Theon of Alexandria | Encyclopedia.com

(*fl*. Alexandria, second half of fourth century),

mathematics, astronomy.

Theon's scholarly activity is firmly dated by his reports of two eclipses that he observed at Alexandria in 364: the solar eclipse of 16 June and the lunar eclipse of 26 November.[1] Other chronological references in his works all point to the 360's and 370's. The solar eclipse of 364 is used as an example of calculation in both the greater and the lesser commentaries on Ptolemy's *Handy Tables*, the lesser commentary providing examples of calculations that correspond to the dates 15 June 360 and 17 November 377.[2] Also, a list of Roman consuls preserved in one manuscript of Theon's edition of the *Handy Tables* stops with the consuls of the year 372.[3] There is only one ancient biographical notice on Theon, and that very brief.[4] It states that Theon lived under the emperor Theodosius I (reigned 379–395), a date consistent with the above evidence. Theon's daughter, Hypatia, who was famous in her own right as a mathematician (she is credited, among other things, with a revision of book 3 of her father's commentary on the *Almagest*) and as a Neoplatonic philosopher, was torn to pieces by a mob of fanatic Christians at Alexandria in 415. Since there is no mention of Theon in the circumstantial account we have of this event, it is likely that he was already dead. Like his daughter, Theon was certainly a pagan. Whether he, too, favored Neoplatonism cannot be determined.

The ancient biographical notice also informs us that Theon was a member of the "Museum." This was an institution for the support of advanced learning, established at Alexandria about 300 b.c. by Ptolemy I, which had nourished many famous scholars but by Theon's time had declined sadly–if, indeed, it still existed (Theon is the last attested member). Whether he was connected with the Museum or not, Theon was certainly actively engaged in higher education. In the preface to his commentary on the *Almagest*, he says that he has composed the work at the urging of those who attended his lectures on the subject.[5] Indeed, all his extant works are the outcome of his "professorial" activity, being either commentaries on or editions of recognized classics of mathematics and astronomy, intended for the use of students. I will deal with the commentaries in the order in which Theon wrote them, which is established by internal references from one to the other.

Theon's most extensive work is his commentary on Ptolemy's *Almagest*. This was originally in thirteen books, corresponding to the number of books of the *Almagest*: but book 11 is lost, only a fragment of book 5 survives, and there are probably lacunae in other books. The passage in the preface mentioned above suggests that the commentary is a redaction of Theon's lectures, and that is how it reads. It is for the most part a trivial exposition of Ptolemy's text, explaining obvious points at excessive length. Despite Theon's promise to improve over previous commentators on the *Almagest*, "who claim that they will only omit the more obvious points, but in fact prove to have omitted the most difficult,"[6] the commentary is open to precisely this criticism. It is never critical, merely exegetic. To the modern reader it is almost useless for understanding Ptolemy; but it is of value for the occasional information it provides on now-lost mathematical and astronomical works, notably Zenodorus' treatise "On Isoperimetric Figures" in book 1. This passage probably is taken from the earlier commented on the *Almagest* by Pappus (*fl*. 320), of which only books 5 and 6 survive. Comparison of the two commentaries for book 6 (the only area where they overlap) shows that while Theon borrows much from Pappus, his work is not a mere rewriting of his predecessor's but contains extensive contributions of his own.

Theon also published two commentaries on the *Handy Tables*. The latter, issued by Ptolemy after he had completed the *Almagest*, were meant to provide a convenient means of computing the positions of the heavenly bodies and other astronomical phenomena. In the preface to the larger commentary Theon claims that whereas he had predecessors who commentary on the *Almagest*, he is the first to write a commentary on the *Handy Tables*. The earlier of the two commentaries is an extensive one, in five books, addressed to Eulalius and Origenes, whom Theon calls his "companions" (in the Museum ?). In it Theon explains not only how to use the tables but also the reasons for the operations and the basis of the tables' construction, and provides geometrical demonstrations. Thus it frequently covers the same ground as the commentary on the *Almagest*. The second, much smaller, commentary is addressed, like the commentary on the *Almagest*, to Epiphanius, presumably a pupil of Theon's. In the preface Theon refers to the larger commentary as "the more reasoned (λογικωτέρα) introduction to computation with the *Handy Tables*," and explains that he has written this new work for that majority of his pupils in the subject who are unable to follow geometrical proofs.[7] The smaller commentary, then, merely sets out the rules for computation with the tables, adding occasional worked examples but no reasons. Theon's remark indicating the low mathematical caliber of his students is corroborated by what we should surmise from the nature of his works in general.

All other extant works by Theon are editions of previous authors. "Edition" here does not mean an attempt to establish the authentic text but, rather, a reworking of the original in a form considered more suitable for students. The most notable of Theon's editions is that of Euclid's *Elements*, which was so influential that it consigned the original text to near oblivion.

