii ingrediatur, quem, ut statim dicemus, primum anni esse dicunt: cumque omnia signa 30 contineant gradus, paulatim singulos discurrit ita, ut 21 die Aprilis deserat Arietem, et ingrediatur Taurum, signum autem Gemini ingreditur 21 die Maii, Cancrum 22 die Junii, ubi fit solstitium vernale; Leonem vero 24 Julii, Virginem 24 Augusti, Libram 24 Septembris, ubi fit aequinoctium autumnale; Scorpionem ingreditur 24 Octobris, Sagittarium 23 die Novembris, Capricornium 22 Decembris, Aquarium 21 Januarii, Pisces vero 19 die Februarii. Initium vero anni ab eo puncto desumunt, quo sol primum Arietis gradum ingreditur; tum quia sol ibi in medio caeli existens incipit ad nos accedere, secundo quia ab eo tempore ver incipit, ut statim dicemus, omniaque florescerent, tertio quia in eo puncto, scilicet in puncto aequinoctii vernalis, mundus creditur fuisse creatus, ut tenent[1] D.Cirilus, Eusebius, D.Leo Papa, et alii. Unde congruum esse iudicant, ut annus ab eo tempore incipiat computari, in quo probabiliter creditur fuisse creatus. Ecclesia tamen in hoc, ut diximus, antiquam Romanorum servat consuetudinem propter rationes supra adductas.

Quattuor etiam anni tempora consequenter iuxta hunc ordinem distingunt, unicuique qualitates assignantes, ita ut cum sol Arietem ingreditur, ver incipiat, solque dum in his tribus signis moratur usque ad Cancrum, humiditatem et calorem influat, quibus mediis omnia virescere facit, in animantibus vero sanguini praedominatur, qui calidus et humidus est. Deinde cum sol Cancrum ingreditur, aestas incipit, et durat usque ad Libram, solque sua vicinitate et calore humores exsiccat[2], fructus maturescere facit, in animantibus vero humori[3] calido et colerico praedominatur. Rursus sole Libram ingrediente aestas desinit, autumnusque incipit, siccitatemque causat ex vi praeteriti[4] caloris, simulque frigiditatem in fine propter absentiam solis et vicinitatem[5] hiemis, unde et in animantibus humori melancolico et[6] terreo praedominatur; ultimo dum sol Capricornium ingreditur usque ad principium Arietis, est hiems, quae suis frigoribus et tempestatibus terram sterilem reddit, et in animantibus humori aqueo flegmaticoque praedominetur. Solentque etiam quattuor haec anni tempora hominum aetatibus accommodare, **[f.12v]** ita ut ver sit anni pueritia, aestas adolescentia, autumnus virilis aetas, hiems vero frigida senectus.

Quia vero mentionem fecimus de differentia anni Ecclesiastici et astronomici, obiter etiam dicemus, quae fuerit causa renovationis anni factae per S.Pontificem Gregorium 13 anno Domini 1582. Ex hac enim anni diversitate ortum sumpsit; cum enim anni periodus secundum veram computationem astronomorum 365 integros dies 5 horas, et 49 minuta tantum contineat, in anno vero communi et Ecclesiastico 6 integrae horae numerentur, fit

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[1] *correxi ex* tenet, *Obara* tene[n]t

[2] *correxi ex* exciccat

[3] *correxi ex* humore, *Obara* humore

[4] *correxi ex* praeteritis

[5] *correxi ex* vicinitate, *Obara* vicinitate

[6] *addidi*

enters the signs of the Zodiac by such order that, first, it enters the first degree of Aries on March 21st and they say that this is the beginning of a year, as we shall mention immediately. And since all the signs have 30 degrees, the sun goes through each of them one by one so that it leaves Aries behind on April 21st and enters Taurus, and then enters the sign of Gemini on May 21st, and Cancer on June 22nd, where comes the summer solstice; Leo on July 24th, Virgin on August 24th, Libra on September 24th, where comes the autumnal equinox; then it enters Scorpius on October 24th, Sagitarius on November 23rd, Capricorn on December 22nd, Aquarius on January 21st, then Pisces on February 19th. They set the beginning of a year at the point where the sun enters the first degree of Aries, because the sun, staying there in the middle of the heavens, starts to come close to us; secondly because from that moment the spring begins and, as we shall mention immediately, all things begin to flourish; thirdly because at that point, that is, the point of the vernal equinox, the world is believed to have been created, as said by Cyril, Eusebius, Pope Leo and others. Thence, astronomers think it right that we count a year from that time when the world is plausibly believed to have been created. As for this, however, the Roman Church, as we have said, holds to the ancient custom of the Romans according to the reasons mentioned above.

Consequently, they also distinguish the four seasons of the year according to this order, assigning qualities to each of them, so that when the sun enters Aries, spring begins. When the sun lingers in these three signs down to Cancer, it increases humidity and heat through which it makes all the things green; while in animals the blood predominates, which is hot and humid. Next, when the sun enters Cancer, summer begins and continues all the way to Libra. The sun dries up the humor by its vicinity and heat and makes fruit ripen; while in animals the hot and choleric humor predominates. When the sun enters Libra, summer finishes and autumn begins. It produces dryness from the power of the earlier heat. At the same time, it produces frigidity in the end because of the recession of the sun and the coming of winter. Thence the melancholic and earthy humor predominates also in animals. Finally, while the sun enters Capricorn until the beginning of Aries, it is winter. It turns the earth sterile by its own coldness and weather, and the watery and phlegmatic humor predominates. People often relate these four seasons of the year to the lifetime of human beings, so that, of a year, spring is childhood, summer is adolescence, autumn is the age of maturity and cold winter is old age.

Since we have mentioned the difference between the Ecclesiastical and the astronomical year, we will take this opportunity to mention what was the reason for the renovation of the calendar performed by the Supreme Pontiff Gregory XIII in 1582 A.D. For it originated from the following diversity of the years: for, since the period of a year is only 365 whole days, 5 hours and 49 minutes according to the true computation of astronomers, but 6 whole hours are enumerated in the common and the Ecclesiastical

ut annus Ecclesiasticus maior sit vero anno et[1] astronomico minutis prope 11. Indeque resultat, ut equinoctia et solstitia quotannis totidem minutis sedem suam anticipent, ita ut si v.g. hoc anno fuit equinoctium vernum 21 die Martii hora 12, sequenti anno 11 prope horae minutis, antequam annus Ecclesiasticus expleatur, erit equinoctium. Annus enim hic communis totidem minutis, ut diximus, maior est anno vero et astronomico, et sequenti anno similiter continget, eruntque in 2 annis 20 prope duo minuta, quae sic multiplicata in 400 annis 3 prope dies conficient, ita ut post 400 annos aequinoctium vernale[2] non iam in 21 diem Martii incidat, sed in 18 diem eiusdem mensis vel prope. Atque ita compertum est, ut cum dictum equinoctium temporibus Concilii Niceni (quod fuit celebratum anno 325 a nativitate Christi Domini) in dicta 21 die Martii contingeret, propter istam minutorum 11 multiplicationem, iam nostris temporibus, anno scilicet 1582, non nisi 11 die Martii contingeret, solstitium vero Cancri 12 die Junii, equinoctium autumnale 14 die Septembris, solstitium vero brumale 12 die Decembris etc.. Tot enim dies propter illa 11 minuta superaddita quotannis accreverant ad haec usque tempora. Ut ergo Ecclesia propter usum festorum mobilium huic maximae varietati remedium abhiberet, aequinoctiaque et solstitia in proprias reduceret sedes, gravissimo habito consilio anno 1582, 10 dies, qui ex praedictis 11 minutis multiplicatis false accreverant, ademit, ita ut eo anno 1582 post quartam diem Octobris sequens dies quinta decima diceretur, atque ita factum est, ut tunc aequinoctia in primam et vicesimam diem Martii, et 24 diem Septembris incidant, sicut temporibus Concilii Niceni contingebant, et ne deinceps similis contingeret error, praeceptum est, ut in 400 annis 3 anni bissextiles[3] omitterentur ita, ut licet secundum ordinem bissexti 366 dies deberent habere, non nisi 365,5 horas **[f.13r]** et 49 minuta continerent. Haec de anno solari.

