A Reluctant Innovator:

Greco-Arabic Astronomy in the *Computus* of Magister Cunestabulus (1175)

C. Philipp E. Nothaft

All Souls College, Oxford

philipp.nothaft@all-souls.ox.ac.uk

ABSTRACT

This article is dedicated to the obscure *Computus* of Magister Cunestabulus (England, 1175), which offers a unique spotlight on the way the twelfth-century 'Renaissance' in mathematical astronomy impacted the Latin computistical tradition. Armed with an unusually broad array of sources newly translated from Arabic, among them Ptolemy's *Almagest*, Cunestabulus applied his advanced knowledge in the service of traditional Latin learning and established Church doctrine, defending the non-existence of Antipodeans in the southern hemisphere and as well as the astronomical foundations of the ecclesiastical *computus*. His intricate explanation of the error underlying the Julian calendar, which was based on the Arabic theory of the "access and recess of the eighth sphere," makes for a technically sophisticated and conceptually intriguing case of Greco-Arabic science being used for apologetic ends in twelfth-century Latin writing.

KEYWORDS

medieval astronomy; Greco-Arabic science; *computus*; calendars; Easter reckoning; Twelfth-Century Renaissance; medieval England; Magister Cunestabulus; Ptolemy

Introduction

Compared to the sophisticated mathematical astronomy from Arabic and Greek sources that entered the lands of Western Christendom during the twelfth century, the Latin *computus*, with its focus on calculating the date of Easter, often looks like a humdrum and unappealing affair, one that is too far removed from the former to warrant serious interest. And yet, a closer look at the development of *computus* during the high Middle Ages reveals some intriguing continuities between the two fields, which highlight the value of studying their respective histories in tandem. One important case in point is the emergence of the so-called *computus naturalis* during the eleventh and twelfth centuries, which involved a shift of focus from “mere” Easter reckoning toward more abstract astronomical goals, such as the calculation of lunar and solar longitudes as a function of time and the prediction of eclipses. Thanks to the recent and forthcoming editions of major works from this sub-genre produced by Hermann of Reichenau (d. 1054), Gerland (*fl.* 1093), and Walcher of Malvern (d. 1135), future scholars will be in a much better position to appreciate the achievements of Latin computists in the area of mathematical modelling of nature and to delineate their role in paving the way for the assimilation of more advanced forms of astronomy in the course of the twelfth century.[1]

---

[1] Alfred Lohr, *Der Computus Gerlandi: Edition, Übersetzung und Erläuterungen* (Stuttgart, 2013); C. P. E. Nothaft, *Walcher of Malvern:* De lunationibus *and* De Dracone; *Study, Edition, Translation, and Commentary* (Turnhout, 2017). A comprehensive edition of Hermann of Reichenau’s computistical works is currently being prepared by Immo Warntjes for the MGH series “Quellen zur Geistesgeschichte des Mittelalters.” For the meantime, see Immo Warntjes, “Hermann der Lahme und die Zeitrechnung: Bedeutung seiner Computistica und Forschungsperspektiven,” in Felix Heinzer and Thomas Zotz, eds., *Hermannus Contractus: Ein Reichenauer Mönch und Universalgelehrter des 11. Jahrhunderts* (Stuttgart, 2016), 277–313. A pioneering study arguing for the continuity between early medieval *computus* and twelfth-century astronomy is Stephen C. McCluskey, *Astronomies and Cultures in Early Medieval Europe* (Cambridge, 1998). See also Immo Warntjes, “Seventh-Century Ireland: The

Beyond its status as a rudimentary precursor to mathematical astronomy in the Latin West, however, there is also the complementary question of how the art of *computus* itself was impacted by new data received from translated texts during the twelfth and later centuries and how computists from this period reacted to the various challenges the new style of astronomy posed to their traditional practices and assumptions. Ever since Charles Homer Haskins published his *Studies in the History of Mediaeval Science* in 1924, specialists have been aware that an early witness to the incursion of "Arabic influence" into works on the *computus* is "an anonymous treatise of thirty-nine chapters composed in 1175, apparently in England," whose author showed himself familiar with names such as "Ptolemy, Hipparchus, Thabit, al-Battani, al-Zarkali, and al-Fargani."[2] Even though this remark identified the English *computus* of 1175 as a prime candidate for close study, the text has received scant attention over the past 90 years, the two most important exceptions being the articles by P. J. Willetts (1965), who identified the author in question as a certain *Magister Cunestabulus*, and by Jennifer Moreton (1999), who made a first attempt at analysing and transcribing a chapter of the work.[3] Thanks to a recent critical edition by Alfred Lohr historians now have access to all the preserved portions of this unusual text, which

---

Cradle of Medieval Science?", in Mary Kelly and Charles Doherty, eds., *Music and the Stars: Mathematics in Medieval Ireland* (Dublin, 2013), 44–72.

[2] Charles Homer Haskins, *Studies in the History of Mediaeval Science* (Cambridge, MA, 1924), 87–88.

[3] P. J. Willetts, "A Reconstructed Astronomical MS from Christchurch Library Canterbury," *The British Museum Quarterly*, 30 (1965), 22–30; Jennifer Moreton, "The *Compotus* of 'Constabularius' (1175): A Preliminary Study," in Joël Biard, ed., *Langage, sciences, philosophie au XII^{e} siècle* (Paris, 1999), 61–82.

opens up some new and hitherto unexplored vistas on the history of science in twelfth-century England.[4]

In what follows, my goal will be to subject to closer scrutiny what Haskins viewed as the most salient feature of Cunestabulus's *Computus*:[5] its author's evident familiarity with the works of Arabic astronomers as well as with Ptolemy's *Almagest*, to whose availability this *Computus* is an important early witness. The bulk of this article will be devoted to two instances where Cunestabulus utilized these new sources creatively with an aim towards addressing problems that were of long-standing interest to readers of Latin *computus* texts. One of these problems related to the question of the Earth's habitability and distribution of climate zones, which was in turn linked to theological anxieties concerning the existence of Antipodeans in the southern hemisphere. The other, more challenging, problem revolved around the date of the vernal equinox and the computational accuracy of the ecclesiastical calendar, which provided the basis for the calculation of Easter and the whole structure of the liturgical year. In both of these

---

[4] See the introduction, manuscript descriptions, and edition in Alfred Lohr, ed., *Opera de computo saeculi duodecimi*, Corpus Christianorum Continuatio Mediaevalis 272 (Turnhout, 2015), xiii–xix, xxxiv–xl, 57–124. I shall cite passages from this edition as follows: Cunestabulus, *Computus* [chapter number] (ll. [line number]).

[5] In medieval usage, *computus* can refer both to the discipline of calendrical reckoning and to any text devoted to this subject. Twelfth- and thirteenth century sources often use an alternative spelling of *compotus*, which I shall normalize to *computus* in all contexts except for direct quotations from manuscripts. For general introductions to the field, see Faith Wallis, "The Church, the World and the Time: Prolegomena to a History of the Medieval *Computus*," in Marie-Claude Déprez-Masson, ed., *Normes et pouvoir à la fin du Moyen Âge* (Montreal, 1990), 15–29; Max Lejbowicz, "Computus: le nombre et le temps altimédiévaux," in Bernard Ribémont, ed., *Le temps, sa mesure et sa perception au Moyen Âge* (Caen, 1992), 151–95; Arno Borst, *The Ordering of Time: From the Ancient Computus to the Modern Computer*, trans. Andrew Winnard (Chicago, 1993). See also the bibliography provided in Faith Wallis, "Calendars and Time (Christian)," in *Oxford Bibliographies*, DOI: 10.1093/obo/9780195396584-0130.

instances, Cunestabulus's use of newly acquired astronomical knowledge turns out to have been motivated by an overall intent to safeguard traditional Church doctrines against potential critics or attempts at subversion. His technical arguments were thus imbued with an apologetic purpose, whose specific manifestations offer us an intriguing perspective on the status of Greek and Arabic authorities in twelfth-century scientific writing. In Cunestabulus's scheme of things, these authorities served as allies against innovators found within, rather than outside, the fold of the Latin Church.

Cunestabulus's mission statement

Our information on the author of the *Computus* of 1175 and the place and context in which he worked is so meagre that attempts to identify him with one of the known writers of late-twelfth century England are probably doomed to failure. Indeed, it is not even clear what significance the monicker *Magister Cunestabulus* ('Master Constable'), as employed by a contemporary excerptor of the work, was supposed to possess.[6] Equally elusive is the identity of two other persons mentioned in the work's prologue. One is the prologues's addressee, to whom Cunestabulus affectionately wrote as "my very dear one" (*dilectissime*), revealing that he had been encouraged by the latter to pen a treatise defending traditional doctrines of the ecclesiastical

---

[6] MS London, British Library, Egerton 3314, fols. 1v and 8r. On fols. 6v–8r, this manuscript contains excerpts from c. 17, 19–20, and 39 in Cunestabulus's *Computus*, which were made ca. 1185 by the monk Salomon of Christ Church, Canterbury. Salomon may have been familiar with the author from his own environment, referring to him by the office he administered rather than by his proper name. For this reason Lohr suggests that Magister Cunestabulus may have been an official in the service of Christ Church or the Canterbury diocese. See Lohr, *Opera de computo* (n. 4), xiv.

computus against the brash mouths of certain innovators.[7] The other individual is referred to only by the initial *G.* and appears to have been a student or younger relative of the author. Cunestabulus expresses his desire to see *G*. "flourish in every form of knowledge and virtue" and insinuates that he expanded his initial work into a comprehensive textbook on all areas of the *computus* in order to aid in *G.*'s education.[8]

The work he produced in pursuit of this goal was not in all respects an original one. Large parts of it were in fact drawn from an earlier *computus* treatise found, uniquely it seems, in an astronomical-mathematical codex now in the Bibliothèque Mazarine, whose ancient table of contents identifies the text as *Computus Petri*. Written four years before Cunestabulus's *Computus*, in 1171, the work of this mysterious Peter was a voluminous affair. It comprised 70 chapters distributed over two parts, which were respectively dedicated to the solar and lunar components of calendrical time reckoning.[9] Several of the chapters in the *Computus Petri* reappear in a similar form in the work of Cunestabulus, who reduced the number of chapters to 39 and generally shortened and rearranged Peter's wording, often leaving out what he appears to have considered superfluous information. In some instances, the bits left out can be very informative. For example, c. 32 of Cunestabulus's *Computus* contains a puzzling reference to the

---

[7] Cunestabulus, *Computus*, praefatio (ll. 16–21).