Theon himself attests his work in his commentary on the *Almagest*, book 1, chapter 10, where he says: "That sectors of equal circles are in the ratio of the angles [at the centers] we have proved in our edition of the *Elements* at the end of the sixth book."[8] Indeed, nearly all extant manuscripts of the *Elements* have a proposition to that effect attached to book 6, proposition 33; and many of the manuscripts have titles indicating that they are "from the edition of Theon" or even "from the lectures (συνουσίαι) of Theon."

It was not until the early nineteenth century, however, when Peyrard discovered that the manuscript Vaticanus Graecus 190, which lacks that proposition and is significantly different from the vulgate in other respects, must be an example the pre-Theonic text, that it became possible to determine the nature of Theon's alterations of Euclid. They are many but mostly trivial, leaving the essential content of the *Elements* almost unchanged. In many places the wording has been altered or expanded to achieve consistency or perspicuity of expression. Of the occasional changes of mathematical substance, a very few are corrections of real mistakes in Euclid's text. More are due to Theon's misunderstanding the original. In some cases he apparently omits what he considers wrong. He makes frequent additions to fill what he considers gaps in Euclid's reasoning, even interpolating whole propositions, as in the above example. On the whole, his edition can hardly be said to improve on the original, although it may well have fulfilled its purpose of being easier for his students to use.

Other works by Euclid of which Theon produced editions are the *Data* (a treatise on what elements of a geometrical figure must be given to determine it) and the *Optics*, both of which exist in Theonic and pre-Theonic versions. The first of these obviously was intended for more advanced students but shows the same general characteristics as the edition of the *Elements*, except that in it Theon is more inclined to abbreviate Euclid's exposition. The Theonic version of the *Optics*, on the other hand, is so different from the original, not only in its language (which is characteristic of the later *koine*) but also in the form of the proofs, that Heiberg conjectured that the text we have consists of Theon's lectures on the subject as taken down by one of his students. This view is supported by the introduction to the Theonic version, which is an exposition of the principles of optics, mostly in indirect speech, occasionally introduced by "he said" or the like. "He" is not identified in the text; but this part clearly has been taken down from a lecture, and it is a plausible guess that "he" is Theon. There is no direct evidence, however, that Theon was responsible for this version, although he is the most likely candidate.

The same may be said of a treatise on catoptrics (theory of visual reflection) that in the manuscripts is attributed to Euclid but must be judged spurious on stylistic grounds alone. Analysis of the contents shows that it is a late compilation containing a mixture of Euclidean and post-Euclidean optical theory. The style and nature of the treatise would be appropriate for Theon, but that does not prove his authorship. Both the *Optics* and the *Catoptrics* are elementary, and are on a far lower scientific level than Ptolemy's *Optics*, which was, however, neglected in later antiquity and has survived only through the Arabic tradition. If, then, it is correct to associate Theon with these "Euclidean" optical works, we have an example in yet another branch of mathematics of his pedagogical activity, directed toward beginning students.

Theon also produced the version in which Ptolemy's *Handy Tables* have come down to us, according to the superscriptions in the manuscripts. The only evidence we have for the original version is Ptolemy's own introduction giving instructions for their use. From this it appears that the changes introduced by Theon were slight, and confined mostly to the arrangement of the tables and updating the chronological list. No one, however, has yet investigated the problem thoroughly.

Among lost works attributed to Theon by the ancient biographical source is a "Treatise on the Small Astrolabe."[9] Arabic bibliographical works also attribute to him a work entitled "On Operation With the Astrolabe."[10] The term "small astrolabe" evidently is used to distinguish this instrument from the "armillary sphere" (which is always the meaning of ἀστρολάβον in the medieval and modern sense, that is, an instrument used to solve problems in spherical astronomy by means of projection of the celestial sphere onto a plane. This interpretation is confirmed by the Arabic sources, which use asturlāb in the sense.

No work on the astrolabe predating the sixth century survives, but we do have the treatise of John Philoponus (*fl.* 520) in Greek, and that of Severus Sebokht (written before 660) in Syriac. The latter draws on a previous treatise, the author of which he calls "the philosopher." The historian al-Ya'qūbī. Since Sebokht distinguishes "the philosopher" from Ptolemy (whose tables he quotes by name), and since al-Ya'qūbĪ attributes to Ptolemy works (such as "On the Armillary Sphere") that other Arabic bibliographical sources attribute to Theon,[11] Neugebauer concludes, plausibly, that Theon is the author of the astrolabe treatise described by al-Y'qūbī and used by Sebokht. It is most unlikely, however, that Theon invented the astrolabe. The essential mathematical theory (of mapping circles of the celestial sphere onto a plane by stereographic projection) is treated by Ptolemy in his *Planisphaerium*, and the instrument may well predate Ptolemy.

