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(*b*. [probably] Novara, Italy, first quarter of thirteenth century; *d*. Viterbo, Italy, 1296),

mathematics, astronomy.

Our scanty information on the life of Campanus is derived from a few references in contemporary documents and writers supplemented by inferences from his own works. His full style is Magister Campanus Nouariensis (there is no authority for the fore-name Iohannes occasionally applied to him from the sixteenth century on). He refers to himself as Campanus Nouariensis.[1] This presumably indicates that Novara was his birthplace. Contemporary documents usually refer to him as Magister Campanus. The title Magister would in this period usually mean that the holder was a member of a faculty at a university; but we have no other evidence connecting Campanus with any university. His birthdate can be only approximately inferred from the fact that he was holding ecclesiastical office and writing major works in the late 1250's and early 1260's.

The earliest piece of biographical evidence is contained in one manuscript of Campanus' edition of Euclid, which seems to connect the work with Jacques Pantaléon, patriarch of Jerusalem. This would date it between 1255 and 1261,[2] the years of Pantaléon's tenure of that position. The connection is a likely one, since when Pantaléon was elected to the papacy in, 1261, becoming Urban IV, he took Campanus as one of his chaplains, as we learn from the latter's preface to his *Theorica planetarum*, which he dedicated to Urban. The letters of Urban reveal that he conferred other benefices on Campanus, including the rectorship of the Church of Savines in the diocese of Arles (reconferred 1263) and a canonicate in the cathedral of Toledo (1264). Urban died in 1264, but Campanus had another powerful patron in the person of Ottobono Fieschi, cardinal deacon of St. Adrian's and papal legate to England (later Pope Adrian V). Campanus was Ottobono's chaplain in 1263–1264, and it was probably through the influence of the cardinal that he became parson of Felmersham in Bedford-shire, England (he is attested as holding this benefice by a document of 1270).

Campanus' scientific reputation was already great enough by 1267 for Roger Bacon to name him as one of the four best contemporary mathematicians (although not one of the two "perfect").[3] Benjamin has suggested that Campanus may have accompanied Cardinal Ottobono when the latter was in England from 1265 to 1268, and there made Bacon's acquaintance. This hypothesis, although attractive, remains unproven, and indeed Campanus may never have left Italy, since the holding of benefices in absence was a common practice.

Later documents show that Campanus held a canonicate of Paris and was chaplain to popes Nicholas IV (1288–1292) and Boniface VIII (1294–1303). It is probable that he spent his later years at the convent of the Augustinian Friars at Viterbo. A letter of Boniface VIII, dated 17 September 1296, informs us that Campanus had just died at Viterbo; and in his will Campanus gave instructions for the construction of a chapel to St. Anne in the Church of the Holy Trinity there. The general impression one gets from these scattered pieces of information is of a life spent tranquilly cultivating the mathematical sciences under the patronage of powerful ecclesiastical figures, assisted by the income from a plurality of benefices that had made him a comparatively wealthy man at his death.

Of Campanus' numerous surviving works only one (the *Theorica planetarum*) exists in a modern critical edition. The unsatisfactory printed editions of others belong to the fifteenth and early sixteenth centuries; some exist only in manuscript. Much scholarly work remains to be done on these. Therefore the present survey, which is based mostly on arbitrarily selected manuscripts of the works in question, can be no morethan an interim report on Campanus' output. It is not yet possible to set up even a relative system of dating of his writings as a preliminary to tracing his mathematical development. Certain individual works, however, can be quite closely dated. We have already seen that the Euclid can probably be dated to 1255–1259 and that the *Theorica* certainly belongs to the period of Urban IV's papacy (1261–1264). The planetary tables predate 1261, since they are cited in that year by Petrus Peregrinus of Maricourt. The *Computus maior* is dated to 1268 from a computation occurring in it. The *Sphere* is later than 1268, since it cites the *Computus*. An introductory letter to Simon of Genoa's *Clavis sanationis* belongs to the papacy of Nicholas IV (1288–1292), and the letter to Raner of Todi is datable to about the same period on internal evidence. But I am unable to draw any significant conclusions from the above dates, and therefore restrict myself to a description of the content of the surviving works.