[8] Cunestabulus, *Computus*, praefatio (ll. 34–38): "Ceterum propter instructionem aliorum et praecipue G. mei, quem in omni scientia et virtute proficere cupio, universum apposui percurrere computum, quatenus singula, quae mihi dubitabilia visa sunt, explanarem."

[9] See the text in MS Paris, Bibliothèque Mazarine, 3642, fol. 13r–47r (missing beginning), which will be hereafter cited as *Computus Petri*. It has gone unnoticed apart from a brief mention by Haskins, *Studies* (n. 2), 86n25, who was mistaken in suggesting that it may be the same *computus* text as that contained in MS Paris, Bibliothèque nationale de France, lat. 2020, fols. 198ra–200vb. The two works have nothing in common except for their year of composition.

tituli Arabici in which one could supposedly read that “the year of the Romans contains 365 days and one quarter-day. If this quarter-day is doubled, it will be ignored; if tripled, it is counted as a whole day.”[10] It is only from Peter’s more extended discussion that we learn that the *tituli Arabici* refer to “a certain book containing the calendrical calculation of various nations that Petrus Alfonsi [*Petrus Andelfulsus*] translated from Arabic into Latin.”[11] A remark on the “Roman year” very much like the one just cited does indeed appear among the chronological instructions that accompany Petrus Alfonsi’s pioneering Latin version of the astronomical tables of al-Khwārizmī, which is roughly datable to 1116. It thus turns out that the monicker *tituli Arabici*, which goes unaccounted for in Cunestabulus’s version of the passage, was inspired by the converted Jewish scholar Petrus Alfonsi (on whom see pp. 18 and 27 below) and his way of referring to the four sections dealing with the Arabic, Persian, Roman, and Egyptian calendars as individual *tituli* (*Primus itaque titulus est arabicus de annis lune* etc.).[12]

When it came to lending structure to his work, Cunestabulus followed an approach long familiar from early medieval *computus* manuals in the Irish or insular tradition, which was to

---

[10] Cunestabulus, *Computus* 32 (ll. 7–10): “Legitur enim in titulis Arabicis: Annus Romanorum continet CCCLXV dies et quadrantem. Qui quadrans duplicatus neglegitur, triplicatus pro integro die reputatur.”

[11] *Computus Petri* (c. 28), fol. 2va: “Legitur enim scriptum de anno Romano in titulis Arabicis, libro videlicet quodam continente compotum diversarum gentium quem Petrus Andelfulsus ab Arabico transtulit in Latinum: annus Romanorum continet CCCLXV dies et quadrantem. Qui quadrans dupplicatus neglegitur, triplicatus pro integro die reputatur.”

[12] See MSS Oxford, Corpus Christi College, 283, fols. 143r–45r, as edited in Otto Neugebauer, *The Astronomical Tables of Al-Khwārizmī* (Copenhagen, 1962), 216–26 (see pp. 222–23 for the remark on the Roman calendar). On Alfonsi’s tables, see also Josep Casulleras, “Las *Tablas astronómicas* de Pedro Alfonso,” in María Jesús Lacarra, ed., *Estudios sobre Pedro Alfonso de Huesca* (Huesca, 1996), 349–66.

proceed according to the divisions of time into units and periods, from smallest to largest.[13] The initial sequence of topics progresses from time itself (c. 2) to day and night (c. 3–4), the hour and its parts (c. 5), the week (c. 6), the month (c. 7–10), the year (c. 11), the seasons (c. 12), and onwards to cycles of years such as the Olympiad (c. 13), the *lustrum* (c. 14), the indictional cycle (c. 15), the 19-year lunar cycle (c. 16), and the 28-year solar cycle (c. 28). The last-mentioned two chapters provide starting points for more drawn-out discussions pertaining to various aspects of lunar and solar computation (c. 17–27, 29–33), which make up the technical core of the treatise. The progression towards larger periods finishes with a chapter on the 532-year Easter cycle (c. 34) and a brief discussion of the *saeculum* as the greatest possible stretch of time (c. 35). Even though the *saeculum* might seem like an appropriate coda to the work as a whole, Cunestabulus follows it up with four more chapters, the first three of these were meant to offer explanations for the troubling discrepancies that had been noticed in his time between astronomical observation and calendrical prediction, as is clear from the individual headings:

> XXXVI. Why the solstices and equinoxes are no longer found on the dates on which the ancients found them (*Quare solstitia et aequinoctia non inveniantur in his datis, in quibus ea invenerunt antiqui*)
>
> XXXVII. Why we do not find the Sun’s entry into the signs on the same dates as the ancients (*Quare ingressus solis in signa non inveniamus in his datis, in quibus antiqui*)
>
> XXXVIII. Why the Moon is sometimes seen sooner than when it is said to be [in its] first [day] (*Quare luna videatur interdum citius, quam dicatur prima*).[14]

---

[13] Immo Warntjes, *The Munich Computus: Text and Translation; Irish Computistics between Isidore of Seville and the Venerable Bede and Its Reception in Carolingian Times* (Stuttgart, 2010), cvii–cxxii.

[14] See the table of contents reproduced in Lohr, *Opera de computo* (n. 4), 60–61.

The 39th and final chapter, “On the Years from the Lord’s Incarnation” (*De annis ab incarnatione Domini*), is by far the lengthiest of the entire treatise and amounts to a sophisticated defence of the Dionysiac incarnation era against the attempts of certain eleventh-century authors to revise its beginning on computistical grounds.[15] According to the chronicle of Marianus Scottus (d. 1082), which enjoyed a certain degree of popularity in twelfth-century England, Jesus died in AD 12, and was born 33 years earlier, in 22 BC.[16] His contemporary Gerland took a different approach and shifted the birth of Jesus to AD 8, with a Passion in AD 42.[17] Cunestabulus vehemently opposed these corrections on both doctrinal and astronomical grounds, closing his treatise with an extended argument to the effect that the Church had been right all along in its way of counting the years of the Lord. That the whole *Computus*, beyond its pedagogical function, was primarily conceived of as an apologetic for established ecclesiastical custom is already strongly indicated in the prologue, where Cunestabulus expressed his contempt for certain

> novelty-hunters and shameless scorners of antiquity, who even in matters of Christian doctrine arrogantly reject the position sanctioned by authority, as if it was not sophisticated enough, and who in relying on their own wit wish to think otherwise than the entire Church, as if they were the only ones in the know. But, what is even worse, I

---

[15] Cunestabulus, *Computus* 39. The chapter is discussed in C. P. E. Nothaft, *Dating the Passion: The Life of Jesus and the Emergence of Scientific Chronology (200–1600)* (Leiden, 2012), 146–154. On the wider background, see Peter Verbist, *Duelling with the Past: Medieval Authors and the Problem of the Christian Era, c. 990–1135* (Turnhout, 2010).

[16] See C. P. E. Nothaft, “An Eleventh-Century Chronologer at Work: Marianus Scottus and the Quest for the Missing 22 Years,” *Speculum*, 88 (2013), 457–482.

[17] See Gerland, *Computus* 1.24–26, ed. Lohr (n. 1), 143–159, and the commentary on pp. 403–409.

> have seen and was pained to see it put into writing that some things are one way according to the Church and another way according to the truth.[18]

Incarnation era aside, another such unwelcome attempt at innovation could be spotted in Gerland's insistence that the so-called *circulus lunaris* should more properly begin in the third year of the ordinary 19-year cycle, when 1 January coincided with the beginning of a lunation, rather than in the fourth year, as was the case in the traditional tables of Dionysius Exiguus and the Venerable Bede.[19] To Cunestabulus's dismay, this doctrine of "Gerland and his partisans" had already impacted the way the *cartulae paschales*—scraps of parchment attached to Easter candles that gave the computistical information for the current year—were inscribed in some churches.[20] As if to underline his own orthodoxy, he proclaimed that "in this entire work I say

---

[18] Cunestabulus, *Computus*, praefatio (ll. 8–15): "Sunt enim quidam novitatis venatores et antiquitatis improbi calumniatores, qui etiam in doctrina Christiana locum ab auctoritate tam quam inartificiosum superciliose repudiant et de suo confidentes ingenio aliter quam tota ecclesia soli sentire volunt, ut soli scire videantur. Sed quod deterius est, vidi equidem doluique videre scripto quod commendatum quaedam aliter se habere secundum ecclesiam, aliter secundum veritatem."

[19] Gerland, *Computus* 1.27, ed. Lohr (n. 1), 159.

[20] Cunestabulus, *Computus* 20 (ll. 3–10): "Quod in pascha, quando I^{us} est annus cycli lunaris, IIII^{us} sit annus cycli decennovennalis, tota clamat ecclesia. Solus Gerlandus et sui fautores asserunt, quod III^{us}. Cum ecclesia faciunt omnium aliorum auctorum computi. Revolve chartulas paschales in quibuscumque ecclesiis, sed non recenter editas: Omnes astruunt cum ecclesia, quod IIII^{us}. Sed in quibusdam ecclesiis hae chartulae a quibusdam modernis nuper corruptae sunt." See also Cunestabulus, *Computus,* praefatio (ll. 6–8): "His quidam nostrorum modernorum applaudentes nuper ausi sunt chartulis paschalibus suas novitates inscribere et sanctorum patrum vestigia praeterire." Cunestabulus addresses further points of disagreement between Gerland and ecclesiastical tradition in Cunestabulus, *Computus* 24 (ll. 60–94), 31–33.

very little that I do not have from another author and I make absolutely no additions of my own, except in cases where I indicate certain doubts."[21]

Ptolemaic astronomy and the Earth's habitability

In practice, of course, such dogged reliance on authority could itself be a source of innovation, provided one had access to sources that were unknown to other, or earlier, contributors to the same discipline. A prime example in this regard is Cunestabulus's own repeated use of Ptolemy's *Almagest*, the most celebrated work of mathematical astronomy to be extant from antiquity. As far as can be ascertained, the *Almagest* was translated into Latin on at least three separate occasions in the twelfth century,[22] but only one of these translations, produced in Toledo by Gerard of Cremona on the basis of an Arabic text, exerted any influence on the further development of medieval European astronomy. A clear indication that Cunestabulus already had access to this particular translation can be discerned in his renderings of the names of the ancient Greek astronomers Callippus and Hipparchus, which both here and in Gerard's Arabic-to-Latin translation appear as *Felis* and *Abrachaz*.[23] One of several examples is the following passage in c. 36 of the *Computus*, which attributes a quote on the length of the tropical year to Hipparchus. A

---

[21] Cunestabulus, *Computus*, praefatio (ll. 29–31): "Attamen scias me in toto hoc opere admodum pauca dicere, quae non habeam ex auctore, nihilque penitus de meo adicere, nisi quod nota dubitationis insigniam."