§ [4]
De anno lunari

Ut de anno lunari aliquid dicamus, notandum prius est lunam corpus esse perfecte sphericum, quod de se luminosum non est, sed densum, opacum, aptumque ut a maxima solis reverberatione claritatem et splendorem accipiat, et quidem sphericam habere figuram, vel experientia ipsa constat; numquam enim in alia figura visa est, sive in plenilunio, sive in quolibet alio die, nisique rotunditatem referat et ostendat. Quod vero eius media pars, quae directe aspectui solis opponitur, ab ipso sole illuminetur, multis etiam experientiis patet, tum quia in tertia die lunae vel prope, ea sola pars inferior lunae, quae soli opponitur[4], apparet illuminata, reliquum vero corpus sub obscurum remanet, praecipue circa centrum ipsius lunae, in circuitu tamen aliquam claritatem per modum coronae ostendit, ita ut manifeste rotunda esse videatur, nobisque indicet eius superiorem

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[1] *addidi*

[2] *Obara* vernalem

[3] *correxi ex* bissextilis

[4] *in margine habet* ab ipso sole … quae soli opponitur

year, it happens that the Ecclesiastical year is longer than the true and the astronomical year by about 11 minutes. Thence it follows that the equinoxes and solstices of every year anticipate their own places by the same number of minutes, so that if, for example, the vernal equinox is at 12 o'clock of March 21st this year, in the next year the equinox will fall about 11 minutes of an hour before the Ecclesiastical year finishes. For the common year, as we have said, is longer than the true and the astronomical year by the same number of minutes. Likewise, this will happen also in the following year. They will amount to about 22 minutes in two years and, if multiplicated in this manner, to about 3 days in 400 years. Thus, 400 years later, the vernal equinox would no longer fall on March 21st, but on or around 18th of the same month. Also, it is certain that if the vernal equinox had fallen on the very March 21st at the time of the Nicene Council (which was held in 325 A.D.), the same equinox would never fail to fall on March 11th in our time, that is, in 1582, because of this multiplication of 11 minutes, while the solstice of Cancer would be on June 12th, the autumnal equinox on September 14th, the winter solstice on December 12th etc.. For, because of these 11 minutes accumulated every year, this number of days has been augmented towards our time. Therefore, in order to administer a remedy for this great discordance for the determination of the movable feasts and to put the equinoxes and solstices back to their own places, the Ecclesia removed 10 days, which had accumulated falsely from the multiplication of the above-mentioned 11 minutes at the Grand Council held in 1582, so that the next day of October 4th should be the 15th in this year. Thus, it follows that now the equinoxes fall on March 21st and September 24th as they did at the time of Nicene Council. Moreover, in order for the same error not to happen thereafter, it is ordained that 3 bissextiles should be omitted in 400 years, so that bissextiles would have only 365 days, 5 hours and 49 minutes, although they must have 366 days according to the custom of the bissextile. So much concerning the solar year.

§ 4
The luar year

In order to say something about the lunar year, it should be noted first that the moon is a perfect spherical body, which is not luminous on its own, but dense, opaque and suitable for receiving brightness and brilliance by the great reflection of the sun. Indeed, it is evident rather by experience itself that it has a spherical figure, for it has never been seen in another figure, whether on the day of full moon or on any other day, and it represents and shows only rotundity. However, it is evident from much experience that the half part [of the moon], which is in direct opposition to the sun, is illuminated by the sun itself. This is firstly because only that lower part of the moon, which is facing the sun, appears bright on or around the 3rd day of the moon [=lunar month], but the remaining part stays in the dark, especially around the center of the moon. But it shows some brightness in the periphery like a coronary form. Thus, it is clear that the moon is completely round and this shows us that its upper part, which is facing to the sun, is illuminated, although we

partem, quae solis obtutui patet, illuminatam esse, licet propter corporis sui opacitatem a nobis videri non possit nisi secundum eam partem, quae versus nos est. Tum etiam, quia non semper luna apparet tota luminosa, sed quo magis discedit a sole eique opponitur, magis illuminata apparet, ita ut cum sub sole est vel ei propinqua, vel nullam vel minimam claritatem videatur habere, sed quo magis ab eo discedit clarior appareat, et hoc secundum eam partem, quae soli propinquior est. Quando vero omnino illi opponitur, omnino illuminata videtur, quasi directe claritatem solis recipiat in ea parte inferiori, quae versus nos est; iterumque, quo magis soli appropinquat, eius superior pars illuminatur, inferior vero obscuratur. Quod signum est eam de se luminosam non esse, sed lumen suum a sole recipere. Quod etiam experientia patet in eclipsibus, ut in sequenti capite dicemus.

Luna ergo sicut et omnes alii planetae impulsu primi mobilis quotidie ab oriente trahitur in occidens, sed ipsa nihilominus[1] omnium velocissima suum naturalem motum conficit sub Zodiaco 27 dierum spatio cum 8 ferme horis, ita ut 13 gradus plus minusve suo naturali cursu quotidie[2] perficiat ab occidente in oriens, atque fit ut, si v.g. hodie luna a principio Arietis exeat, post 27 dies et horas ferme 8 ad eundem Arietis punctum revertatur. Ab hoc ergo naturali cursu lunae aliqui menses et annum conficiant lunarem. Est tamen advertendum, quod huiusmodi mensium et anni lunaris **[f.13v]** principium vel etiam periodos ab aliquo Zodiaci vel caeli puncto fixo desumi non posset, sicut diei solaris principium a puncto mediae noctis, mensium vero ab ingressu solis in signa Zodiaci, anni quoque solaris principium a principio Arietis desumi diximus. Sed unam lunam vel unum mensem lunarem ab una eius coniunctione cum sole in aliam usque coniunctionem connumerant, ita ut ab eo puncto, quo luna intra eundem gradum Zodiaci cum[3] sole est (licet non sit sub ecliptica), mensis lunaris incipiat, eiusque medietas sit, dum luna e diametro opponitur soli, mensisque finiatur, cum luna iterum ad coniunctionis punctum convertitur estque intra eundum gradum Zodiaci cum sole; unde fit, ut una lunae circulatio integra, quam sub toto Zodiaco motu naturali efficit, non constituat unum mensem integrum lunarem, sed ulterius requiritur, ut solem insequatur quousque cum illo coniunctionem efficiat ut, si v.g. in principio Arietis facta est lunae coniunctio cum sole, mensis lunaris incipit, post 27 dies et 8 fere horas luna motu suo retrogrado totum Zodiacum circumiens ad eundem Arietis punctum convertetur, sed quia hoc dierum spatio sol etiam motu suo retrogrado 27 gradus conficit, necessarium est, ut luna 2 fere diebus eosdem gradus suo motu naturali conficiat, ut solem assequatur, et tunc fiet unus mensis lunaris constans 29 diebus et horis fere duodecim.

Annus vero solaris constat ex 12 mensibus lunaribus, ita ut post 12 coniunctiones solis cum luna annus unus lunaris censeatur absolutus, qui ex 354 diebus constabit: viginti

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[1] *Obara* nihilomines

[2] *conieci ex* quodie, *Obara* quo[ti]die

[3] *conieci ex* sub, *Obara* sub

can only see that part which is facing us because of the opacity of its own body. Secondly, because the moon does not always appear totally luminous but the more it stays away from the sun and reaches opposition to the sun, the more it appears illuminated. Thus, when it is under or near the sun, it is evident that the moon has no or minimal brightness, but the more it stays away from the sun, the brighter it appears in regard to that part which is nearer to the sun. Indeed, when the moon is exactly opposite to the sun, it is seen to be completely illuminated, as if it would directly receive the brightness of the sun in that lower part, which is facing us. Moreover, the closer it comes to the sun, the more its upper part is illuminated, and its lower part is darkened. This shows that the moon is not luminous by itself, but receives its light from the sun. This is also evident by experience in eclipses, as we shall mention in the following chapter.

Therefore the moon, like all the other planets, is dragged from east to west every day by the impulse of the *primum mobile*, but nevertheless the moon itself, the fastest of all planets, completes its own natural motion on the Zodiac in 27 days and about 8 hours. Thus it would move 13 degrees or so every day from west to east by its own natural motion and, also, it happens that if, for example, the moon leaves the beginning of Aries today, it would return to the same point of Aries after 27 days and about 8 hours. Therefore, some constitute the lunar months and year from this natunal motion of the moon. It should be noted, however, that we can select neither the beginning of these lunar months and year nor the periods from some fixed point of the Zodiac or the heaven, as we have said that we can select the beginning of the solar day at the point of midnight, of the solar months by the entry of the sun into the signs of the Zodiac and also of the solar year at the beginning of Aries. But people count a "moon" or a lunar month from its one conjunction with the sun to another, so that the lunar month begins from that point at which the moon is on the same degree of the Zodiac as the sun (although it is not exactly on the ecliptic), and its middle is when the moon is diametrically opposite to the sun, and it would end when the moon returns to the point of conjunction again and is on the same degree of the Zodiac as the sun. Thence it happens that one perfect revolution of the moon by the natural motion on the whole Zodiac would not constitute one whole lunar month, but it further requires that the moon pursues the sun until conjunction. Thus if, for example, at the beginning of Aries the conjunction of the moon with the sun has occurred, i.e. the lunar month begins, the moon, going around the whole Zodiac by its own retrograde motion, would return to the same point of Aries after 27 days and about 8 hours, but since the sun moves 27 degrees by its own retrograde motion in the meantime, it is necessary that the moon moves through the same degrees for about 2 days by its own natural motion in order to catch up with the sun. Then, there will be one lunar month, comprising 29 days and 12 hours.

The solar year is composed of 12 lunar months. Thus, one complete lunar year, which is composed of 354 days, is reckoned after 12 conjunctions of the sun with the moon, for

enim novem dies cum dimidio duodecies[1] multiplicati eundem fere numerum conficiunt; quod si annum istum lunarem cum anno solari conferamus, videbimus 11 diebus illo minorem esse, qui 11 dies tertio quoque anno 33 dies conficiunt; atque ideo[2] ubi haec mensura anni lunaris est, tertio quoque anno unus mensis intercalaris addendus est, sicut superius de anno bissextili diximus, et amplius 3 dies erunt superstites, ut cum 11 sequentis anni coniungantur, ex quo Epactae numerus pro festis mobilibus communiter desumitur ab Ecclesia.