The work by which Campanus is best known is his (Latin) edition of Euclid's *Elements* (in fifteen books, including the non-Euclidean books XIV and XV). This is the text of the *editio princeps* of Euclid, and it was reprinted at least thirteen more times in the fifteenth and sixteenth centuries. There are also very many manuscripts. It was undoubtedly the version in which Euclid was usually studied in the later Middle Ages. Yet surprisingly little is known of its general characteristics, and many false or misleading statements about it can be found in reference works. Thus it is frequently referred to as his "translation" of Euclid, and sometimes as his "commentary" on Euclid. Neither is accurate. We can state with confidence that Campanus did not possess the linguistic competence to translate from either Arabic or Greek: in none of his other works does he display any knowledge of either language (despite the fact that as chaplain of Urban IV he almost certainly came into close contact with the most competent Grecist of the time, William of Moerbeke, who was attached to the papal court as *poenitentiarius minor*). Campanus' edition is in fact a free reworking of an earlier translation or translations, at least one of which was made from the Arabic, as is evidenced by his retention of such terms as (*h*) *elmuhaym* (= Arabic *al-mua'yyan*) for "rhombus" and *(h)elmu(r)arife* (= Arabic *al-munḥarif*) for "trapezium." He may also have used existing translations from the Greek. Determination of the exact relationship of Campanus' edition to its antecedents must await publication and examination of the numerous versions of Euclid that were current in the Middle Ages. But it already seems certain that he was heavily dependent on one or more of the versions attributed to Adelard of Bath (early twelfth century).

If one compares Campanus' edition with the standard edition of the original Greek by Heiberg, one finds that the content (although not the wording) is much the same, except for some rearrangement of material and numerous additions, both small and large, in the Campanus text. Some of these additions can be found in other Greek or Arabic versions, but a number appear to stem from Campanus himself, and indeed in some manuscripts some are explicitly headed *commentum Campani*. They are, however, a commentary only in the medieval sense of "proof of an enunciated theorem," since they consist of alternative proofs, corollaries, and additional theorems. These additions are not necessarily original contributions of Campanus.

Clagett has pointed out that two demonstrations added to book I, prop. I, are taken from the commentary of al-Nairīzī (Anaritius, translated from the Arabic by Gerard of Cremona),[4] and has printed *in extenso* a theorem on the trisection of an angle, added to book IV in some manuscripts, that seems to be related to a solution of the problem in the *De triangulis* of Jordanus de Nemore.[5] Murdoch has noted Campanus' dependence on the same author's *Arithmetica*. particularly in book VII.[6] The whole question of Campanus' originality in the *Elements* has still to be answered. But at the very least he produced from existing materials a textbook of elementary geometry and arithmetic that was written in a readily comprehensible form and language (unlike many versions of Euclid then current). Its popularity for the next 300 years is attested by the large number of manuscripts and printed copies still extant.

No other work of pure mathematics can be definitely attributed to Campanus. Most of his other writings are concerned with astronomy. Of these the most influential was the *Theorica planetarum*. It is a description of the structure and dimensions of the universe according to the Ptolemaic theory, together with instructions for the construction of an instrument for finding the positions of the heavenly bodies at any given moment (such an instrument was later known as an equatorium). Campanus' main source was the *Almagest* of Ptolemy, which he must have studied closely (probably in Gerard of Cremona's translation from the Arabic). He reproduces accurately the geometrical models evolved by Ptolemy for the explanation of the apparent motions of the heavenly bodies but refers the reader to Ptolemy's own writings for their justification (i.e., the groundwork of theory and observation).

In the *Almagest* Ptolemy had given no absolute dimensions, except for the distances of sun and moon: for the other five planets he had given only relative parameters, i.e., the size of epicycle and eccentricity in terms of a standard deferent circle with a radius of sixty units. Campanus, however, gives in addition the absolute dimensions of the whole system (in both earth radii and "miles," where one "mile" = 4,000 cubits). The mathematical basis for this lies in the assumptions that the order of the planetary spheres is known and that there is no space wasted in the universe. Then the farthest distance from the central earth reached by a planet is equal to the nearest distance to the earth reached by the planet next in order above it. Given an absolute distance of the lowest body, the moon (which Campanus takes from the *Almagest*), one can then compute all the other absolute distances. The author of this ingenious idea is also Ptolemy, in his *Planetary Hypotheses*. Campanus derived it from the work of the ninth-century Arabic author al-Farghānī (Alfraganus), which he knew in the Latin translation of John of Seville. From the latter he also took other data, such as his figure for the size of the earth and the relative sizes of the bodies of the planets. But the computations are all his own and are carried out with meticulous (indeed absurd) accuracy. Campanus obviously delighted in long arithmetical calculations, and went so far as to determine the area of the sphere of the fixed stars in square "miles."