[22] See Haskins, *Studies* (n. 2), 103–110, 157–64, 191–93; Charles Burnett, "Abd al-Masīḥ of Winchester," in Lodi Nauta and Arjo Vanderjagt, eds., *Between Demonstration and Imagination* (Leiden, 1999), 159–69; Burnett, "'Ptolemaeus in Almagesto dixit': The Transformation of Ptolemy's *Almagest* in Its Transmission via Arabic into Latin," in Georg Toepfer and Hartmut Böhme, eds., *Transformationen antiker Wissenschaften* (Berlin, 2010), 115–140; Dirk Grupe, "The 'Thābit-Version' of Ptolemy's *Almagest* in MS Dresden Db.87," *Suhayl*, 11 (2012), 147–153.

[23] References to *Felis* and *Abrachaz* appear in Cunestabulus, *Computus* 1 (ll. 9, 12), 36 (ll. 105, 117, 129, 131, 135, 160), 38 (ll. 61, 64), and 39 (ll. 97, 111, 159, 196).

comparison with the corresponding passage of *Almagest*, bk. III, c. 1, makes it extremely likely that Cunestabulus worked directly from Gerard of Cremona's translation:

Cunestabulus, *Computus* 36[24]	*Almagest* 3.1[25]
Inquit Abrachaz: "Secundum quod dixerunt Mitan et Actimon, est longitudo temporis anni CCCLXV dies et IIII^{a} et una pars et dimidia diei divisi in partes LXXVI, sed secundum quod dixit Felis, CCCLXV dies et IIII^{a} tantum. Nos autem invenimus lunationes integras contineri a XIX annis quemadmodum illi. Longitudinem vero anni invenimus iam minorem IIII^{a} per unam CCC partium diei."	[Abrachis] quoque in libro suo de mensibus et diebus [...] dixit: "Secundum vero quod dixerunt Midan et Attamin est longitudo temporis anni 365 dies et quarta et una pars 76 partium et medietas diei unius. Sed secundum quod dixit Felis est 365 dies et quarta tantum." Post hoc quoque dixit [...]: "Nos autem iam invenimus menses integros contineri a 19 annis quemadmodum invenerunt illi. Longitudinem vero anni invenimus iam minorem quarta per unam 300 partium diei unius."

Cunestabulus's *Computus* thus confirms the year 1175 as the *terminus ante quem* for at least one version of the *Almagest* translation made by Gerard of Cremona, who probably started work on this project in the 1150s.[26] Chronology aside, Cunestabulus's various appeals to the *Almagest* are

---

[24] Cunestabulus, *Computus* 36 (ll. 128–136). I here reproduce the names as found in MS London, British Library, Vitellius A.XII, fol. 95va, as opposed to the normalized versions used in Lohr's edition.

[25] Ptolemy, *Almagestum*, trans. Gerard of Cremona (Venice, 1515), fol. 28r.

[26] See on this point Richard Lemay, "Gerard of Cremona," in *Complete Dictionary of Scientific Biography*, 27 vols. (Detroit, 2008), 15:174, and Paul Kunitzsch, "Gerard's Translations of Astronomical Texts, Especially the

of interest for the specific purpose they served in the overall context of his *Computus*, which was written to defend traditional ecclesiastical doctrines against their doubters and critics. The first major example for an apologetic use of Ptolemy's astronomical treatise appears in c. 12, titled *De temporibus anni*, which was modeled after the account of the four seasons, elements, and humours in c. 35 of the Venerable Bede's *De temporum ratione* (written in 725). At the beginning Cunestabulus followed Bede almost verbatim, citing diverging calendrical definitions for the beginnings of the four seasons according to Isidore, the Greeks, and Anatolius of Laodicea. From an astronomical point of view, such calendrical conventions had to be taken with a pinch of salt, since it was obvious that none of them applied to the entire surface of Earth. Indeed, dwellers between the tropic of Cancer (*circulus solstitialis aestivus*) and the equator could be argued to experience two summers and two winters each year, "as astronomers have shown," due to the Sun's being found directly overhead twice each year.[27] Cunestabulus expanded on this intriguing remark about the tropical regions with the following excursus:

> It is not a very safe thing for believers to opine that anybody can live beyond the equinoctial, where the sea seethes like a kitchen pot, and further beyond. But even according to the astronomical truth the depression of the Sun in Sagittarius and its

---

Almagest," in Pierluigi Pizzamiglio, ed., *Gerardo da Cremona* (Cremona, 1992), 71–84, at pp. 80–83, who distinguishes two versions or manuscript classes of Gerard's *Almagest*. In the absence of a critical edition, it is not possible to tell which of these versions Cunestabulus may have used.

[27] Cunestabulus, *Computus* 12 (ll. 23–27): "Verumtamen (ut demonstratum est ab astronomis) non ubique terrarum mundi vices in his IIII partibus anni similiter variantur. Nam his, quibus punctus capitalis est inter circulum solstitialem aestivum et aequinoctialem, binae sunt aestates in anno et binae hiemes." Cunestabulus here echoes the *Computus Petri* (c. 11), fol. 15va: "In media vero ubi sunt alii ortus siderum sunt bine in anno estates, bine yemes sic et de alii temporibus, bine sunt ibi messes vel quatuor."

elevation in Gemini are so great that there is necessarily extreme cold there when we have summer and a most immoderate heat when we have winter. The [degree to which] the Sun is more depressed in Sagittarius than in Gemini and closer to the centre of the Earth is the 12th part of the line that separates the centre of the Earth from the centre of the Sun at mean distance. This 12th part is more than one hundred times the Earth's radius. For this reason it seems to me not just a possible opinion, but much rather necessary to believe that nobody can live there because of the extreme climate. Ptolemy also suggests that it is true for all [observers] that the Sun, whether it is more elevated or more depressed, still increases its heat as it ascends towards their zenith and diminishes it as it descends, because the ray of the Sun that falls down from a right angle imposes the heat and makes it last, whereas the one coming from an oblique angle decays and passes the heat further on. This is the reason why in our regions, even though the Sun is more remote [from us] in summer than in winter, it nevertheless generates greater heat. But whatever lies beyond the equator is not just heated, but burned up completely during the summer, due to both the proximity [of the Sun] and the verticality [of its rays]. May the foxes who try to demolish the vineyard of the Lord God Sabaoth [cf. Song of Solomon 2.15] therefore cease to try and use the Antipodeans as a pretext for not believing. For nature does not allow for the existence of any nation whom the preaching of the Lord Jesus can never reach.[28]

---

[28] Cunestabulus, *Computus* 12 (ll. 27–51): "Ultra aequinoctialem, ubi mare fervet ut caccabus, atque ulterius quempiam habitare non valde tutum est fidelibus opinari. Sed et secundum veritatem astronomicam tanta est depressio solis in Sagittario et elevatio in Geminis, ut necesse sit ibi esse frigus acutissimum, dum nobis est aestas, et, dum nobis hiems, calorem immoderatissimum. In XII^a parte lineae, quae est a centro terrae usque ad centrum solis in remotione media, depressior est sol in Sagittario quam in Geminis et centro terrae vicinior. Quae XII^a

In gauging the eccentricity of the Sun's circular path around the Earth, Cunestabulus most likely followed *Almagest*, bk. III, c. 4, where it is stated that Hipparchus found the line segment between the centre of the Sun's eccentre and the centre of the ecliptic to be equivalent to approximately 1/24th of the eccentre-radius.[29] The difference between the Sun's minimum and maximum distance from the Earth was hence 2 × 1/24 = 1/12 of the mean distance, which was enough to suggest that considerable climatic effects could result from the Sun's changing position on the ecliptic. According to the same chapter, the apogee of the solar orbit was located 24 ½ degrees "in advance of the summer solstice,"[30] that is to say, 5 ½ degrees into Gemini. The point of the Sun's closest proximity could thus be found at the equivalent point in the sign of Sagittarius, as is indeed suggested in Cunestabulus's text. Another passage that would have supported some of his insights on solar astronomy appears in *Almagest*, bk. II, c. 6, where Ptolemy lays out the general characteristics of the Earth's parallel circles. Concerning the

---

semidiametro terrae plus quam centupla est. Quapropter mihi videtur non opinabile, immo necessarium arbitrandum propter nimiam aeris intemperantiam neminem illic posse habitare. Suadet etiam Ptolomaeus solem sive elevatiorem sive depressiorem, omnibus tamen, quando illis ascendit ad punctum capitalem, calorem intendere et remittere, cum descendit, eo quod radius solis directius descendens calorem infigat et remanere faciat, ex obliquo veniens prolabatur et calorem ad ulteriora transmittat. Unde apud nos, licet sol remotior sit in aestate quam in hieme, magis tamen calefacit. Quod autem ultra aequinoctialem est, in sua aestate tum propter vicinitatem tum propter directiorem non modo calefacit, sed exurit. Cessent igitur vulpeculae, quae vineam Domini Dei sabaoth demoliri conantur, propter antipodes occasionem non credendi quaeritare. Nullam enim gentem esse natura patitur, ad quam praedicatio Domini Iesu pervenire non possit."

[29] Ptolemy, *Almagestum* (n. 25), fol. 31r: "...unam vigintiquattuor partium linee que progreditur a centro egrediente usque ad orbem suum." See also Ptolemy, *Almagest*, trans. G. J. Toomer (Princeton, NJ, 1998), 153.