§ [5][3]
De climatibus et de diversis regionibus

[f.14r] Ex iis, quae diximus § 2 de inaequalitate dierum, et in tertio[4] de quattuor temporum initiis aliqua colliguntur; cum enim dixerimus eandem diem maximam, v.g. alteram et vicesimam Junii, plures vel pauciores continere horas, secundum quod magis aut minus regio aliqua polo propinquior fit, colligunt […][5] diversa esse assignanda climata regionum, ita ut spatium illud, in quo dies maxima excedit per mediam partem horae magnitudinem diei, qui in aliis regionibus observatur, clima unum constituat. Et quia, ut diximus, habitantes sub equinoctiali vel prope habent semper dies aequales cum noctibus, etsi quae differentia[6] maximi ad minimum diem non est nisi aliquorum minutorum. Propterea incipientes ab iis, qui habent altitudinem poli 12 graduum cum 43 minutis, dividunt terras in 23 climata usque ad eam partem, quae habet altitudinem poli 66 graduum cum dimidio et plus; nam usque ad istum locum secundum varietatem climatum eadem dies maxima maior est per spatium dimidiae horae, et minima minor est per spatium etiam dimidiae horae. In gradu autem 66 cum dimidio et plus eadem dies maxima noctem non habet, sed 24 horarum est dies artificialis. Unumquodque autem clima totum mundum ab oriente in occidens ambit ita ut, si v.g. a gradibus 12 usque ad 20 sit unum clima, omnes, qui in toto mundo sub his gradibus sunt, idem clima habere dicantur. Totidem vero climata et eodem ordine in parte australi ponenda sunt. Verum est tamen, quod non omnia climata habent eandem amplitudinem, sed quo magis polo propinqua sunt, eo pauciores gradus et minuta continent. Ut v.g. a gradibus 12 cum 43 minutis usque ad gradus viginti[7] cum dimidio fit unum clima primum, et tamen continet in se 7 gradus cum 50 minutis, et tamen clima 14 non nisi unum gradum et unum minutum continet, ut videre est in tabella climatum.

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[1] *correxi ex* duodeties, *Obara* duodeties

[2] *correxi ex* adeo, *Obara* adeo

[3] *Obara* 4

[4] *correxi ex* quarto, *Obara* quarto

[5] *non legitur*, *Obara* diversis

[6] *post* differentia *scripsit et delevit* est, *Obara addidit* est

[7] *correxi ex* gradum 20^{m}, *Obara* gradum 20^{m}

29 and a half days times 12 constitute almost the same number. If we compare this lunar year to the solar year, we will see the former is 11 days shorter than the latter. These 11 days would constitute 33 days every 3 years, and therefore when this mensuration of the lunar year is involved, one intercalary month should be added every 3 years, as we have said above about the bissextile year, and another 3 days will be left over, so that they will be added to the 11 days of the following year, from which the Church generally selects the number of the Epact for the movable feasts.

§ 5
On the *climas* and the various regions

From what we have said about the inequality of days in § 2 and about the beginnings of four seasons in § 3 follow some conclusions. For, as we have said that the same longest day, for example, June 22nd, would have more or less hours depending on whether some region is nearer to or further from the pole, they [astronomers] conclude that different *climas* of regions should be so assigned that the space, in which the longest day exceeds the length of the day observed in other regions by half an hour, would constitute one *clima*. Also, as we have said, the inhabitants on or near the equinoctial always have the day equal to the night, although the difference between the longest and shortest day is only of some minutes. Therefore those people divide the earth into 23 *climas*, counting from the places which have the latitude of 12 degrees and 43 minutes to that part of 66 and a half degrees or more, for, up to that place, the longest day is longer by half an hour and the shortest day is shorter by half an hour, too, according to the variety of the *climas*. On the latitude of 66 and a half degrees or more, the longest day does not have night, but the artificial day has 24 hours. Each *clima* surrounds the whole world from east to west, so that if, for example, one *clima* is from 12 to 20 degrees, all the places which are under those degrees in whole world are said to have the same *clima*. But just as many *climas* should be placed in the southern part in the same order. It is true, however, that not all the *climas* have the same amplitude, but the closer they are to the pole, the less degrees and minutes they have. Thus, for example, the first *clima* is from 12 degrees and 43 minutes to 20 and a half degrees and has 7 degrees and 50 minutes in itself, whereas the 14th *clima* has only 1 degree and 1 minute, as can be seen in the table of the *climas*.

Ultimo, quia de quattuor temporum periodis superius egimus, notandum est non esse id universale in omnibus regionibus, sed in diversis diversa contingere. Hi enim qui sub equinoctiali sunt, perpetuum habent equinoctium, sol bis in anno supra illorum Zenith transit. Quatuor habent solstitia, duo alta et 2 ima. Cum enim solstitium nihil aliud sit, quam ultimus accessus et recessus solis ab uniuscuiusque Zenith, sol bis in anno existens in equinoctiali efficiet[1] illis 2 alta solstitia, i.e. tunc maxime ad illorum caput accedit; deinde cum sol fuerit in Cancro **[f.14v]** et Capricornio, tunc efficiet alia duo ima solstitia, i.e. tunc maxime ab illorum Zenith elongabitur. Habent et consequenter duas aestates[2] in anno totidemque hiemes, si aestas accessum solis, eiusque maximum calorem dicit, et hiemes recessum solis calorisque remissionem. Quarto habent quatuor umbrarum differentias, mane versus occidentem, vespere versus orientem, in meridie vero versus septentrionem, si sol est in parte australi, nullam, si sol est in aequinoctiali, et si est in signis septentrionalibus, umbram habebunt versus austrum. Ultimo, omnia astra omnesque caeli partes continuo eis oriuntur et occidunt, exceptis polis arctico et antarctico, quia scilicet spheram et horizontem habent rectos transeuntes per polos mundi.

Idem proportionaliter[3] dicendum est de his, qui intra utrumque tropicum sunt, duobus exceptis, unum quod non habent perpetuum equinoctium, sed aliquando dies habent inaequales, ut superius diximus; aliud est quod non omnia astra nec omnes partes caeli sibi oriuntur et occidunt, cum habent horizontem obliquum. Hi vero, qui directe sub tropico Cancri sunt, duo tantum habent equinoctia, duoque solstitia, et 4 temporum differentias iuxta ordinem supradictum § 4; sed semel in anno sol ascendit supra illorum caput, in principio scilicet Cancri; et idem proportionaliter dicendum est de omnibus aliis, qui ab hoc tropico in circulum usque arcticum habitant, uno excepto, quod numquam sol supra eorum caput ascendit. De his vero, qui sub utroque circulo arctico et antarctico sunt, iam dictum est, quod dies plures et noctes continuas habent. Sed de iis, qui a tropico Capricornii usque ad antarcticum circulum habitant, solum notandum videtur, quod habent quidem quattuor temporum differentias, contrario tamen modo ac nos habemus ita, ut hiems nostra illorum sit aestas, ver nostrum illorum autumnus, aestas nostra illorum hiems, autumnus noster illorum ver, quia omnino nobis oppositi sunt.

De solis et lunae eclipsibus, deque astrorum et caelorum magnitudinibus Cap. 5[4]

Communis omnium astronomorum et philosophorum sententia est eclipsim solis nihil aliud **[f.15r]** esse praeter interpositionem lunae inter solem et nos. Cum enim luna corpus

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[1] *Obara* eficiat

[2] *correxi ex* aestas, *Obara* aestas *et addidit* (sic!)

[3] *correxi ex* porportionaliter

[4] *hinc a manu alia scriptum est*

Lastly, since we have investigated the periods of four seasons above, it should be noted that there is no universal thing in all regions, but different things happen in different regions. For, [1] those who are on the equinoctial have perpetual equinox: the sun traverses over their zenith twice in a year. [2] They have four solstices: two are high and two are low. For since the solstice is nothing but the sun's ultimate access to and recess from each zenith, the sun, which is on the equinoctial twice in a year, will produce for them two high solstices, i.e. at that time the sun reaches their head the most. Then when the sun is in Cancer and Capricorn, it will produce another two low solstices, i.e. at that time it is most distant from their zenith. [3] Consequently, they would have two summers and as many winters in a year, if summer means the access of the sun and its maximum heat, and winter the recess of the sun and the remission of the heat. [4] Fourthly, they have four differences of shadows: toward the west in the morning; the east in the evening; the north at noon if the sun is in the sourthern part; none if the sun is on the equinoctial; and they will have a shadow toward the south if the sun is in the northern signs. [5] Lastly, for those people, all stars and all parts of the heaven continuously rise and set, except northern and southern poles, because they have the right sphere and right horizon which are passing through the poles of the world.