Among the most interesting features of the work are the parts describing the construction of an equatorium. This is the first such description known in Latin Europe. It seems improbable, however, that Campanus conceived the idea independently. Descriptions of equatoria were written nearly 200 years earlier in Islamic Spain by Ibn al-Samh and al-Zarqāl.[7] It seems likely that Campanus got the idea, if not the particular form, of his equatorium from some (as yet unknown) Latin translation of an Arabic work. The instrument he describes is the simplest possible, being merely a scale model of the Ptolemaic system for each planet (motion in latitude is neglected, and hence a two-dimensional model suffices). Thus in Figure 1, which depicts the model for an outer planet, the outer graduated circle represents the ecliptic, the next smaller the equant, and the smallest the planet's epicycle. The double and dotted lines represent parts of the instrument that can be freely rotated. The user arranges the instrument to imitate exactly the positions of the various parts of the planet's mechanism at the given moment according to Ptolemaic theory, and then stretches a thread attached to *D*, which represents the observer (earth), through the point representing the planet and reads off its position on the outer circle.

The disadvantage of such an instrument is that it would be extremely laborious to construct, bulky to transport, and clumsy to use. The earliest treatise on the equatorium after Campanus, that of John of Lignières (early fourteenth century), is an explicit attempt to improve on Campanus' instrument.[8] This and later works on the subject describe much more compact and sophisticated instruments, and preserved examples of equatoria from the Middle Ages are far superior to

Campanus' crude model.[9] But we cannot doubt that Campanus' description was a major (although not the sole) influence toward the subsequent development of the equatorium.

The *Theorica*, although it omits Ptolemy's proofs, is nevertheless a highly technical work; and its influence seems to have been confined mostly to professional astronomers. Campanus later produced a more popular work on the *Sphere* (*Tractatus de spera*). This is a description of the universe in language intelligible to the layman, requiring no great geometrical skill, and with none of the precise details of the *Theorica*. It is similar in plan to the earlier works of the same name by Johannes de Sacrobosco and Robert Grosseteste, and shows no originality.[10]

Although the equatorium of the *Theorica* is explicitly intended for those who find operating with conventional astronomical tables too wearisome or difficult,[11] Campanus also describes in detail in that work how to use such tables. It is obvious that his examples are drawn from the Toledan Tables, an incongruous hodgepodge of tables carelessly extracted from the works of al-Khwārizmī, al-Battānī, and al-Zarqāl, probably translated by Gerard of Cremona and widely used in western Europe from the twelfth to the fourteenth centuries. This use of the Toledan Tables is not surprising, since Campanus had already produced an adaptation of them to Julian years, the Christian era, and the meridian of Novara (the originals are constructed for Arabic years, era of the Hegira, and the meridian of Toledo). The result is, naturally, no more satisfactory than the original, but the conversion is carried out fairly accurately. As we should also conclude from reading the relevant passages of the *Theorica*, Campanus was not merely able to use astronomical tables but understood the underlying structure of most of them, an uncommon accomplishment in his time.

Campanus' third major work besides the Euclid and the *Theorica* is his *Computus maior*. The "computus" or "compotus" is a form of literature of which literally hundreds of examples were composed in the Middle Ages. Its origins lie in the difficulties of early Christians in computing the date of Easter. Works were written explaining the rather complicated rules governing such computation (on which different doctrines were held at different times by various branches of the Church). Since the computation involved both a lunar and a solar calendar, it was natural for dissertations on the calendar to be included in such works and for a sketch of the astronomical basis to be added. Bede's *De temporum ratione* (written in 725) gave the computus a form that was to be widely imitated and is essentially that adopted by Campanus.

After giving a definition of "time," Campanus discusses the various subdivisions of time: day, hour, week, month, and year. This naturally involves a good deal of astronomical discussion, and it is this portion that distinguishes Campanus' treatise from other such works, since he is able to introduce the most "modern" astronomical doctrine. The lengthy chapter 10 ("On the Solar Year") is especially notable. It contains an extended (and slightly erroneous) description of the theory of trepidation (oscillation of the equinoxes with respect to the fixed stars) of Thābit ibn Qurra, and criticisms of Ptolemy and Robert Grosseteste. From chapter 13 on, the treatise is more strictly calendrical, leading up to the computation of Easter by various methods, including the use of tables. The work concludes with a calendar giving, besides the main feast days, the tables necessary for the calculations described in the text. This part, although providing little scope for originality, is written in Campanus' usual clear and orderly way, and the work as a whole is one of the most successful examples of its genre. Since Campanus himself refers to it as "my greater computus," [12] it is probable that he is the author of the shortened version that is found in some manuscripts.