[30] Ptolemy, *Almagestum* (n. 25), fol. 31r; Ptolemy, *Almagest*, trans. Toomer (n. 29), 153.

equator, the Alexandrian astronomer remarks that "the Sun comes into the zenith twice [a year] for those living beneath it," which may well have inspired Cunestabulus's more general statement that there are two winters and summers between the tropic of Cancer and the equator.[31] Ptolemy further reports that

> some say that it is possible for the part that is below the [celestial equator] to be habitable, since its climate is very pleasant, because the Sun does not continue to cast down its shadow from the zenith for long due to its swift decline in [noon altitude] after having reached the equinoctial point. And the summer and winter have a pleasant climate, because the Sun is at a short distance from the zenith when it is at either of the two solstices.[32]

Cunestabulus's more specific statements concerning the angle of the Sun's rays and their impact on climate are found nowhere in the *Almagest* and it may appear doubtful if he could have inferred them from the passage just cited. It is nevertheless clear that his argument, according to which the compounding effects of the Sun's proximity in Sagittarius and the intensity of its rays when at or near the zenith made habitation of the southern hemisphere impossible, was a conscious reaction to a more traditional view of the Earth's habitability, which had been passed on to the medieval Latin West by late Roman encyclopaedic sources. According to the Venerable

---

[31] Ptolemy, *Almagestum* (n. 25), fol. 13v; Ptolemy, *Almagest*, trans. Toomer (n. 29), 82–83.

[32] Ptolemy, *Almagestum* (n. 25), fol. 13v: "Quidam autem dicunt quod possibile est ut illud quod est sub hac linea equidistante ex terra sit habitabile, ideo quod eius complexio est valde bona, eo quod Sol non prolonget obumbrationem suam supra puncta summitatis capitum propter velocitatem sue declinationis in latitudine ab equatione diei. Et propter hoc sunt estas et hiems bone complexionis propter brevitatem longitudinis Solis a summitate capitum quando est in utrisque tropicis."

Bede's rendition of this view, which appears in c. 34 of his *De temporum ratione* and partly relied on Pliny's *Natural History* (2.172), the equatorial region located between the two tropics was a torrid zone unfit for human habitation, since the perpendicular angle of the Sun's rays caused the land below to be "parched and burned up by flames [and] baked by being so close to the heat."[33] Things were different, however, for the zone in the southern hemisphere located between the tropic of Capricorn and the antarctic circle, which just like the corresponding zone in the northern hemisphere was deemed temperate and therefore habitable. This symmetrical arrangement of the earth's climate zones made it plausible that the lands south of the winter tropic might be inhabited by another race of people, whose existence had indeed been affirmed by Macrobius and Martianus Capella.[34] The allure of these fifth-century encyclopaedists was strong enough to make at least a few medieval commentators come dangerously close to making the same admission, despite the fact that the two temperate zones north and south of the equator were thought to be separated by an unbridgeable torrid zone and a wide ocean band that lined the equator.[35] In the absence of any viable conduit between the northern and southern hemispheres,

---

[33] Bede, *De temporum ratione* 34, ed. Charles W. Jones, Corpus Christianorum Series Latina 123B (Turnhout, 1977), 389: "Ipsa est aequinoctialis quam, quia semper sol aut praesens aut hinc vel inde vicinius illustrat, nimirum subiecta terrarum exusta flammis et cremata cominus vapore torrentur."

[34] Macrobius, *Commentarii in Somnium Scipionis* 2.5.22–36, ed. James Willis, 2nd ed. (Stuttgart, 1970), 113–116; Martianus Capella, *De nuptiis Philologiae et Mercurii* 6.604–608, 8.874, ed. James Willis (Stuttgart, 1983), 211–12, 331.

[35] Patrick Gautier Dalché, "Guillaume de Conches, le modèle macrobien de la sphère et les antipodes: antécédents et influence immédiate," in Barbara Obrist and Irène Caiazzo, eds., *Guillaume de Conches: philosophie et science au XII^e^ siècle* (Florence, 2011), 219–251. For more on the medieval discussions surrounding the Antipodes and the earth's habitability, see W. G. L. Randles, "Classical Models of World Geography and Their Transformation Following the Discovery of America," in Wolfgang Haase and Meyer Reinhold, eds., *The Classical Tradition and*

the notion of human populations living on both halves of the globe undermined the idea that mankind was united in stemming from the seed of Adam, being subjected to original sin, and destined to receive the good news of the Gospels before the end of days. Theologically informed writers such as Bede therefore generally followed St Augustine in uttering sharp denials of the existence of Antipodeans, humans living on the southern hemisphere with their feet planted against those in the north.[36] An attractive way of turning their denial from theological dogma into philosophical proof was opened up at the start of the twelfth century by Petrus Alfonsi, a converted Jew from the Iberian peninsula who had travelled to France and England to share with Latin students the secrets of Arabic astronomy. Alfonsi's Latin works include the *Dialogue against the Jews* (ca. 1110), in which he affirmed the habitable and temperate nature of the equatorial region, as Ptolemy had done, but denied the same for the rest of the southern hemisphere based on the fact that the Sun's eccentric orbit had its perigee in the sign of Sagittarius.

> When the Sun descends to the six signs of the southern region, which are from Libra to Aries, since it is then nearer to the Earth, burning the Earth with its heat due its proximity,

---

the Americas, vol. 1 (Berlin, 1994), 5–76; Gabriella Moretti, "The Other World and the 'Antipodes': The Myth of the Unknown Countries between Antiquity and the Renaissance," in *ibid.*, 241–284; Alfred Hiatt, *Terra Incognita: Mapping the Antipodes before 1600* (London, 2008), 38–144; Matthew Boyd Goldie, *The Idea of the Antipodes: Place, People, and Voices* (New York, 2010), 15–70; Alfred Hiatt, "*Terra Australis* and the Idea of the Antipodes," in Anne M. Scott, Alfred Hiatt, Claire McIlroy, and Christopher Wortham, eds., *European Perceptions of Terra Australis* (London, 2011), 9–43.

[36] Bede, *De temporum ratione* 34, ed. Jones (n. 33), 390; Augustine of Hippo, *De civitate Dei* 16.9, ed. Bernhard Dombart and Alfons Kalb, Corpus Christianorum Series Latina 48 (Turnhout, 1955), 510. See Pablo de Felipe, "The Antipodeans and Science-Faith Relations: The Rise, Fall and Vindication of Augustine," in Karla Pollmann and Meredith J. Gill, eds., *Augustine beyond the Book* (Leiden, 2012), 281–311.

> it renders it unfruitful for all things and altogether sterile, and this is why it is uninhabitable.[37]

Following Alfonsi's intervention, the Sun's proximity to the Earth's southern hemisphere was also invoked by Hermann of Carinthia, who in 1143 wrote that "Sagittarius completely prevents a passage between this hemisphere and that on the other side of the Zodiac, making infertile around it a space of 50 days."[38] The introduction of the Hipparchan-Ptolemaic solar model thus caused an important shift in Latin European thought about habitability of the Earth, which could be used to bolster orthodox belief in the non-existence of people living in the regions beyond the equator.[39] It appears that Cunestabulus was the first Latin author to make this idea explicit, combining received views on the relation between heat intensity and the impact-angle of solar rays with the new data provided by Ptolemy's *Almagest* in order to wipe the Antipodeans off the map once and for all.

---

[37] Petrus Alfonsi, *Dialogus contra Iudaeos* 1, ed. Klaus-Peter Mieth (Huesca, 1996), 22: "Unde cum sol ad sex meridianae plagae signa, quae sunt a libra ad arietem, descenderit, quia tunc terrae propior est, vicinitate sua calore terram exurens omnium rerum infecundam et omnino sterilem reddit, ideoque inhabitabilis existit." For the impact of Arabic knowledge on twelfth-century Latin geographical thought, see most recently Patrick Gautier Dalché, "Géographie Arabe et Géographie Latine au XII^{e} siècle," *Medieval Encounters*, 19 (2013), 408–433, at pp. 411–421.

[38] Hermann of Carinthia, *De essentiis* (II), ed. Charles Burnett (Leiden, 1982), 221.

[39] See on this point already Alessandro Scafi, *Mapping Paradise: A History of Heaven on Earth* (London, 2006), 173.

In defence of the Julian calendar

Apart from c. 12, most of the evidence for Cunestabulus's familiarity with Ptolemy's solar theory comes from the lengthy c. 36, where readers could learn that the interval between the true vernal equinox and the mean vernal equinox was 2 days and 6 hours, "if Ptolemy and Hipparchus did not err."[40] This information is correct in light of the table for the Sun's anomaly included in *Almagest*, bk. III, c. 6, where the equation for 114° from the apogee or perigee is given as 2;13°.[41] The vernal equinox (0° Aries) lies 65;30° before the apogee and thus 114;30° after the perigee. At a daily rate of solar mean motion of 0;59,8°, a difference in longitude of 2;13° amounts to a time gap of very roughly 2 days and 6 hours. Cunestabulus mentioned this interval immediately after having cited the years, dates, and hours of four occurrences of the true vernal equinox as observed by astronomers in the distant past:[42]

- Meton and Euctemon in 432 BC on 25 March (= 17th day of the 4th month of the Egyptian calendar), 1st hour of the night
- Hipparchus in 146 BC on 24 March (27th day of the 6th month of the Egyptian calendar), 4th hour of the day
- Ptolemy in AD 140 on 22 March (7th day of the 9th month of the Egyptian calendar), 8th hour of the day
- Thābit ibn Qurra in AD 831 on 17 March (19th day of the 11th month of the Persian calendar, 2nd month of the Egyptian calendar), 8th hour of the night.

---

[40] Cunestabulus, *Computus* 36 (ll. 116–19): "Nam si Ptolemaeus et Abrachaz non erraverint, in omnibus fuit aequinoctium secundum medium cursum tardius quam secundum <veritatem> duobus diebus et VI horis fere."

[41] Ptolemy, *Almagestum* (n. 25), fol. 33v; Ptolemy, *Almagest*, trans. Toomer (n. 29), 167.

[42] Cunestabulus, *Computus* 36 (ll. 97–114).