The same should be said proportionately for those who are between each tropic but with the two exceptions: one is that they do not have perpetual equinox but sometimes have unequal days, as we have said above; the other is that, for them, neither all stars nor all parts of the heaven rise and set, since they have the oblique horizon. In fact, those who are directly on the tropic of Cancer have only two equinoxes, two solstitices and the differences of 4 seasons according to the order mentioned above in § 4: but once in a year, the sun rises above their head, that is at the beginning of Cancer. Moreover, the same should be said proportionately for all the others, who live from this tropic circle to the arctic circle with one exception: the sun never rises above their head. For those who are on the arctic and antarctic circle, we have already said that they have many continuous days and nights. But for those who live from the tropic of Capricorn to the antarctic circle, it should be only noted that they have, indeed, differences of 4 seasons, but in the contrary way: and so we conclude that our winter is their summer, our spring their autumn, our summer their winter and our autumn their spring, because they are entirely opposite to us.

Chapter 5
The solar and lunar eclipses and the magnitude of the stars and heavens

The common opinion of all astronomers and philosophers is that [1] a solar eclipse is none other than the interposition of the moon between the sun and us, for the moon is an

sit opacum, sic interposita, impedit radios solis, ne directe terram illuminent[1]; lunae autem eclipsim interpositionem esse terrae inter solem et lunam, ita ut umbra terrae impediat radios solis, ne lunam attingant et illuminent. Et quidem utrumque ipsa experientia manifestissimum est, tum quia eclipsis solaris nunquam nisi in coniunctione lunae fieri contingit, et tum instrumentis, aut etiam in vase aqua pleno lunare corpus soli interpositum aliquando representari contingit. De lunari etiam manifestum est. Nunquam enim nisi[2] in oppositione seu in plenilunio fit. Et tali oppositione, ut e[3] diametro sol et luna directe opponantur[4] terra in medio utriusque exsistente. Sed licet hoc verissimum sit, ut melius tamen intelligatur aliqua prius adnotabimus.

§ [1]

Primo ergo supponimus cum communi astronomorum sententia solem esse veluti fontem luminis, ita ut ab eo non solum luna, verum etiam omnia caeli astra suam participent claritatem. De luna quidem evidentissimum est. Ex diversitate enim aspectuum ad solem aliquando media, aliquando vero plena claritate apparet, ut capitulo 4 diximus. Sed de reliquis stellis eadem videtur ratio esse. Idemque probant[5] inter alia solis immensa claritas, qua medium mundum hunc inferiorem semper aequaliter et intensissime illuminat: et[6] debilitas item luminis stellarum, quae in eius conspectu sunt quasi non sint. Deinde experientia, planetae enim et reliquae stellae, quo propinquiores sunt soli, quando apparent, maiorem claritatem ex eius vicinitate videntur effundere; unde stellae communiter cristallo aut carbunculo assimilantur, quae licet ex se aliquam habeant claritatem, soli tamen oppositae multo maiorem effundunt claritatem. Comparantur etiam speculo, quasi in se solis imaginem et splendorem recipiant et repraesentent.

Secundo notandum quod licet terra simul cum aqua immensae magnitudinis esse videatur, sole tamen multo minores sunt, maiores tamen luna. Quod praeter rationes subtilissimas, quibus id probat Ptolemeus, ex ipsa terrae umbra facillime comprobari potest. Si enim sol minor esset terra, umbra terrae in infinitum protracta semper augeretur fieretque maior, atque adeo impediret solis radios, ne partem contrariam posset illuminare, unde magna stellarum pars continuo eclipsaretur. Quod falsum esse experientia demonstrat. Et idem inconveniens sequitur, si sol terrae esset aequalis. Licet enim umbra tunc non augeretur, in infinitum tamen protracta semper aliquas stellas deberet eclipsare. Quod nunquam contigit, et utrumque in figuris patebit.

[f.15v] [Fig. 11,12] Deinde quia, si sol multo minor esset terra, cum ab ea longissime

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[1] *correxi ex* illuminet

[2] *Obara omisit*

[3] *correxi ex* est

[4] *scripsit* opposi nantur *et delevit* si

[5] *Obara* probat

[6] *addidi*

opaque body, being thus interposed, it hinders the sun's rays from illuminating the earth directly. And [2] that the lunar eclipse is none other than the interposition of the earth between the sun and the moon so that the shadow of the earth hinders the sun's rays from reaching and illuminating the moon. Indeed, both are clearly evident by experience itself, partly because the solar eclipse never occurs except in conjunction with the moon, partly because the body of the moon interposed between the sun [and us] sometimes happens to be seen in instruments or in a vessel filled with water. It is also manifest as to the lunar eclipse, for it never happens except in opposition or at full moon. In such opposition, the sun and the moon are diametrically opposite, while the earth is in the middle of them. Although this is certainly true, we will make some remarks in advance for our better understanding.

§ 1

Firstly, we suppose that, in agreement with the common opinion of astronomers, the sun is like a fountain of light so that not only the moon but also all the stars of the heaven receive their brightness from the sun. As for the moon, this is clearly evident, for it sometimes appears as half and sometimes full in its brightness according to the diversity of the aspects with regard to the sun, as we have mentioned in chapter 4. And the same reason seems to hold true for remaining stars. Among other things the same is proved by the immense brightness of the sun, by which it always illuminates the lower half of this world equally and intensely, and by feebleness of the lights of stars, which are almost non-existent when they are faced by the sun. Next, this is proved by experience, because the closer the planets and remaining stars come to the sun, the brighter light they are seen to send forth from its vicinity to the sun when they appear. Thence, stars are usually compared with a crystal or carbuncle: although possessing some brightness by themselves, they set forth much more light when in opposition to the sun. They are also compared to a mirror, as they receive and represent the image and brilliance of the sun in themselves.

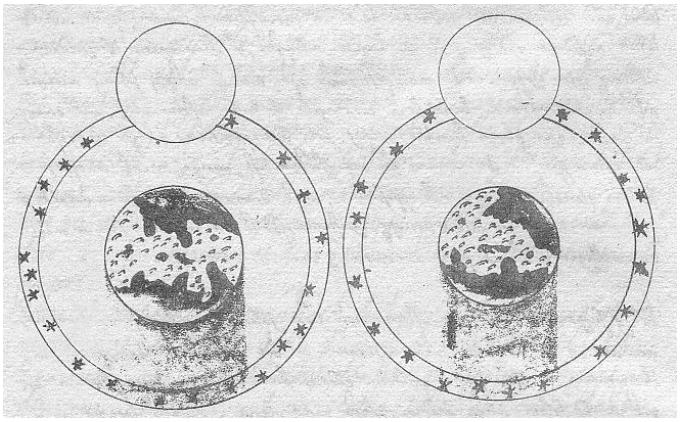

Fig. 11,12

Secondly, it should be noted that although the earth, together with water, is thought to be of immense magnitude, it is much smaller than the sun and bigger than the moon. This can easily be confirmed by the shadow of the earth, leaving aside the ingenious reasons by which Ptolemy proves it. Because if the sun were smaller than the earth, the shadow of the earth, protracted *in infinitum*, would always increase and become wider. Eventually, it would

distet, eo maiorem deberet umbram terrae facere, quo minor ipse existeret sol, atque ideo[1] contingeret, ut aliquando eclipsis lunae per 6 et 7 horas duraret, quamdiu scilicet spatium illud caeli obumbratum percurrit. Quod nunquam est visum. Est ergo sol multo maior terra, ita[2] enim fiet, ut umbra terrae interpositae formam habeat piramidis, paulatimque minor ac minor fiat quousque in punctum indivisibile desinat, atque ideo[3] nec planetas, nec stellarum caelum attingere possit aut eclipsare. Et ex hoc maxime cognoscitur summa solis distantia a terra. Res enim licet maxima sit, tunc solum minima videretur, cum longissime a visu nostro distat. Cum ergo sol multo maior sit terra, et in minima quantitate videatur, signum est, quod a nobis longissime distat.[4]

De luna vero, quod minor sit sole, manifestum est etiam. Licet enim multo propinquior sit nobis quam sol ab eoque maxime distet, in eclipsi tamen solari contingit saepe, ut paragrapho sequenti dicemus, totum corpus lunare interponi inter nos et solem, et adhuc non eclipsari totum solem, sed circulum quendam claritatis per modum coronulae in circuitu apparere. Quod fieri nequaquam posset, si luna vel aequalis vel maior sole esset. Corpus enim aequale vel maius luminoso interpositum inter illud et nos facile luminosum corpus totaliter occultat, ut experientia patet. Idem etiam **[f.16r]** comprobari posset[5] ex eo, quod superiori diximus in secunda vel tertia die lunae coronulam quandam claritatis in circuitu videri. Hoc enim indicat solem quia maior est[6] luna plus quam eius dimidietatem.

Deinde[7] luna multo minor sit sole et terra. Evidenter constat ex eo, quod umbra terrae, ut diximus, quanto magis protrahitur seu quanto magis elongatur a terra, tanto minor efficitur quousque in puncto efficiat per modum piramidis, et tamen tota luna occultatur seu eclipsatur a umbra terrae, eiusque eclipsis aliquanto temporis spacio durat. Signum ergo est terram multo maiorem esse luna. Si quidem ipsa terrae umbra maxime contracta sufficiat ad totum eius corpus occultandum, et ex consequenti, luna multo minor erit sole. Sol enim ut diximus multo maior est quam terra.