Other lost works attributed to Theon in the Greek biographical source are "On Omens [for weather?] and Examination of Birds and the Cry of Ravens," "On the Rising of the Dog Star," and "On the Rising of the Nile." Nothing is known of these; and some or all should perhaps be attributed to the grammarian Theon of the first century of the Christian era, as should certainly the commentary by "Theon" on Aratus' astronomical poem *Phaenomena*. A slight work on the composition of an astronomical ephemeris found in one manuscript of Theon's commentary on the *Handy Tables* and ascribed to Theon by Delambre[13] certainly belongs to a later period.

Theon was a competent mathematician for his time, but completely unoriginal. He typifies the scholastic of later antiquity who was content to expound recognized classics in his field without ever attempting to go beyond them. The parts of his works that are of most interest for the modern reader, apart from the occasional pieces of historical information, are the worked examples of computations in his commentaries. It is of no small interest to see how the Greeks carried out calculations using their form

of the sexagesimal placevalue system (Theon provided worked examples of extraction of a square root, as well as multiplication and division). The detailed calculation of the solar eclipse of 364 (which Theon demonstrated both according to the Almagest tables and according to the *Handy Tables*) is also most instructive.

For a man of such mediocrity Theon was uncommonly influential. As we have seen, it was his version of Euclid's *Elements* that gained most currency. It was in his edition that the *Handy Tables* passed to Islamic astronomers (among whom it went under his name), and thence (via al-Battānī's work and the Toledan Tables) to Latin Europe in the twelfth century. His commentaries on the *Almagest* and the *Handy Tables* continued to be studied in the Greek-speaking Eastern Empire, and are the basis of at least one Byzantine commentary, that of Stephen of Alexandria on the *Handy Tables*. The work on the astrolabe was probably the main, if not the sole, source of transmission of the theory of that instrument to Islamic astronomy, whence it came to medieval Europe.

One short passage in Theon's shorter commentary on the *Handy Tables* had a remarkable history. He states that "certain ancient astrologers" believed that the tropical and solstitial points had a vibrating back-and-forth motion over eight degrees of the ecliptic. Although not accepting this theory, he explains how to compute the resultant correction to be applied to the positions of the heavenly bodies.[14] According to Theon, the tropical points of "the astrologers" are eight degrees in advance of (to the east of) those of Ptolemy in 158 B.C., and move westward with respect to the latter at a rate of one degree in eighty years. (Thus they would coincide in 483, at which point they would begin to move eastward again.) There is perhaps one other trace of this theory in antiquity, but it was not until Theon's description reached the Islamic astronomers that it bore fruit.

When observational astronomy began to be seriously practiced, under the caliph al-Ma'ūn (early ninth century), it was soon realized that the rate of precession (motion of the tropical points with respect to the fixed stars) as determined by Ptolemy (one degree in one hundred years) was not valid, and that 1.5 degrees in one hundred years was closer to the truth. Rather than impute error to the admired Ptolemy, many preferred to believe that the rate of precession was not a constant, but varied cyclically; the idea undoubtedly came from this passage of Theon's as is shown by the earliest reference we have, in which the astronomer Habash al-Hāsib (*ca*. 850) is said to have introduced into one set of his astronomical tables "the back-and-forth motion of the ecliptic according to the opinion of Theon."[15] Soon afterward Thābit ibn Qurra (*ca*. 870) wrote a treatise expounding the theory and proposing a physical model to account for it. This was translated into Latin in the twelfth century under the title "De motu octave spere," and proved enormously influential in western Europe. The theory, usually known as "trepidation," was adopted by the makers of the Alfonsine Tables, and appears in various forms in the works of Peurbach, Johann Werner, and Copernicus. It was still seriously discussed in the late sixteenth century.

NOTES

1. Both in bk. 6 of his commentary on the *Almagest*, Basel ed., 332 and 319, respectively.

2.*Tables manuells astronomiques*, N. Halma, ed., I, 77–87; examples are on 31 and 74. In the second passage the "90th" year of Diocletian was corrected by H. USener in his *Kleine Schriften,* III, 22. n. 20. to "94th" on the basis of MS readings. The correction is confirmed by my computations. This passage, however, is probably an interpolation.

3. "Fasti Theonis Alexandrini," H. Usener, ed., 367–368, 381.

4.*Suda Lexicon*, Ada Adler, ed., II, 702.

5.*Commentaires. . . de ThÉon . . .*, A. Rome, ed., II, 317.

6.*Ibid*., 318.

7.*Tables manuelles astronomiques*, I, 27.

8.*Commentaires. . .de Théon. . .*, A. Rome, ed., II, 492.

9.*Suda Lexicon*, loc. cit.

10. For instance, *Fihrist*, G. Flügel, ed., I, 268.

11. Translated by M. Klamroth in *Zeitschrift der Deutschen morgenländischen Gesellschaft*, **42** (1888), 23–25.

12. *Ibid*., 20–23; compare *Fihrist, loc cit*.

13.*Histoire de l'astronomie ancienne*, II, 635.

14. Tables manuelles astronomiques, I. 53.

15. Ibn al-Qiftī, J. Lippert, ed., 170.

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