According to Cunestabulus's own testimony, he drew the latest of these four dates from the treatise *De anno solis*, a ninth-century work traditionally attributed to Thābit ibn Qurra (d. 901), but much more likely to have been written by the Banū Mūsā brothers in Baghdad.[43] In their efforts to establish the eccentricity of the solar orbit, the changing location of the apogee, and the length of the tropical year, the author(s) of *De anno solis* drew heavily on ancient observations cited in the *Almagest* as well as on more recent ones carried out in 830–32. Cunestabulus availed himself of one of these observations, but not without transposing the information contained in his source text into an era and calendar system more familiar to his readers. According to *De anno solis*, the vernal equinox of the 199th year of the Late Sasanid-Persian era of Yazdegerd III (*Iezdagerd* in the Latin text), which was the 216th of the Hijrah (*in anno 216 Expulsionis*), fell on the 19th day of the Persian month of Bahman (*Bihemenmeh*), two hours after midnight.[44] Cunestabulus understood enough about the Persian Zoroastrian calendar to know that Bahman was the eleventh month of a 'wandering' year of 365 days and that it went in lockstep with the second month of the old Egyptian calendar (Phaophi), which, too, worked without any bissextile

---

[43] Of the rare twelfth-century Latin version, only a single and incomplete copy appears to have survived in MS London, British Library, Harley 1 (s. XIII$^{1/2}$), fols. 19r–22r. A somewhat longer Latin text was edited in Francis J. Carmody, *The Astronomical Works of Thabit b. Qurra* (Berkeley, CA, 1960), 63–79, and translated into English by Otto Neugebauer, "Thâbit ben Qurra 'On the Solar Year' and 'On the Motion of the Eighth Sphere'," *Proceedings of the American Philosophical Society*, 106 (1962), 264–299, at pp. 265–289. The Arabic text and a French translation appear in Régis Morelon, ed., *Thābit ibn Qurra: Oeuvres d'Astronomie* (Paris, 1987), 27–67. On the text's authorship, see ibid., xlvi–liii. The contents are discussed in Kristian Peder Moesgaard, "Thābit ibn Qurra between Ptolemy and Copernicus: An Analysis of Thābit's Solar Theory," *Archive for History of Exact Sciences*, 12 (1974), 199–216; Régis Morelon, "Eastern Arabic Astronomy between the Eighth and the Eleventh Centuries," in Roshdi Rashed, ed., *Encyclopedia of the History of Arabic Science*, 3 vols. (London, 1996), 1:20–57, at pp. 26–31.

[44] *De anno solis* (26), ed. Carmody (n. 43), 68 = MS London, British Library, Harley 1, fol. 19v.

intercalation. In addition, he must have been aware that the regnal era of Yazdegerd III had begun on 16 June AD 632, making 19 Bahman of year 199 identical to 17 March AD 831. Cunestabulus is likely to have derived all of this information from calendrical conversion tables of the type that regularly circulated as part of the so-called Toledan Tables, an Andalusian *zīj* translated into Latin on at least two separate occasions in the twelfth century.[45] A clear hint at his familiarity with such tables comes from c. 30, which notes that the Egyptians used to calculate their years "in the manner of the Persians," and hence without bissextile days, until they finally admitted the leap day under "Chiltilenuz, who lived many more than 200 years after Christ."[46] This remark can be linked to a specific set of conversion tables involving the eras of Alexander (= Seleucid era), Diocletian, and Yazdegerd, which appears in several early copies of the Toledan Tables and goes back to the work of Maslama b. Aḥmad al-Majrīṭī ("of Madrid"), who revised the astronomical tables of al-Khwārizmī around 1000. Among the calendrical options it offers are Egyptian years counted from the era of Diocletian with intercalated bissextile days, a package here referred to as *Anni Chilithienuz et sunt bissextiles*.[47]

Cunstabulus's dexterity at calendrical conversion also explains his rendering of the equinoctial dates observed by Hipparchus and Ptolemy, which appear both in the *Almagest* (bk. III, c. 1) and in pseudo-Thābit's *De anno solis*, but in each case without the Julian dates and years

---

[45] A wealth of examples is edited in Fritz S. Pedersen, *The Toledan Tables*, 4 vols. (Copenhagen, 2002), 3:878–929.

[46] Cunestabulus, *Computus* 30 (ll. 54–57): "Nam Aegyptii—Chiltilenuz, qui fuit plus quam CC multis annis post Christum—ante computaverunt annum CCCLXV dierum ad modum Persarum neglecto bisexto. Hunc tamen tandem admissum in fine anni sui posuerunt."

[47] Pedersen, *The Toledan Tables* (n. 45), 3:906.

of the Christian era his *Computus* conveniently provided.[48] His conversions were accurate, excepting the fact that Ptolemy's original text placed the equinoxes observed in 146 BC and AD 140 at dawn (*in principio diei*) and at 1 pm, whereas Cunestabulus, for unclear reasons, moved them to the 4th and 8th hour of the day in question. A somewhat mysterious item on his list of equinoxes is the observation attributed to the Athenian astronomers Meton and Euctemon (*Mitan et Actimon*), who are famously credited with having recorded the date and time of the summer solstice of 432 BC. According to the *Almagest* (bk. III, c. 1), this happened in "the year when Apseudes was archon at Athens, on Phamenoth 21 in the Egyptian calendar, at dawn," which was 571 years earlier than the summer solstice Ptolemy had found in AD 140.[49] In *De anno solis*, the date is given more handily as "year 316 after the reign of Nabonassar in the month of Phamenoth on the 21st day at the beginning of the day."[50] Either source would have been enough for Cunestabulus to conclude that the summer solstice of Meton and Euctemon fell on 27 June 432 BC. Yet, rather than citing this recorded date, he attributed to the same astronomers an otherwise unattested vernal equinox on 25 March of the same year, which allegedly occurred during the 1st hour of the night. The key to this mystery is found in Cunestabulus's knowledge of the precise

---

[48] *De anno solis* (23, 25), ed. Carmody (n. 43), 67–68 = MS London, British Library, Harley 1, fol. 19v; Ptolemy, *Almagestum* (n. 25), fols. 27r, 28r.

[49] Ptolemy, *Almagest*, trans. Toomer (n. 29), 138–139. For Gerard of Cremona's Latin version, see Ptolemy, *Almagestum* (n. 25), fol. 28r: "Illa enim consideratio fuit in tempore Assuris regis civitatis sapientum et in vigesimoprimo die mensis phemenut, qui est unus mensium Egyptiorum, in principio diei."

[50] *De anno solis* (28), trans. Neugebauer, "Thâbit ben Qurra" (n. 43), 269. For the Latin text, see MS London, British Library, Harley 1, fol. 19v: "Quia in tempore Ansoris principis civitatis sapientium consideraverunt Mitan et Actimon in anno CCCXVI post regnum Nabugodonosor in mense Cametuz in die XXI° in principio diei." The spelling of Meton and Euctemon (*Mitan et Actimon*) happens to be identical to that in Cunestabulus's *Computus*, MS London, British Library, Cotton Vitellius A.XII, fol. 95rb.

astronomical lengths of the four seasons as established by Hipparchus in the second century BC and listed in *Almagest*, bk. III, c. 4:[51]

spring: 94 ½ days
summer: 92 ½ days
autumn: 88 1/8 days
winter: 90 1/8 days

Not only did Cunestabulus cite all four of these values (converting 1/8th of a day into 3 hours), but he explicitly ascribed them to Hipparchus and Ptolemy, thereby revealing that his source was indeed the *Almagest*, rather than possible alternatives such as Pliny (*Natural History* 18.220–21) or Calcidius (*Commentary on the Timaeus*, c. 77–80).[52] If the solstice observed by Meton and Euctemon occurred on 27 June at dawn, subtracting 94 ½ days for the period between the vernal equinox and summer solstice would have led back to the beginning of the night that preceded the dawn of 25 March—*in prima hora noctis*, as is expressly stated in the text.[53] By thus shrewdly converting the earliest solstice recorded in his sources into a vernal equinox, the English computist was able to document how the time of the vernal equinox had undergone a shift of 7 days and 17 hours over the roughly twelve-and-a-half centuries that separated 432 BC and AD 831. This calendrical creep was the very phenomenon referenced in the title of c. 36, "Why the

---

[51] Ptolemy, *Almagestum* (n. 25), fol. 31r–v; Ptolemy, *Almagest*, trans. Toomer (n. 29), 153–157.

[52] Cunestabulus, *Computus* 36 (ll. 159–164).

[53] Cunestabulus, *Computus* 36 (l. 101). For Cunestabulus, the beginning of the night coincided with sundown, as seen from the fact that he put pseudo-Thābit's equinox at the 8th hour of the night, whereas his source text *De anno solis* spoke of two hours after midnight (n. 44 above).

solstices and equinoxes are not found on the dates on which the ancients found them."[54] A similarly titled chapter had previously appeared in the *Computus Petri* of 1171, whose words on the topic Cunestabulus freely recycled while enriching them with new information drawn from astronomical sources.[55] As Peter and Cunestabulus both documented in some detail at the start of their respective chapters, a broad alliance of ancient pagan, Christian, and Jewish authorities placed the vernal equinox on 25 March and by doing so supported an old tradition of putting the four cardinal points of the solar year on the eighth day before the Kalends of the respective month (25 March, 24 June, 24 September, 25 December), to which the liturgical calendar assigned the dates of the conception and birth of Jesus Christ and his precursor John the Baptist. This popular tradition conflicted with the standard practice of the computists, who followed the Alexandrian patriarchs Cyril and Proterius in placing the vernal equinox on the twelfth day before the Kalends of April (21 March), using it as the official lower boundary for the date of Easter Sunday (22 March–25 April). One influential later promoter of this Greek or Alexandrian tradition was the Venerable Bede, who popularized the idea that its veracity could be confirmed by observations carried out with a sundial (*horologica consideratio*).[56] In this he was followed towards the end of the ninth century by the computist Helperic of Auxerre and Grandval, who described a method of visually tracking solar rising points with an aperture knocked into the wall of a dining room

---

[54] A deeply deficient transcription of this chapter appears in Moreton, "The *Compotus*" (n. 3), 79–82. Since her examination of the same chapter (ibid., 74–78) failed to pick up on a number of salient points, a fresh look at the material seems justified.