De orbibus planetarum
[§ 2]

Tertio praeterea notandum multis observationibus et rationibus coactos fuisse astrologos, ut assererent unumquemque orbem planetarum ex pluribus partialibus[8] orbibus constare,

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[1] *correxi ex* adeo, *Obara* adeo

[2] *post* ita *delevit* ut

[3] *correxi ex* adeo, *Obara* adeo

[4] *hinc a manu alia scriptum est*

[5] *correxi ex* possem, *Obara* possem

[6] solem quia maior est] *sic. Obara* solem quod maior est

[7] *post* Deinde *Obara addidit* [quod]

[8] *conieci ex* partibus, *Obara* partibus

hinder the sun's rays from illuminating the opposite side, and thence a major part of the stars would always be eclipsed. Experience shows this is false. Moreover, the same inconvenience follows if the sun were as large as the earth, for although it would not increase in this case, the shadow, protracted *in infinitum*, would always have to eclipse some stars. This never happens, and both cases will be evident in the figures.

Next, if the sun were much smaller than the earth and the former is so far away from the latter, the smaller the sun is, the larger the shadow of the earth it would make. Therefore, it could happen that sometimes the lunar eclipse would continue for 6 and 7 hours while the moon passes through the overshadowed space of the heaven. This has never been observed. Therefore the sun is much bigger than the earth: and thence it will follow that the shadow of the interposed earth has a pyramidal form, and it becomes smaller and smaller until it comes to an end at an indivisible point. Therefore, it can neither reach nor eclipse both the planets and the starry heaven. From this speculation, moreover, we reasonably recognize the great distance of the sun from the earth. Because, even though something is very big, it would look small only when it is very far from us. Therefore, since the sun is much bigger than the earth and is seen to be very small, we notice it is very far from us.

It is also manifest that the moon is smaller than the sun. Because, although the moon is much closer to us than the sun and is very far from it, it often happens at solar eclipse that although the whole body of the moon is interposed between the sun and us, the whole sun is not eclipsed but a circle of light appears in coronary form at the periphery, as we shall see in the subsequent paragraph. This could never happen, if the moon were as big as or bigger than the sun. For the body which is as big as or bigger than a luminous thing, interposed between the thing and us, would easily and entirely conceal the luminous body, as is evident by experience. The same could be proved from what we said above that some coronary form of light is seen at the periphery on the second or third day of lunar month, for this shows that the sun is one and a half times bigger than the moon[?].

Next, the moon is much smaller than the sun and the earth. This is clearly evident by the following: as said above, the more the shadow of the earth is extended or elongated from the earth, the smaller it becomes until it comes to point in a pyramidal form; but the whole moon is occulted or eclipsed by the shadow of the earth and the eclipse continues for a certain interval of time. Therefore, this indicates that the earth is much bigger than the moon. If, indeed, the shadow of the earth, even when it is very much contracted, is enough to occult the whole body of the moon, it follows that the moon is much smaller than the sun, for the sun is much bigger than the earth, as we have said above.

§ 2
On the orbs of the planets

Thirdly, it should be noted that astronomers had been forced, from many observations and reasons, to assert that each orb of the planets is contituted of several partial orbs, whose

quorum crassities[1] inaequales sint[2], ita ut ex una parte crassiores[3], ex alia vero subtiliores sint, quos eccentricos et concentricos vocant, ut statim dicemus. Nec hoc a modernis authoribus adinventum est. Feretur enim Pitagoram multo antiquiorem Aristotele et Platone id docuisse, quod ipse ab antiquissimis Aegiptis didicisse videtur. Idem Hipparcus annis ante Christum Dominum natum 140 et Ptolemeus astronomorum princeps totidem annis[4] post Christum natum latissime comprobarunt. Sed ut melius ea, quae dicemus intelligantur, duo praesupponenda sunt.

Primum quid sit orbis concentricus et eccentricus. Est autem orbis seu circulus concentricus ille, cuius superficies concava et convexa secundum omnem sui partem aequaliter distant a centro mundi. Eccentricus vero dicitur orbis, cuius superficies secundum omnem sui partem non aequaliter sed inaequaliter differt a centro, sed hoc tripliciter contingere potest: vel quia superficies convexa concentrica est, concava autem eccentrica, vel e contrario quia superficies convexa eccentrica est, omnesque eius partes inaequaliter a centro distant, superficies vero concava concentrica, ita ut partes[5] eius aequaliter[6] a centro distent. Et utrumque **[f.16v]** fieri non potest, nisi una eius pars crassior[7] sit, alia vero subtilior, et tunc pars crassior[8] aux vocatur, subtilior autem pars vocatur oppositum augis.

Tertio modo quia idem orbis secundum utrumque superficiem eccentricus est atque ideo[9] secundum omnem partem inaequaliter a centro differt, potestque tunc habere eandem crassitudinem secundum omnem sui partem. Haec tamen est differentia, quod eccentricum hoc tertio modo, scilicet quod secundum utramque superficiem inaequaliter a centro mundi distat, dicitur simpliciter eccentricum; reliqua vero duo priora dicuntur eccentrica secundum quid, scilicet corpora eccentrica non simpliciter, sed secundum unam superficiem concavam vel convexam. Dicunt ergo astronomi caelum cuiusque[10] planetae ex tribus orbibus partialibus constare, quorum unum sit eccentricus simpliciter, alii vero concentrici[11] secundum unam superficiem, eccentrici[12] vero secundum aliam, ut patebit in figura posita. Verum est quod Mercurio et Lunae plures quam tres orbes eccentricos assignare solent, sed de hoc alibi [Fig. 13].

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[1] *correxi ex* cracities

[2] inaequales sint] *conieci ex* inaequalis sit, *Obara* inaequalis sit

[3] *correxi ex* cratiores

[4] *Obara* anni

[5] *correxi ex* pars, *Obara* par[te]s

[6] *correxi ex* inaequaliter, *Obara* inaequaliter

[7] *correxi ex* cratior

[8] *correxi ex* cratior

[9] *correxi ex* adeo, *Obara* adeo

[10] *Obara* eiusque

[11] *correxit*

[12] *correxi ex* concentrici, *Obara* concentrici *et post quod addidit* (eccentrici?)

thickness is unequal so that they are thicker in one part and thinner in another part: they are called eccentrics and concentrics, as we will mention immediately. This indeed is not an invention of modern authors, for people say that Pythagoras, who lived long before Aristotle and Plato, had taught what he himself seems to have learned from the more ancient Egyptians. This had also been approved in great detail by Hipparchos in 140 B.C., and Ptolemy, the princeps of astronomers in 140 A.D.. But in order to understand better what will be said, two things must be explained first.

Firstly, what are concentric and eccentric orbs? A concentric orb or circle is that whose concave and convex surfaces are equally distant from the center of the world in every part. An eccentric orb is that whose surface is not equally but unequally distant from the center, though this could happen in a triple manner: the first is that whose convex surface is concentric, while its concave surface is eccentric; the second is, to the contrary, that whose convex surface is eccentric and all its parts are unequally distant from the center, but whose concave surface is concentric, so that its parts are equally distant from the center. Both orbs cannot be made unless part of it is thicker and another is thinner; then the thicker part is called "apogee", the thinner part is called the "opposite of apogee".

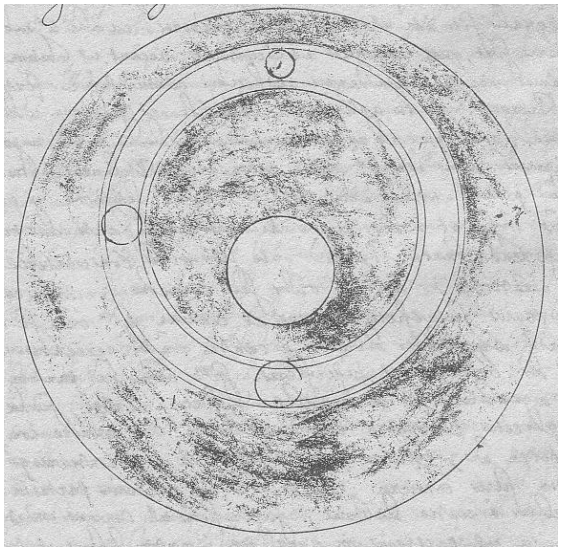

Fig. 13

The third kind is that the orb itself is eccentric as to both surfaces and thus is unequally distant from the center in every direction; in this case, it can have the same thickness in every part. There are the following differences: being eccentric in this third manner, i.e. being unequally distant from the center of the world as to both surfaces, is called "simply eccentric"; the former two are called "eccentric *secundum quid*", i.e. being not "simply eccentric" but eccentric as to one surface, either the concave or the convex one. Therefore, astronomers say that the heaven of each planet is composed of three partial orbs, of which one is "simply eccentric" while the others are eccentric as to one surface but concentric as to another, as is evident in the figure below. It is true that they usually assign more than three eccentric orbs to Mercury and the moon, but we will speak about this elsewhere.