The interest in astronomical instruments that is apparent in the *Theorica* led Campanus to compose two other short works, on the quadrant and on the astrolabe. The first is an instrument for measuring angles at a distance, and its principal use was to measure the elevation of the sun, although it could be applied in many other ways, e.g., to find the angular elevation of the top of a tower in order to compute its height. The second is a schematic representation of the celestial sphere on a plane by means of stereographic projection, and was used for the solution of problems involving the rising, setting, and transits of stars or parts of the celestial sphere that would otherwise have required spherical trigonometry. Campanus' *De quadrante* does little more than explain how to solve certain types of astronomical and mensurational problems by means of the quadrant, and is very similar to other medieval works on the subject, such as that attributed to Robert the Englishman (dated 1276). The slight work on the astrolabe, however, is unusual in that it is neither a description of the construction of the astrolabe nor of its use, but rather a series of theoretical geometrical problems connected with the astrolabe as an example of stereographic projection. I am not convinced that its attribution to Campanus is correct.

In later times Campanus had a considerable reputation as an astrologer.[13] Although the details of his prowess may be legendary, there is no doubt that like every highly educated man of his time he was well versed in astrological doctrine (this is obvious from, e.g., the *Computus* or the *Quadrant*). It seems that Campanus also wrote specifically astrological works, for a method of his for dividing the heavens into the twelve "houses" is mentioned by Regiomontanus and others, but no such work survives that can definitely be assigned to him. A long anonymous work on astrology that is found in three manuscripts is attributed to Campanus in the margin of one, but its authorship still awaits investigation.

A number of other mathematical and astronomical treatises and commentaries are occasionally attributed to Campanus in manuscripts or early printed editions. Of these the only one that is certainly his is a letter addressed to the Dominican friar Raner of Todi in response to a query of the latter on a point in Campanus' *computus*. Others are certainly not his, e. g., a work on the instrument known as the solid sphere, and the so-called "Quadrature of the Circle."[14] A verdict on the others must await detailed examination of their contents, vocabulary, and style.

Whatever the result of such an examination, it is unlikely to have much effect on our judgment on Campanus as a man of science. He was a highly competent mathematician for his time and was thoroughly acquainted with the most up-to-date works on the subject, including the available translations from the Arabic. Thus he had read and understood Ptolemy's *Almagest*, and was able in his *Theorica* not only to summarize its conclusions but even on occasion to apply one of its techniques in another context.[15] Similarly, he was able to produce from the often obscure earlier translations of and commentaries on Euclid a version embodying their mathematical content in a more acceptable form. He had a gift for clear and plain exposition. But although he had a good understanding of his material and made few errors, he can hardly be called an original or creative scientist. His philosophical position was an unreflective Aristotelianism; his mathematics and cosmology were equally conventional for his time. His talent was for presenting the work of others in a generally intelligible form.

As such, Campanus was a writer of considerable influence. His Euclid was almost the canonical version until the sixteenth century, when it was gradually superseded by translations made directly from the Greek.[16] The continuing popularity of his *Computus* and *Sphere* is attested by their being printed several times in the sixteenth century. The *Theorica* was never printed, probably because, unlike the others, it was not a popular work but a technical one that would appeal only to those with a professional interest. It was nonetheless influential: this is shown both by the large number of surviving manuscripts and by the references to it in astronomical works of the fourteenth and fifteenth centuries. By the sixteenth century, however, it seems to have been little read (one may suspect that its role as a summary of the *Almagest* had been taken over by the Peurbach-Regiomontanus epitome of Ptolemy's work). Perhaps its greatest single contribution was the popularization of the idea of the planetary equatorium (the introduction of this is also Campanus' strongest claim to originality, but, as stated above, I believe that he owes the idea to some hitherto undiscovered Arabo-Latin source). The history of that instrument after Campanus is a good illustration of the technical ingenuity of the astronomy of the later Middle Ages and early Renaissance.

NOTES

1. E.g., *Theorica planetarum*, §1.

2. The earliest known manuscript of the work is dated II May, 1259 (Murdoch, *Revue de synthèse*. 3rd ser.,**89** [1968], 73, n. 18).