[55] See *Computus Petri* (c. 17), fols. 18va–20ra, where the chapter is headed "Quare solstitia et equinoctia non modo inveniantur ubi olim inveniebantur.“

[56] See C. P. E. Nothaft, 'Bede's *horologium*: Observational Astronomy and the Problem of the Equinoxes in Early Medieval Europe (c.700–1100)', *English Historical Review*, 130 (2015), 1079–1101, at pp. 1082–1091.

(*coenaculum*).[57] Cunestabulus inserted an oblique reference to this room into his own account, claiming that “Helperic agrees with [the Alexandrians], insinuating that both he and his masters had found [this date] by means of some simple method of investigation.”[58] At the same time, however, he knew only too well that observations carried out in the here and now were no longer supportive of the dates recorded in *computus* textbooks. In 1171, his predecessor Peter alleged that the winter solstice, once observed on 25 December, had already arrived on the feast day of St Lucy and hence on 13 December, “as the peasants say and perceive.”[59] Cunestabulus echoed some of Peter’s words when he wrote that, nowadays,

> any layman who observes how a ray of the Sun cast through an aperture ascends and descends [in the course of a year] will not doubt that the summer solstice much rather occurs around the 16th day before the Kalends of July [16 June] than around the 8th or 12th [24 or 20 June].[60]

---

[57] Helperic, *Liber de computo*, c. 31 (PL 137, cols. 40D–43B). See Nothaft, “Bede’s *horologium*” (n. 56), 1092–1095. On Helperic, see Marie-Hélène Jullien, ed., *Clavis Scriptorum Latinorum Medii Aevi: Auctores Galliae 735–987*, vol. 3 (Turnhout, 2010), 421–429.

[58] Cunestabulus, *Computus* 36 (ll. 46–48): “His assentit Helpericus et hoc tam se quam magistros suos simplici quodam modo quaerendi invenisse insinuat.” See also *Computus Petri* (c. 17), fol. 19ra: “Helpericus autem, qui subtilissime de solstiis et equinoctiis disputavit, asserit se invenisse solstitia et equinoctia XII kl. illorum mensium, modum etiam inveniendi edocet. Huic autem oppinioni plurimi compotiste consentiunt.”

[59] *Computus Petri* (c. 6), fol. 14ra: “Nec tamen nunc ibi modo est, sed in festo sancto Lucie, ut dicunt et sentiunt rustici.”

[60] Cunestabulus, *Computus* 36 (ll. 86–89): “Nunc autem quilibet laicus considerans ad foramen aliquod radium solis ascendentem et descendentem non dubitat aestivum solstitium potius contingere circa XVI Kalendas Iulii quam circa VIII Kalendas vel XII°.” This is a variant of *Computus Petri* (c. 17), fol. 18va: “Nunc autem quilibet laicus ad fenestram suam considerans ascensum et descensum radii solis non dubitat solstitium estivum magis contingere circa

The insight that empirical evidence contradicted bookish tradition when it came to the equinoxes and solstices had been dawning on Latin scholars since the eleventh century.[61] On the British Isles it was first made explicit by the Lotharingian abacist Walcher, who served as the prior of Great Malvern until his death in 1135. According to a remark contained in Walcher of Malvern's treatise *De Dracone* (1120), careful observation revealed the summer solstice to fall on 16 or 17 June and therefore rendered false the familiar claims of it falling on 20 or 24 June, which were still ubiquitous in the available books. Walcher also believed to have an explanation for this bewildering situation, which had been passed down to him by his teacher, who was none other than the aforementioned Petrus Alfonsi:

> In the course of 900 years the Sun slows down by 7 degrees in the zodiac and in another 900 years it regains these with its speed, which is why the solstices and equinoxes do not always happen on the same days, but on different ones. In these our present times, however, the Sun uses this slower course, which is why it seems to us that it does not complete the entire zodiac in a year.[62]

XVII^o kl. Iulii quam circa VIII^o kl." Peter's claim that the solstice currently fell on 15 June was supported by astronomical calculations he had carried out for the present year 1171 (ibid., fol. 19ra). Cunestabulus puts the solstice on 16 June instead, although this might just be the result of a scribal error (*XVI* for *XVII kl. Iul.*).

[61] See the discussion of William of Hirsau's observational method in Nothaft, "Bede's *horologium*" (n. 56), 1095–1101.

[62] See the edition of Walcher's text in José M.ª Millás Vallicrosa, "La aportación astronómica de Pedro Alfonso," *Sefarad*, 3 (1943), 65–105, at p. 92: "Ut de uno dicam, solstitium estivum 8 kalendis iulii in quibusdam libris, in aliis 12 kalendis iulii scribitur et utrumque falsum invenitur. Si enim bene perspexeris 15 kalendis iulii vel fortasse 16 kalendis iulii solstitium estivum deprehendere poteris. Ad hec ille in 900 annis 7 gradibus solem retardare in zodiaco dicebat et in aliis 900 velocitate eas recuperare; et ideo non semper eisdem diebus vel in diversis solstitia et

The passage complemented a series of cumbersome calculations, at the end of which Walcher had been forced to conclude that the Sun, if it moved at the daily rate Petrus Alfonsi had assigned to it (0;59,8,15°/d), could not go full circle on the ecliptic in a Julian year of 365 ¼ days, falling short by a 0;0,1,41,15° each year. This carried the implication that the dates of the equinoxes and solstices did not remain fixed in the Julian calendar, but slowly drifted towards the end of their respective months. Taken by itself, this was hardly an explanation why present-day observers found the summer solstice to occur up to eight days earlier than the ancients had claimed. Yet Petrus Alfonsi had also equipped Walcher with the knowledge that the Sun was capable of hurrying along the zodiac at two different speeds, the present slow one as well as a swifter one, which it must have followed in the past. If this swift pace made the Sun complete the zodiac in a period considerably shorter than 365 ¼ days, an explanation why the solstice had been able to move from 24 June to 16 June was suddenly forthcoming.[63]

In the context of Latin computistics, Walcher's claims about the length of the solar year were a revolutionary step, at least in so far as they challenged the reigning dogma that the Julian calendar and its 28-year solar cycle were perfect representations of nature. Once this dogma was abandoned it became possible to regard the different sets of equinoctial and solstitial dates encountered in old books as snapshots of the past, which reflected observations made by different astronomers in different time periods. As the twelfth century entered its fourth quarter, the continuing influx of astronomy from Arabic and Greek sources had created an opportunity to flesh out this insight in much greater detail. As already seen, Cunestabulus made good use of this

---

equinoctial fieri, his autem nostris temporibus illo tardiore cursu solem dicebat uti, unde videtur nobis quia totum sol in anno zodiac non peragit."

[63] See my discussion of c. 3 of Walcher's *De Dracone* in Nothaft, *Walcher of Malvern* (n. 1).

opportunity when he excerpted four equinoctial dates recorded in the *Almagest* and *De anno solis*. Taken together, these exhibited a shift from 25 March to 17 March between the fifth century BC and the ninth century AD, which was best explained by assuming that the length of the tropical year had remained below the Julian average of 365 ¼ days during the period thus documented. For those who still wanted to think otherwise and insist that only one of these four dates, or perhaps none of them, could be treated as accurate, Cunestabulus had a blunt warning:

> Nobody, I think, will be so insane as to opine that the sleep of ignorance crept upon the vigilance of the ancients such that they erred in a matter where even the layman's simplicity can find out something close to the truth. Perish the thought! Instead, it is doubtlessly the case that the authors of our *computus* did not use the true length of the year—either on purpose, that is, out of their desire for a handy computation, or because their were influenced by less than perfect observation, which is only human.[64]

While there was clearly no need to heap blame on the inventors of the Easter *computus*, who had founded the 19-year lunar cycle on the average year length of the Julian calendar, the implications of calendrical error were nevertheless worrying, especially if one looked to the future. If nothing was done about the excess length of the Julian year, the equinoxes and solstices were going to continue to drift through the calendrical months "for all eternity, if this shortness of

---

[64] Cunestabulus, *Computus* 36 (ll. 89–96): "Neminem tamen arbitror esse tam insani capitis, ut opinetur vigilantiam antiquorum ignorantiae somnum adeo subrepsisse, ut fallerentur in ea re, quam prope verum indagare potest laicalis simplicitas. Absit. Sed procul dubio auctores nostri computi vel consulto, scilicet commodae computationis desiderio, vel etiam, quod humanum est, minus perfecta consideratione inducti veram quantitatem anni solaris non habent." Cunestabulus here modifies a passage already encountered in the *Computus Petri* (c. 17), fol. 18va.

the year were to persevere. But will it really persevere?"[65] Constabularius gave the answer right away, by listing various historical estimates of the length of the solar year.[66] To the three estimates mentioned in bk. III of the *Almagest*, namely

Meton and Euctemon: 365 ¼ + 1/76 days

Callippus [*Felis*]: 365 ¼ days

Hipparchus and Ptolemy: 365 ¼ – 1/300 days[67]

he added

Thābit (*De anno solis*): 365 ¼ – 1/150d[68]

and

al-Battānī: 365 ¼ – 1/106d.[69]

Given this confusing variety and the implied downwards trajectory in the length of the tropical year, it appeared understandable why al-Battānī had come to wonder "whether there may be some motion that makes the year decrease in this way," as Cunestabulus noted at the end of his

---

[65] Cunestabulus, *Computus* 36 (ll. 125–128): "Et retrograderetur aequinoctium in perpetuum, si haec anni quantitas perseveraret. Sed numquid perserverabit? Vide, quid super hoc speculatores dixerint."

[66] Cunestabulus, *Computus* 36 (ll. 128–138).

[67] See n. 25 above.

[68] Contrary to Cunestabulus's claim, this estimate is not recorded in *De anno solis*, but see Abraham Ibn Ezra, *Liber de rationibus tabularum*, ed. José M.ª Millás Vallicrosa, *El libro de los fundamentos de las Tablas astronómicas de R. Abraham Ibn Ezra* (Madrid, 1947), 76: "Tebit ben Core composuit duos libros de anno solari, in uno quorum docuit deesse 4te 106^{am}, in altero superesse 4te 150^{am}."