[f.17r] Hos autem eccentricos necessario dandos esse in caelis planetarum probant astrologi multis experientiis et rationibus. Primo, quia evidenter experientia constat solem multo propinquiorem esse terrae, dum Sagittarium et Capricornium lustrat, quam dum Geminos et Cancrum discurrit, et idem experientia monstrat in luna et aliisque planetis. Sed hoc fieri non potest ex eo, quod sol vel planetae sicut pisces in aqua moventur aliquandoque nobis appropinquent et aliquando distantiores fiant, tum quia huiusmodi propinquitas non quolibet tempore, sed certis et statis temporibus reperitur, tum etiam quia in capite secundo[1] probavimus omnes stellas fixas esse in suis orbibus sicut nodus in tabula. Fit ergo huiusmodi maior propinquitas ex eo quod pars una caeli crassior est, subtilior alia; atque ideo[2] dum sol fuerit in auge, scilicet in crassiori parte, magis distans, dum vero in opposito augis, scilicet in subtiliori parte, magis propinquus[3] apparebit. Secundo, quia omnes planetae, imo et omnes caeli, semper uniformiter moventur, ita ut nunc velocius[4] nunc tardius moveri, non contingat, atque inde fit, ut omnes immutabiliter semper habeant eosdem motuum periodos; semper enim sol 365 diebus etc.. motum suum perficit, Mars duobus annis etc..

Idemque probatur ratione quia, si nunc velocius[5] nunc tardius sol v.g. moveretur, vel id fieret, quia aliquando maiorem impulsum ab intelligentia recipit, aliquando vero minorem, sicut in sagitta patet, quae velocius[6] movetur in principio quam in fine, quia maiorem impulsum in principio recipit, vel quia, virtute intelligentiae seu impulsu eodem modo manente, maior resistentia est ex parte ipsius caeli moti in una parte quam in alia, sicut in motu animali contingit: facilius enim homo trahitur, dum non resistit quam dum resistit. Sed neutro horum modorum potest contingere, non primo quia intelligentia sola virtute sua caelum movet neque unquam fatigatur aut cessat ab opere; non et secundo quia cum sol animatum non sit neque habeat inclinationem maiorem ad hoc, quod moveatur in unam partem quam in aliam. Nullo modo poterit aliquando resistere, aliquando vero non resistere intelligentiae; atque ideo[7] idem[8] caelum semper cum eadem velocitate aut tarditate **[f.17v]** movebitur. Sed experientia constat solem plus temporis consumere[9], dum 6 signa borealia lustrat quam dum australia. Ab Ariete enim in Libram per Cancrum 187 conficit dies, et a Libra in Arietem per Capricornium 178. Cum tamen totidem gradus sint in utraque parte, australi et boreali, hoc autem fieri non potest ex eo, quod in una parte

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[1] *correxi ex* primo

[2] *correxi ex* adeo, *Obara* adeo

[3] propinquus] propinqua nobis *Obara*

[4] *correxi ex* velotius, *Obara* velotius

[5] *correxi ex* velotius, *Obara* velotius

[6] *correxi ex* velotius, *Obara* velotius

[7] *correxi ex* adeo, *Obara* adeo

[8] *Obara omisit*

[9] *correxi ex* consummere

Astronomers prove that these eccentrics must be set in planetary heavens from a lot of experiences and reasons. [1] First, because it is evident by experience that the sun is much closer to the earth while it passes through Sagittarius and Capricorn than through Gemini and Cancer; and experience shows the same thing for the moon and other planets. However, this cannot happen for the reason that the sun or the planets move like fish in water and they are sometimes closer to and at other times further from us, firstly because this kind of propinquity is not repeated at any time but in a certain and fixed interval of time, and secondly because we have proved in chapter 2 that all the stars are fixed in their orbs like a knot in wood. Therefore this kind of greater propinquity follows from the fact that one part of the heaven is thicker and another part thinner and, eventually, the sun will appear more distant from us while in its apogee, i.e. in thicker part, and appear closer to us while in the opposite of the apogee, i.e. in thinner part. [2] Secondly, because all the planets and all the heavens always move uniformly, so that it does not happen that they move sometimes faster and at other times slower. Thence it follows that all of them always have their own periods of motions without change: for the sun always completes its motion in 365 days or so and Mars in 2 years etc..

The same thing is proved by reason. For if the sun, for example, would move sometimes faster and at other times slower, this would happen either because the sun receives sometimes more and at other times less impulse from [its] *intelligence*, as is evident in an arrow which is moved faster at the beginning than at the end since it receives more impulse at the beginning, or because while the power or impulse of [its] *intelligence* remains the same, there is more resistance on the side of the moved heaven at one part than the other, as happens in the motion of animate beings: for a man is dragged more easily when he does not resist than when he does. In neither way, however, can this happen: not in the first way, because an *intelligence* moves the heaven only by its own power and neither gets tired nor ceases working; also, not in the second way, because the sun does not have a stronger inclination of motion in one direction than in the other, since it is not animate. It will never happen that the sun sometimes can resist an *intelligence* and at other times cannot and, indeed, the same heaven will always move with the same velocity or tardiness. However, it is evident by experience that the sun spends more time passing the six northern signs than passing the sourthen ones, for it spends 187 days from Aries through Cancer to Libra and 178 days from Libra through Capricorn to Aries. Since there are as many degrees in each part, i.e. southern and northern, and this cannot happen

velocius[1], in alia vero tardius moveatur ut diximus. Fit ergo, quia in parte septentrionali pars caeli crassior est, atque ideo[2] in ea percurrenda necessario plus temporis debet consumere[3]. Tertio quia experientia animadversum est solis et lunae eclipses saepissime fuisse inaequales, ita ut v.g. lunae totum corpus interponeretur inter solem et nos, eumque totum eclipsaret[4], ita ut nulla eius pars conspiceretur, duraretque eclipsis aliquantulo temporis, sicut contigit anno 1559. Aliquando vero totum corpus lunae interpositum non valet eclipsare totum solem, quin aliqua coronula[5] claritatis in circuitu conspiciatur, brevissimoque temporis spatio[6] duret eclipsis, cuius nulla alia ratio dari potest nisi quia luna in secunda[7] eclipsi erat in auge, maximeque a nobis distabat, unde minorem umbram debebat efficere. In prima[8] vero, quia in opposito augis erat nobisque propinquior, maiorem efficiebat umbram atque ideo[9] totum occultabat solem, sicut in hac figura patebit. [Fig. 14[10]]

[f.18r] Ulterius in eclipsi lunari animadversum est lunae eclipsim aliquando per multum temporis spatium[11] durare, aliquando vero non nisi brevi tempore confici[12], cuius nulla alia ratio esse potest, nisi quia sol in opposito augis existens terrae maiorem partem illuminat, atque ideo[13] umbra, quam proiicit, minor est; dum vero in auge est a nobisque distantior, minorem terrae partem illuminat, atque ideo[14] maiorem proiicit umbram maiorisque temporis spatio[15] eclipsis durat, ut patet in sequenti figura. [Fig. 15[16]]

Ultimo, ratione probatur necessario dandos esse orbes eccentricos, quia omnes inferiores caeli motu diurno rapiuntur a primo mobili ab oriente in occidens, hocque proprium est omni superiori caelo, ut sibi inferiorem post se trahere possit, et ipsum ab inferiori non trahatur. Si ergo planetarum caeli omnes concentrici sunt, procul dubio caeli inferiores semper trahentur ab omnibus singulis superioribus, atque ideo[17] luna novem

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[1] *correxi ex* velotius, *Obara* velotius

[2] *correxi ex* adeo, *Obara* adeo

[3] *correxi ex* consummere

[4] *scripsit* eclipsaretur *et correxit*, *Obara* eclipsaretur

[5] *Obara* cornula

[6] *correxi ex* spacio, *Obara* spacio

[7] *correxi ex* primo, *Obara* 2º

[8] *correxi ex* secunda, *Obara* 2ª

[9] *correxi ex* adeo, *Obara* adeo

[10] *in figura habet* Luna in oppositum [*sic*: opposito] augis; Luna in auge; Sol *(a sinistra ad dextram)*

[11] *correxi ex* spacium, *Obara* spacium

[12] *conieci ex* conficit. *Obara* conficit

[13] *correxi ex* adeo, *Obara* adeo

[14] *correxi ex* adeo, *Obara* adeo

[15] *correxi ex* spacio, *Obara* spacio

[16] *in figura habet* Sol in auge; Sol in opposito augis *(a sinistra ad dextram)*

[17] *correxi ex* adeo, *Obara* adeo

for the reason that, as we have said, the sun moves faster in one part and slower in the other part, it therefore follows that the heaven is thicker in the northern part and, therefore, it must spend more time passing there. [3] Thirdly, because it has been noticed by experience that the solar and lunar eclipses are unequal very often: for example, the total body of the moon is interposed between the sun and us and it eclipses the whole sun, so that none of its part could be seen and the eclipse continues just a little time, as happened in 1559. Sometimes the total body of the moon interposed cannot eclipse the whole sun, but some crown of light can be seen at the periphery and the eclipse continues for just a small interval of time. We cannot give any other reason for this except that the moon in the latter eclipse is in the apogee and farthest from us; and thus it must make a smaller shadow. In the former eclipse, however, that is because the moon is in the opposite of the apogee and closer to us, and it makes a larger shadow; and therefore it covers the whole sun, as is evident in this figure.