3. Bacon, *Opus tertium*, XI. 35.

4.*Isis*, **44** (1953), 29, n. 31 (4).

5. Clagett, *Archimedes*, I, 678–681.

6.*Revue de synthèse*. **89** (1968). 80, n. 41; 82, n. 53: 89, n. 84: 92, n. 100.

7. See Price, *Equatorie*, pp. 120–123.

8.*Ibid*, p. 188.

9. See, e.g., the photograph of the equatorium at Merton College, Oxford, *ibid*., frontispiece.

10. For a detailed outline of the contents, see Thorndike, *Sphere*, pp. 26–28.

11.*Theorica*, §§59–61.

12. "In compoto nostro maiori." MS Bibl, Naz., Conv. Soppr. J X 40, f. 47v.

13. See especially the work of Symon de Phares (late fifteenth century) on famous astrologers, Wickersheimer, ed., pp. 167–168

14. A text of the "Quadratura circuli" has been published by Clagett, in *Archimedes*, I, 581–609, with an introduction in which the editor gives his reasons for doubting the authorship of Campanus.

15. See my note on §1280 of the *Theorica*.

16. The first version from the Greek to be printed was that of Zambertus (Venice, 1505); but Campanus' version continued to be printed for another fifty years.

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On Campanus' life, the unsatisfactory biographies in standard reference works are superseded by Benjamin's account in the Benjamin and Toomer ed. of the *Theoricaplanetarum*, intro., ch. 1. This contains references to all known sources. My summary is drawn from it. Roger Bacon mentions Campanus in *Fr. Rogeri Bacon opera quaedam hactenus inedita*, J. S. Brewer, ed., I (*Opus tertium*), in the "Rolls Series" (London, 1859), cap. 11, 35. The muddled account of Campanus by Symon de Phares is published in *Recueil des plus célèbres astrologues et quelques hommes faict par Symon de Phares du temps de Charles VIII[e]*, E. Wickersheimer, ed. (Paris, 1929), pp. 167–168.

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Campanus' *Sphere* was printed by L. A. de Giunta at Venice in 1518, and three more times up to 1557 (see *Theorica*. intro., ch. **2** , app. I). Similar works by Sacrobosco and others can be found in the modern ed. of Lynn Thorndike. *The Sphere of Sacrobosco and Its Commentators* (Chicago, 1949). Grosseteste's *Sphere* is printed in *Die philosophischen Werke des Robert Grosseteste's Bischofs von Lincoln*, Ludwig Baur, ed., *Beiträge zur Geschichte der Philosophie des Mittelalters*, IX (Münster, 1912), 10– 32. There is no printed ed. of Campanus' astronomical tables, nor of their parent Toledan Tables. An extensive analysis of the latter is given by G. J. Toomer in *Osiris*. **15** (1968). 5–174. The *Computus maior* was printed twice at Venice in 1518, by L. A. de Giunta and by Octavianus Scotus. On the technical content of the medieval computus, the best treatment is W. E. van Wijk, *Le nombre d'or* (The Hague, 1936). Bede's *De temporum ratione*. edited by Charles W. Jones as *Bedae opera de temporibus* (Cambridge, Mass., 1943), contains on pp. 3 ff. a useful account of the historical development of the computus. Campanus' works on the quadrant and astrolabe have never been printed. For the former, compare "Le traité du quadrant de Maítre Robert Anglès… texte latin et ancienne traduction grecque publié par M. Paul Tannéry," in *Notices et ex traits desmanu scrits de la Bibliothèque nationale*, **35** (1897), 561–640, reprinted in Tannéry's *Mémoires scientifiques* (Paris, 1922), pp. 118–197. The work on astrology is attributed to Campanus only in MS Vat. Pal. 1363, where it is found on ff. 66r–88r. The letter to Raner of Todi is in only one MS: Florence, Biblioteca Nazionale Centrale J X 40, ff. 46v–56r. For other works that may or may not be by Campanus, see Benjamin in the Benjamin and Toomer ed. of the *Theorica*, intro., ch. 2.

No detailed study of the influence of Campanus' work exists. Some information will be found in the Benjamin and Toomer ed. of the *Theorica*, intro., ch. 8. The Peurbach-Regiomontanus epitome of the *Almagest* was print edat Venice in 1496 (colophon "Explicit Magne Compositionis Astronomicon Epitoma Johannis de Regio monte"), and several times subsequently.

G. J. Toomer