[69] al-Battānī, *De motu stellarum* (c. 27, 52), trans. Plato of Tivoli (Nuremberg, 1537), fols. 27v, 80v–81r; Carlo Alfonso Nallino, ed., *Al-Battānī sive Albatenii Opus astronomicum*, vol. 1 (Milan, 1899), 42, 129.

enumeration.[70] Later Arabic astronomers working in al-Battānī's wake had done their best to account for these changes by proposing theories according to which the sphere of the fixed stars underwent a motion of "access and recess," which implied a variable and bi-directional rate of precession as well as fluctuations in the length of the tropical year. As far as the Latin world is concerned, the most influential presentation of such a theory appeared in a treatise *De motu octave spere*, which just like *De anno solis* was generally attributed to Thābit ibn Qurra.[71] Despite this traditional ascription, there is good evidence to show that *De motu* was only composed in the eleventh century in connection with the aforementioned Toledan Tables, which came with an identical set of tables for calculating the motion of the eighth sphere.[72] The close connection between the Toledan Tables and the theory of access and recess ensured that later Latin writers would associate this theory not just with Thābit ibn Qurra, but also with the Andalusian astronomer Azarquiel (al-Zarqālī or al-Zarqālluh, d. 1100), whom they regarded as

---

[70] Cunestabulus, *Computus* 36 (ll. 138–139): "Dubitavit etiam Albatheni, utrum aliquis motus esset, qui ita faceret annum decrescere." See al-Battānī, *De motu stellarum* (c. 52), trans. Plato of Tivoli (n. 69), fol. 81r, and F. Jamil Ragep, "Al-Battani, Cosmology, and the Early History of Trepidation in Islam," in Josep Casulleras and Julio Samsó, eds., *From Baghdad to Barcelona*, 2 vols. (Barcelona, 1996), 1:267–298, at pp. 293–295, for an English translation of the chapter in question.

[71] Editions of the Latin text appear in Carmody, *The Astronomical Work* (n. 43), 102–113 (two versions); José M.ª Millás Vallicrosa, "El 'Liber de motu octave sphere' de Ṯābit ibn Qurra," *Al-Andalus*, 10 (1945), 89–108. An English translation was published by Neugebauer, "Thâbit ben Qurra" (n. 43), 291–299. The model and its reception are discussed in C. P. E. Nothaft, "Criticism of Trepidation Models and Advocacy of Uniform Precession in Medieval Latin Astronomy," *Archive for History of Exact Sciences* 71 (2017), forthcoming.

[72] Pedersen, *The Toledan Tables* (n. 45), 4:1542–1566. That the model of *De motu* was designed to work with the Toledan Tables was conclusively demonstrated by Raymond Mercier, "Accession and Recession: Reconstruction of the Parameters," in Casulleras and Samsó, *From Baghdad* (n. 70), 1:299–347.

the principal author of the Toledan Tables.[73] Cunestabulus's predecessor Peter, who must rank among the first Latin authors to describe this theory in any detail, claimed that the bi-directional motion of the fixed stars had been hypothesized by Thābit, son of Qurra, "the greatest philosopher among the Christians," in order to reconcile the divergent findings made at different times by Ptolemy and al-Battānī.[74] Cunestabulus, for his part, appears to have relied directly on the Toledan Tables when writing down the following remark:

> The motion of access and recess, which Azarquiel and many other most esteemed astronomers have endorsed, suggests that all of the abovementioned investigators spoke the truth in their own time. For it teaches that the solar year sometimes increases and sometimes decreases, and in doing so sometimes adds to the quarter-day, sometimes subtracts from it. If this is true, then the equinox will recede towards the beginning of

---

[73] This is the attribution used in a twelfth-century text by John of Spain (*Iohannes Hispanus*), for which no precise date can be established. See José M.ª Millás Vallicrosa, "Una obra astronómica desconocida de Johannes Avendaut Hispanus," *Osiris*, 1 (1936), 451–475, at pp. 469–473. On the identity of the author, see Charles Burnett, "John of Seville and John of Spain: A *Mise au point*," *Bulletin de philosophie médiévale*, 44 (2002), 59–78; Maureen Robinson, "The Heritage of Medieval Errors in the Latin Manuscripts Johannes Hispalensis (John of Seville)," *Al-Qanṭara*, 28 (2007): 41–71, at pp. 64–69.

[74] *Computus Petri* (c. 17), fol. 19va: "Sed Thebit filius Core, Cristianorum philosophus optimus, neutrum precedentium auctorum fuisse mentitum asseverat. Dixit enim stellas fixas quandoque moveri contra firmamentum, modo cicius, modo tardius, quandoque cum firmamento, similiter nunc cicius, nunc tardius, nunc tantum temere, sed motu circulari." The false claim that Thābit was a Christian appears to have originated in Abraham Ibn Ezra, *Liber de rationibus tabularum*, ed. Millás Vallicrosa (n. 68), 76.

> March as long as the year is shorter than 365 ¼ days; and once [the year] adds to the quarter-day, it will return to the dates on which it was found by the ancients.[75]

All of this was sound doctrine, competently presented, but Cunestabulus did not just talk about the “access and recess” of the equinoctial dates in general terms: he was in fact able to cite precise data elucidating its future development. According to his concisely stated prediction, the currently witnessed calendrical retrogradation of the equinoxes and solstices was going to continue only until the year 1392 of the Christian era, when the true vernal equinox could be expected to occur on 13 March, about “eight moments after the noon of Jerusalem.” There was going to follow a period of 2520 during which the vernal equinox kept reverting towards its previous dates until finally arriving at the 19th of April, “and then it will return again.”[76] What Cunestabulus targeted with these remarks were the years in which the changing length of the tropical year, as implied by the Toledan access and recess-model, dropped either above or below the Julian year length of 365 ¼ days, thereby causing a reversal of direction in the drift of the equinoxes and solstices. Yet this was an event the computational tables at hand made it impossible to predict in any straightforward way. To come even close to the results casually

---

[75] Cunestabulus, *Computus* 36 (ll. 139–48): “Motus autem accessionis et recessionis, quem Azarchel et multi alii probatissimi astronomi approbaverunt, innuit omnes supra dictos speculatores verum dixisse in tempore suo. Docet enim annum solis quandoque crescere quandoque decrescere, quandoque addere super IIII^{am} quandoque minuere. Quod si verum est, quamdiu hic annus erit minor CCCLXV diebus et IIII^{a}, retrogradietur aequinoctium versus initium Martii cumque addiderit super IIII^{am}, redibit ad datas, in quibus ipsum inveniebatur ab antiquis.”

[76] Cunestabulus, *Computus* 36 (ll. 148–153): “Anno igitur ab incarnatione Domini MCCCXCII^{o} erit secundum hunc motum vernum equinoctium aequatum III^{o} Idus Martii post meridiem Hierosolymae fere VIII momentis. Postmodum revertetur ad datas sequentes et progredietur circa $\overline{\mathrm{II}}$DXX annos nec cessabit, donec transierit diem XIII^{o} Kalendas Maii, et tunc denuo revertetur.”

mentioned in Cunestabulus's *Computus* would have required repeated calculations of the time of the true vernal equinox for successive years, which itself involved long-winded iterative procedures of adding the so-called equation of the eighth sphere, as yielded by the tables for access and recess, to the true sidereal longitude, as yielded by the Toledan tables for solar mean motion and equation. Cunestabulus's ability to name precise dates and years for the calendrical reversals of the vernal equinox is therefore nothing short of remarkable and must have involved painstaking computational labour, the extent of which is difficult to fathom. With the help of a computerized simulation based on the Toledan solar and precession parameters, it is possible to locate the first reversal after AD 1175 between the years 1365 and 1366, as seen from these projected lengths of the tropical year (reckoned from the vernal equinox in the present year):[77]

Year AD	length of tropical year	true vernal equinox
1365	365.249995d	13 Mar 16:07:53h
1366	365.250020d	13 Mar 22:07:53h
1367	365.250044d	14 Mar 04:07:54h

In light of the difficulties Cunestabulus faced, not to mention the imprecisions inherent in the tables themselves, it is far from surprising that he would have missed this ideal target by some 26 years. Competent use of the Toledan Tables clearly underlies his statement that the vernal equinox of 1392 will occur 13 March, "eight moments" after noon, as calculated for the meridian

---

[77] The values listed above derive from calculations based on Raymond Mercier's program *Deviations* (Devplo), available for download at his website < http://www.raymondm.co.uk/> , as well as on a separate program Prof. Mercier wrote with the specific purpose of simulating the length of the tropical year in the Toledan Tables. I am deeply grateful to Prof. Mercier for sharing his results with me in a private communication of 20 March 2014.

of Jerusalem. In computistical parlance, a moment was 1/40th of an hour,[78] making 8 moments the equivalent of 12 sexagesimal minutes or 0;12h. Modern simulation places the Toledan true equinox of 1392 on 13 March, at 10:20h, so Cunestabulus's result would be accurate for a meridian 28° (1;52h) East of Toledo (the actual distance between Toledo and Jerusalem is closer to 39°). For the even more distant future, his statements imply another reversal in the year 1392 + 2520 = 3912 of the common era. This again comes reasonably close to the modern computerized result, according to which the tropical year will drop below 365 ¼ days in AD 3896/97:

Year AD	length of tropical year	true vernal equinox
3896	365.250022d	19 April 05:56:28h
3897	365.249998d	19 April 11:56:30h
3898	365.249973d	19 April 17:56:30h

More important than any specific numerical detail is Cunestabulus's overall insight that the date of the vernal equinox was going to continue its calendrical drift over time, but do so in two directions rather than just one. Since in the very long run the equinoctial date could be seen to bounce back and forth between 13 March and 19 April, any of the dates in between, as transmitted by Ptolemy, the Church fathers, and other ancient authorities—and this included the 21 March regarded as canonical by computists—were valid only relative to a certain point in the past or future. This, in turn, was tantamount to saying that none of them were incorrect in any absolute sense. Cunestabulus's predecessor Peter, although less technical in his argument, had already deftly used the prospect of a growing tropical year to keep in check the "thoughtless despiser of antiquity" who sought to correct the Julian calendar by removing superfluous days or

---

[78] Cunestabulus, *Computus* 5 (ll. 16–17).

altering its leap-year rhythm. If the equinoxes and solstices were capable of drifting in both directions of the Julian year, this might "force our descendans after a certain span of years not only to make a new addition, but also to compensate for the damage caused by this unlawful removal." At any rate, the debates among astronomers about whether or not the tropical year was variable or constant showed that the Church was best advised not to give in to any actionism when it came to the calendar.