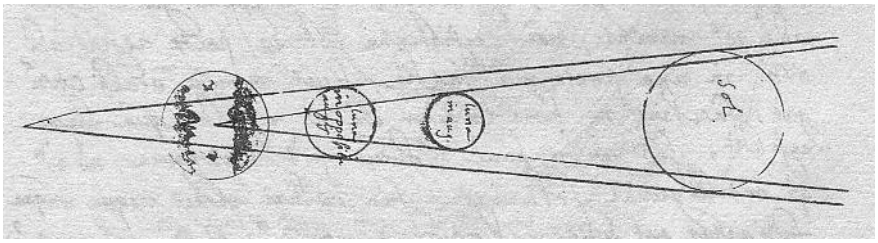

Fig. 14

Moreover, it has been observed that the lunar eclipse sometimes continues for a long interval of time but at other times continues only for a short period. There can be no other reason for this unless the sun which is in the opposite of the apogee illuminates a larger part of the earth; and therefore the cast shadow is smaller. However, while it is in the apogee and farther from us, the sun illuminates a smaller part of the earth; it eventually cast larger shadow and the eclipse continues for a longer interval of time, as is evident in the following figure.

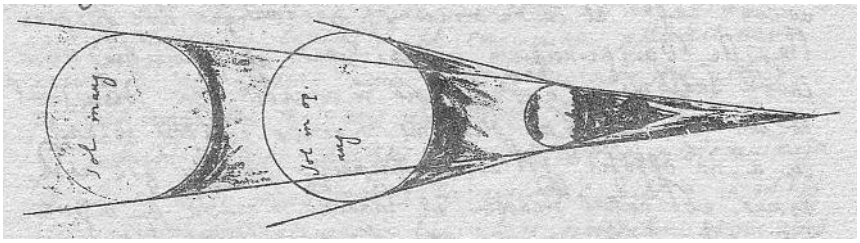

Fig. 15

[4] Lastly, it is necessarily proved by reason that eccentric orbs must be proposed, because all lower heavens are carried round by the diurnal motion, i.e. by the *primum mobile* from east to west and it is characteristic of each higher heaven to be able to drag the lower after it, but it can not be dragged by the lower. If, therefore, all planetary

genera motuum paulatim conficeret tracta ab impulsu omnium superiorum caelorum, quod quidem omni experientiae repugnat, nec enim sol trahitur a Marte aut Venus a sole, sed unusquisque suum habet peculiarem motum. Cum enim caeli planetarum eccentrici sint, ad invicem se impediunt, ita ut superior motu naturali non possit trahere inferiorem contra motum primi mobilis, nec detur duorum augium vel duorum corporum penetratio, atque adeo fit, ut omnes orbes planetarum simul rapiantur ab oriente in occidens; motus autem naturalis cuiuslibet planetae praecipue in medio orbe fit, qui deferens planetam communiter dicitur.

De modo quo fiunt eclipses solis et lunae § 3

[f.18v] His positis, propius[1] ad eclipses accedentes, dicimus solem semper mediam partem Zodiaci tenere nunquamque ab[2] ecliptica discedere in hanc vel in illam partem, ut superius diximus. Luna vero (sicut et reliquae planetae) non semper sub ecliptica est, sed intra Zodiacum aliquando ad austrum aliquando vero ad septentrionem vergit eclipticae.

Cumque 29 dierum spatio cum dimidio totum Zodiacum discurrat, fit ut bis intra eosdem dies eclipticam pertranseat, eamque in duas partes aequales dividat. Puncta ergo, in quibus praedicta eclipticae[3] scissio fit seu duo illa loca, in quibus luna est sub ecliptica, vocantur caput et cauda draconis; fingamusque haec duo puncta esse v.g. principium Arietis caput et principium Librae cauda draconis. Cum ergo contingit[4] in coniunctione lunae solem simul et lunam in capite esse draconis, tunc fit eclipsis solaris, cum vero in oppositione sol est in principio Arietis, quod ut diximus est caput[5] draconis, et luna est in cauda scilicet in principio Librae, tunc terra intercipitur et luna ab umbra terrae eclipsatur.

Ex his plura colliguntur. Primum, cur non in omni novilunio fiat eclipsis solis, et in omni plenilunio non fiat[6] eclipsis lunae? Ratio enim huius est, quia non in omni novilunio luna est in capite aut in cauda draconis, id est, non semper est directe sub ecliptica, sed in aliquam partem declinat in plenilunio, aut cum non semper sit sub ecliptica, non opponitur directe ipsi soli, atque adeo non obumbratur a terra.

Secundo colligitur duo esse genera eclipsium: primum totale, secundum partiale. Totalis eclipsis fit, quando centrum lunae est directe sub ecliptica simul cum sole aut soli oppositum[7], si eclipsis lunaris est; tunc enim tota luna eclipsatur, et si directe sub sole sit, totus sol etiam eclipsabitur. Partialis vero eclipsis est, quando aliqua pars lunae tempore[8]

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[1] *Obara* proprius

[2] *Obara* ad

[3] *correxi ex* ecliptice

[4] *correxi ex* contigit, *Obara* contigit

[5] *correxi ex* capud

[6] *Obara* fit

[7] *conieci ex* opposita, *Obara* opposita

[8] *correxit*

heavens are concentric, lower heavens, without doubt, would always be dragged by every single higher heaven and, therefore, the moon which is dragged by the impulse of all the higher heavens would eventually make nine different kinds of motion. This contradicts all experiences, for neither the sun is dragged by Mars nor Venus by the sun, but each has its own peculiar motion. Since the planetary heavens are eccentric, they impede each other so that neither the higher, by its natural motion, can drag the lower against the motion of the *primum mobile*, nor can the penetration of two apogees or two bodies exist. Therefore it follows that all the planetary orbs are simultaneously dragged from east to west. The natural motion of each planet occurs in the middle orb, which is usually called "that which carries the planet along" [i.e. the deferent].

§ 3
How the solar and lunar eclipses happen

Having dealt with these things, in order to get closer to the eclipses, we say that the sun always keeps to the middle part of the Zodiac and never deviates in one direction or another, as we have said above. But the moon (like the other planets as well) is not always on the ecliptic but inclines within the Zodiac sometimes to the southern and at other times to the northern side of the ecliptic.

Since it passes through the whole Zodiac at intervals of 29 and a half days, it follows that the moon crosses the ecliptic twice in the same period and divides it into two equal parts. Thus, those points at which the above-mentioned scission of the ecliptic happens or those two places in which the moon is exactly on the ecliptic are called the "head and tail of the dragon" and we suppose that these two points are, for example, at the beginning of Aries as the head and at the beginning of Libra as the tail of the dragon. Therefore, when it happens that the sun, in conjunction with the moon, is at the head of the dragon together with the moon, the solar eclipse takes place; and when the sun, in opposition to the moon, is at the begininng of Aries, which is the head of the dragon as we have said, and the moon is at the tail, i.e. at the beginning of Libra, the earth is intercepted [between the sun and the moon] and the moon is eclipsed by the shadow of the earth.

From these propositions many conclusions can be made. First: why does the solar eclipse not take place at each new moon nor the lunar eclipse at each full moon? The reason for this is that the moon is not in the head or tail of the dragon at every new moon, that is, it is not always exactly on the ecliptic but declines to another part at full moon; or since the moon is not always exactly on the ecliptic, it is not directly opposite to the sun itself and, therefore, is not overshadowed by the earth.

The second reasoning is that there are two kinds of eclipse: the first is total and the second is partial. A total eclipse takes place when the center of the moon is exactly on the ecliptic together with or opposite to the sun. In case of a lunar eclipse, the whole moon is eclipsed; and if the moon is directly under the sun, the whole sun will also be eclipsed. A partial eclipse takes place when some part of the moon does not pass the middle of the ecliptic during the eclipse, but declines somewhat to the side. At that time, the moon

eclipsis non mediam eclipticam transit, sed aliquantulum ad latus declinat; tunc non valet eclipsare[1] totum solem, qui directe sub media ecliptica est, sed aliquam eius partem. Nec ipsa in plenilunio totaliter occultari poterit, si non mediam teneat eclipticam sed ad alterutram **[f.19r]** partem declinet.

Tertio sequitur ratio, cur eclipses totales solis aut lunae non sint semper aequales, sed aliquando maiores, aliquando vero minores appareant? Ratio enim est eccentricitas planetarum, sicut in paragrapho praecedenti in tertia ratione diximus.

Quarto colligitur ratio, cur eclipsis solis et lunae non semper videatur in universo mundo. Ratio enim est, quia cum eclipsis non fiat nisi in puncto, aut tempore oppositionis vel coniunctionis lunaris cum sole, et coniunctio et oppositio non semper fiat in nostro hemispherio, sed saepe dum sol oritur nobis, iam transacta est coniunctio, et cum luna ascendit nostrum horizontem, iam transit vera oppositio; inde fit, ut non semper omnes eclipses possimus conspicere.

Quinto sequitur ratio, cur eclipsis lunae videatur a medio mundo, solis vero non nisi in aliqua certa regione. Huius enim ratio est, quia luna vere amittit claritatem suam dum eclipsatur, atque adeo in illo hemispherio, in quo est, sine claritate conspici debet. Sol vero suam claritatem non amittit, sed ab intercepto lunari corpore impedimur nos, ne eius radios possimus recipere. Quia vero luna iuxta supra dicta multo minor est sole, non valet eum ubique occultare, sed in ea tantum regione, inter quam et solem directe interponitur luna.

Sexto constat valde miraculosam fuisse eclipsim solarem, quae in passione Christi Domini contigit. Erat enim dies passionis 14 dies lunae, sed in ictu oculi luna velocissime ab occidente in oriens medium prope discurrens caelum inauditam coniunctionem et eclipsim fecit solarem. Et quod magis est mirandum, radiis solaribus partim interposita luna partim vero a virtute divina omnino retentis, universalis eclipsis et tenebrae in universa factae sunt terra, scilicet in illo hemispherio, in quo tunc sol erat. Quod D. Dionisius adhuc gentilis attente considerans merito exclamavit dicens: aut Deus naturae patitur, aut tota mundi ruit machina.

Ultimo ex eclipsibus, et maxime ex lunari, regionum distantia, quam intra eundem gradum existentes habet, ab oriente in occidens facile cognoscitur. Si enim v.g. nobis incipiat eclipsari luna in puncto mediae noctis, illis vero, qui in India vel in aliqua alia **[f.19v]** regione sunt, non nisi septima hora post meridiem, erit distantia inter nos et eam provinciam 75[2] graduum, ut enim diximus, tunc una hora transacta esse dicitur, cum 15 gradus supra horizontem elevantur[3]. Cum inter nos et illam provinciam quinque horarum differentia sit, cumque per 15[4] gradus multiplicati, 75 conficiunt gradus, et sic de reliquis.

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[1] *conieci ex* eclipsari, *Obara* eclipsari

[2] *correxi ex* 65, *Obara* 65

[3] *correxi ex* elevatur, *Obara* elevatur

[4] *correxi ex* 19, *Obara* 19

cannot eclipse the whole sun, which is exactly on the middle of the ecliptic, but some of its part. Nor will the moon be able to be totally occulted at full moon, if it does not remain in the middle of the ecliptic but declines to one or the other part.

The third reasoning: why is the total eclipse of the sun or the moon not always equal but it appears sometimes longer, at other times shorter? The reason is the eccentricity of the planets as we have said in the third reason in the previous paragraph.

The fourth reasoning: why are the solar and lunar eclipses not always observed all over the world? The reason is that the eclipse does not take place except in the point or at the time of opposition or conjunction of the moon with the sun, and the conjunction and opposition do not always take place in our hemisphere but sometimes take place when the sun is rising for us and the conjunction has already finished, and when the moon is ascending on our horizon and the true opposition is passing: thence it follows that we cannot always observe all the eclipses.

The fifth reasoning: why is the lunar eclipse seen in one half of the world, but the solar eclipse is only seen in a certain specific region. The reason for this is that the moon loses its light while it is eclipsed and should be observed without light over the hemisphere in which it stays. But the sun does not lose its light but the intercepted body of the moon prevents us from receiving its rays. Since the moon, according to what we have said, is much smaller than the sun, it cannot conceal the sun at any place but only in that region between which and the sun it is directly interposed.

The sixth reasoning: it is evident that the solar eclipse which took place at the Passion of Christ was truly miraculous, for the day of the Passion was the 14^{th} day of the lunar month but the moon, instantaneously running through the mid heaven from west to east with high speed, brought about the unheard-of conjunction and the solar eclipse. And what makes it more miraculous is that, while the solar rays were entirely detained partly by the interposed moon and partly by the divine power, a universal eclipse and darkness prevailed on the earth, that is, in that hemisphere in which the sun existed at that time. When St. Dionysius, while still a gentile, considered this carefully, he rightly exclaimed: Either the God of nature suffers or the whole machine of the world is collapsing.

The last reasoning: from the eclipses, especially that of the moon, it is easy to get to know the distance of the regions from east to west, which those who are within the same degree have. Because, if, for example, we see the moon begin to be eclipsed at the point of midnight, but for those who are in India or another region [the same eclipse would not begin] except at 7 o'clock PM, the distance from that province to us will be 75 degrees, for, as we have said, when 15 degrees rise above the horizon, then it is said that one hour has been passed. When the distance from that province to us is 5 hours, when these are multiplicated by 15 degrees, they come to 75 degrees, and so on for the rest.

§ [4]
De astrorum magnitudine et de via lactea seu galaxia

Haec de sole et luna. Restat ut de reliquis astris aliquid agamus, inter quae primum locum obtinent[1] 5 errantes stellae. Quae ideo errantes seu etiam planetae vocantur, quia reliquorum ordinem, motum et situm non servant. Nobis enim viciniores sunt aliis, atque ideo[2] non scintillant praeter unum Saturnum, qui ob maximam distantiam aliquantulum scintillare videtur. Omnium planetarum minimus Mercurius est, qui raro apparet propter maximam eius vicinitatem ad solem. Venus Mercurio maior est stella lucidissima, quae comitatur solem, quae dum antecedit Lucifer dicitur, dum eum insequitur Vesper nominatur. Nec potest a sole separari nisi per gradus 47 cum dimidio. Hii duo planetae simul cum luna minores sunt terra. Mars vero Jupiter et Saturnus, sicut loco ita etiam magnitudine, se superant[3] ad invicem, uno Jove excepto, qui omnes alios praeter solem superat, maioresque sunt terra. De sole vero iam diximus terrae magnitudinum evidenter excedere.

Aliorum autem astrorum, qui stellae fixae communiter dicuntur, quia ordinem et situm non mutant, licet infinitus prope videantur esse numerus, quod et Sacra Scriptura saepe innuit. Astrologi tamen, ut melius de eis possent philosophari, stellas clariores et semper apparentes in 48 constellationes communiter reducunt, quae mille et viginti duarum stellarum numerum conficiunt, de quarum magnitudinibus **[f.20r]** mira dicunt; dividunt enim earum magnitudines in 6 ordines, ita ut primae magnitudinis sint tantum 12, secundae vero 45[4], tertiae magnitudinis 200 et 8, quartae magnitudinis 404, quintae magnitudinis 217, sextae magnitudinis 49, nebulosae quinque, obscuriores 9, quae praedictum numerum conficiunt. Praeter has pars quaedam caeli lucidissima est innumeris et minutissimis stellis abundans, quae via lactea communiter dici solet, scinditque Zodiacum prope Geminos et Sagittarium; est autem caeli pars quaedam crassior, quae in se recipiens solis claritatem, non adeo lucet sicut stellae, nec enim eandem habet cum stellis crassitudinem; remanet autem illa claritas in illa parte recepta, claritatemque effundens non omnino lucidam, sed aliquantulum continet albedinis; remissa enim illa claritas albedinem refert. De caelorum magnitudine iam dictum est in fine secundi [*sive* 21[5]] tractatus primae capitis Compendii.

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[1] *correxi ex* obtinet

[2] *correxi ex* adeo, *Obara* adeo

[3] *correxi ex* superat, *Obara* supera[n]t

[4] *Obara* 48

[5] *conieci ex* 2^{i}

§ 4
On the magnitude of the stars and the milky way or galaxy

So much concerning the sun and the moon. It still remains to deal with the remaining stars, among which the 5 wandering stars hold the primary position. They are called "wanderers" or "planets", because they do not keep the order, motion and place of the others, for they are closer to us than the others and, therefore, do not glitter except one, Saturn, which is seen to be slightly glittering because of the long distant. Of all the planets Mercury is the smallest, which rarely appears because of its immidiate vicinity to the sun. Venus is bigger than Mercury and is the brightest star, which accompanies the sun, and is called "Lucifer" while preceding the sun and "Vesper" while following it, and cannot be separated from the sun by more than 47 and a half degrees. These two planets, together with the moon, are smaller than the earth. With regard to [the three planets, i.e.] Saturn, Jupiter and Mars, one is superior than the other, according to this order, in location as well as in magnitude except for one, Jupiter, which is bigger than all others except the sun, and they are bigger than the earth. As to the sun, we have already said that it evidently exceeds the magnitude of the earth.

As to the other stars, which are usually called the fixed stars, they do not change their order and position, though there seem to be almost an infinite number of them, which the Holy Scripture also often mentions. In order to be able to consider them more carefully, however, astronomers usually arrange the brighter and always visible stars into 48 constellations, which are composed of 1022 stars. They say wonderful things about their magnitudes. For, they divide them into 6 orders: [the stars] of the first magnitude are only 12, the second 48, the third 208, the fourth 404, the fifth 217, the sixth 49, the nebular ones 5 and the more obscure ones 9, [the total of] which constitutes the above-mentioned number. Besides these stars, some very luminous part of the heaven is filled with innumerable and very small stars: it is usually called the Milky Way and it divides the Zodiac near Gemini and Sagittarius. It is a certain thicker part of the heaven, which receives the solar light in itself but does not shine like a star, for it does not have the same denseness as the stars. But the light remains in that part where it is received and, although not completely emitting bright light, it contains some whiteness, for the remitted light takes over the whiteness. We have already spoken about the magnitude of the heavens at the end of the second [or 21st] chapter of the first treatise of the Compendium.

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