> But even if at some future time the Church should sigh for a correction of its calculation, it will now, if it acts advisedly, not hasten things, but wait until it has been ascertained whether the doctrine of Thābit is true or not.[79]

Cunestabulus obviously agreed with this assessment and added to it by emphasizing that the fathers of the ecclesiastical *computus*, rather than being gravely mistaken about the length of the solar year, had simply chosen the most convenient value they could find. Their preferred length of 365 ¼ days contained no small fractions, making it easy to compute with, but it nevertheless came relatively close to the length of the sidereal year, which was the mean between the maximum and minimum tropical year lengths produced by the motion of access and recess.[80]

---

[79] *Computus Petri* (c. 17), fols. 19vb–20ra: "Caveat igitur improvidus antiquitatis despector alicuius diei detraxcione usitatam compoti nostri dispositionem ne deterius incidat violare, ne forte cogantur posteri post aliquot annos non solum novam additionem facere, sed etiam huius iniuriose detractionis dampna recompensare. [...] Quodsi ad correctionem sui compoti aliquando post hoc tempus ecclesia suspiraverit, modo cum consilio non properabit, sed exspectet donec certum fuerit utrum sententia Thebit sit vera vel non."

[80] Cunestabulus, *Computus* 36 (ll. 174–177): "Attende etiam auctores nostri computi commodissimam quantitatem anni solis elegisse, quae medium fere locum tenet inter maximum crementum et decrementum et satis leviter computari potest."

Above all, the lessons drawn from advanced Arabic astronomy served to exonerate most of the ancient authorities, who could no longer glibly be accussed of error for transmitting dates of the equinoxes and solstices that differed from those observed in the here and now. Instead,

> each and every one of the abovementioned authors either stated the solstices and equinoxes to be where he found them in his time or he relied on the wits of the ancients and assented to their authority, and, in my judgement, none of them can be justly refuted.[81]

Conclusion

Magister Cunestabulus's defence of the ancients was technically proficient and at least superficially persuasive, based as it was on a doctrine of "access and recess" that for several centuries remained a widely employed and accepted element of Latin astronomy. Apart from the intellectual merits of Cunestabulus's argument, it is also worth highlighting its implications for the discussions surrounding a potential reform of the ecclesiastical calendar, which in 1175 had only just begun to occupy the minds of Latin scholars. Irrespective of his actual influence as an author,[82] his assumption that the length of the tropical year underwent fluctuations and that the

---

[81] Cunestabulus, *Computus* 36 (ll. 153–157): "Ex hoc ergo videtur, quod unusquisque supradictorum auctorum vel ibi dixit esse solstitia et aequinoctia, ubi ea in tempore suo repperit, vel in antiquorum confisus ingenia eorum auctoritatibus acquievit nullusque eorum meo iudicio potest iuste redargui." This passage expands upon *Computus Petri* (c. 17), fol. 19rb: "Quilibet igitur auctor predictorum vel ita dixit prout in tempore suo reperit vel in antiquorum confisus ingenia auctoritatibus eorum adquievit."

[82] Apart from Salomon of Christ Church (n. 6 above), the most noteworthy among the few examples of Cunestabulus's later reception is the *Summa de etate mundi* (ca. 1310) by Walter Odington, monk of Evesham Abbey. See C. P. E. Nothaft, "Walter Odington's *De etate mundi* and the Pursuit of a Scientific Chronology in Medieval England," *Journal of the History of Ideas*, 77 (2016), 183–201, at pp. 191–192, 199.

drift of the equinoxes and solstices through the calendrical months was therefore a two-way street were bound to look attractive to anyone who, like Cunestabulus himself, had qualms about criticizing the Church's existing calendrical framework or who simply considered a reform of this framework too costly or impractical.[83]

Despite his best efforts, however, not even Cunestabulus was able to create a convincing apologetic for every aspect of the tradition he sought to defend. This holds true in particular for his attempt to explain away the failure of the ecclesiastical calendar's 19-year cycle to predict correctly the current age of the Moon. In Cunestabulus's day, access to new parameters, like those provided by Arabic collections of astronomical tables and the Jewish calendar, had already put Latin computists in a position to recognize both the cause and the magnitude of this error. In the estimation of an anonymous West English computist, who probably wrote in the second quarter of the twelfth century, the "Roman" *computus* used by the Church added a superfluous 4 minutes and 10 seconds of a day (= 1;4h) to every 19-year cycle, causing the predictions made by the ecclesiastical calendar to deteriorate at a rate of 1 day every 285 years.[84] Cunestabulus, for his part, was well aware of these arguments and openly agreed that the average lunation in the Latin 19-year cycle added 160 atoms of time (= 160 × 1/22,560 of an hour) to the value accepted by the

---

[83] Examples for this attitude include the anti-reform treatise of 1345, edited in Chris Schabel, "*Ad correctionem calendarii*... The Background to Clement VI's Initiative? Text and Introduction," *Cahiers de l'Institut du Moyen-Âge Grec et Latin*, 68 (1998), 13–34, at pp. 27–28. The theory of access and recess continued to complicate the calendar reform debate well into the sixteenth century. See Jerzy Dobrzycki, "Astronomical Aspects of the Calendar Reform," in George V. Coyne, Michael A. Hoskin, and Olaf Pedersen, eds., *Gregorian Reform of the Calendar* (Vatican City, 1983), 117–126.

[84] See the edition in C. P. E. Nothaft, "Roman vs. Arabic Computistics in Twelfth-Century England: A Newly Discovered Source (*Collatio Compoti Romani et Arabici*)," *Early Science and Medicine*, 20 (2015), 187–208, at pp. 202–203.

Arabs and 139 atoms and the 9th part of an atom to the mean interval between two conjunctions according to the Jewish calendar. “And this is the reason why the Arabs and Jews call out the new moon both earlier and closer to the Moon’s actual kindling than we do.”[85] How was one to react to this worrying state of affairs? Cunestabulus made an attempt by pointing to the widespread notion that 19 solar years were exactly equal to 235 lunations, which not only underlay the ecclesiastical lunar calendar, but was also shared by ancient Greek astronomers such as Callippus and Hipparchus. Given the long-term variations of the solar year, brought about by the access and recess of the eighth sphere, this equation implied that the length of the lunar month, like that of the solar year, would vary between two extremes and eventually go full circle. In this case, the average lunation presupposed by the present-day *computus* simply corresponded to the mean length of the synodic lunar month observed at the time of Callippus, whose solar year had been exactly 365 ¼ days in length.

> If this is true, the truth of our whole *computus* will return once the equinoxes and solstices return to their later dates. And the foreigners, even though they now seem to make better pronouncements, are to be charged with an even more manifest falsehood.[86]

The argument was a clever one, but ultimately revealed a flawed understanding of the astronomical theory that was supposed to underpin it. Since the Toledan access-and-recess model accepted the usual placement of the sphere of the Moon inside the spheres of the fixed stars, the

---

[85] Cunestabulus, *Computus* 38 (ll. 59–60): “Hinc est, quod Arabes et Iudaei et citius et accensioni lune vicinius lunam primam dicunt quam nos.”

[86] Cunestabulus, *Computus* 38 (ll. 68–71): “Quod si verum est, revertetur veritas totius nostri computi, quando aequinoctia et solstitia ad datas sequentes revertentur. Alieni quoque, licet nunc melius dicere videantur, de multo manifestiori falsitate sunt arguendi.”

Moon's motion would have been affected by the motion of access and recess in exactly the same measure as the Sun. The periods of revolution of both luminaries were accordingly bound to stay the same in relation to each other, leaving the length of the synodic month unaffected. This futility of appeals to access and recess in explaining away the inaccuracy of the ecclesiastical lunar calendar was indeed pointed out only a year later by Roger of Hereford, whose *Computus* of 1176 is another example of a work on the discipline that introduced copious elements from Greco-Arabic mathematical astronomy.[87] Far from claiming that the wisdom of the Arabs and Greeks wholly supported the Latin Church's accustomed *computus*, Roger found it necessary to distinguish between three different approaches to tracking the courses of Sun and Moon. Next to the simple *computus vulgaris* used in the Church, there was the more refined *computus naturalis*, whose practitioners tried to improve precision by working with equal periods involving small fractions of time. Both manifestations of the discipline relied on the same estimate for the mean synodic month, whose accuracy left much to be desired. Astronomy, as a third approach to celestial motion, not only made use of superior parameters, but distinguished between mean and true motions, thus taking into account an observed inequality in celestial motions the computists had ignored. In line with this perspective, Roger made no attempt to exonerate the ecclesiastical calendar from the charge that it consistently failed at its goal of predicting the new and full moon. Instead, he became one of the first Latin authors to openly consider the option of correcting the existing calendar, by resetting the Golden Numbers that marked its new moon dates.[88]

---

[87] See the introduction and edition in Lohr, *Opera de computo* (n. 4), xix–xxvi, xl–xlii, 127–232. Roger of Hereford's treatment of trepidation (c. 26, ll. 82–95) is discussed in Nothaft, *Walcher of Malvern* (n. 1).

[88] See bk. 5 of Roger of Hereford, *Computus*, ed. Lohr (n. 4), 213–232. I shall discuss this work in more detail in C. P. E. Nothaft, "Roger of Hereford and the Transformation of the *Computus* in Twelfth-Century England," in Christian Etheridge and Michele Campopiano, eds., *Travelling Wisdom* (Turnhout, forthcoming).

In spite of these differences in opinion, one should not overlook the shared intellectual ground between Magister Cunestabulus and Roger of Hereford, who saw themselves compelled to write on *computus* at a time when the availability of translated astronomical texts in England had begun to undermine the authority of their discipline, sparking a discussion between experts that was going to continue until the Gregorian reform of the calendar, carried out in 1582. Ironically enough, Cunestabulus's attempt to stem the tide of this discussion in favour of a conservative vision of the *computus* forced him to compose one of the most original and, indeed, innovative treatises that had ever been written on the subject.