through the comet added greatly to our knowledge of its nature and structure. The last chapter gives an historical account of theories of evolution of comets — how they form, how they change, both in orbital properties and physical structure as they age, and how they die.

In addition to the main line of the book, focused on the comets themselves, there are many brief, capsule biographies of some of the more colourful astronomers who studied them. Examples are "Charles Messier, the ferret of comets", "Jean Louis Pons, the champion comet hunter", "Edward Emerson Barnard and the automatic comet seeker hoax", and "Comet hunter, Civil War hero, and embezzler" (Horace Tuttle). Similar boxes contain brief stories of comets as objects of myth, superstition or falsification, such as "The bogus comets of 1784, 1793 and 1798", "The Millerites, the Great Comet of 1843, and the end of the world", and "Horrific missiles or life-giving providers?".

The book is profusely illustrated with an excellent collection of charts, cartoons, drawings and photographs. A 60-page appendix gives a compilation of naked-eye comets reported from the earliest known (in the eleventh century B.C. in China) to A.D. 1700. It is sobering to look at this record and realize that Comet Halley, which we saw just six years ago, was recorded by Chinese watchers of the sky in 240 B.C.

Yeomans, a comet expert who has made important contributions to the study of Comet Halley's orbit and non-gravitational forces on comets, has amassed a tremendous amount of material for this book. The 50-page bibliography alone lists hundreds of original papers, books and other writings over the centuries, as well as very many secondary works. All in all, this book is a monumental achievement, and every astronomer and historian of astronomy with the slightest interest in comets should have a copy of it.

Lick Observatory, University of California DONALD E. OSTERBROCK

BYZANTINE ASTRONOMY OF THE FOURTEENTH CENTURY

Théodore Méliténiote: Tribiblos Astronomique, Livre I (Corpus des Astronomes Byzantins, 4). Régine Leurquin (J. C. Gieben, Amsterdam, 1990). Pp. 436. 120 guilders (paperback).

Byzantine astronomy was dominated by two traditions: the legacy of Ptolemy's *Almagest* and *Handy tables*, directly passed down together with copious commentaries from late Antiquity, and a borrowed tradition of Islamic astronomy. The Ptolemaic tradition was continuous, in the sense that his works were never lost and there had probably always been some people who could follow Ptolemy's (or Theon's or Stephanus's) instructions for the use of the tables. But it is not until the eleventh century that we find the first significant new astronomical writings in Greek since the seventh century, and these are concerned with material derived from Arabic *zījes*. During the first decades of the fourteenth century there was a revival of interest in Ptolemy, beginning with the ponderous (and still unpublished) *Stoicheiōsis astronomikē* ("Elements of astronomy") of Theodore Metochites, and continued by Nicephorus Gregoras, his pupil, and by Nicolaus Cabasilas. Simultaneously, new sets of so-called Persian Tables (including the *Zīj al-Sanjarī* of al-Khāzinī and the *Zīj al-'Alā'ī* of al-Fahhād) became available in translations by Gregory Chioniades.

Among the major astronomical treatises of the fourteenth century, the *Tribiblos astronomikē* ("Astronomical treatise in three books") of Theodore Meliteniotes is unique in its attempt to deal equally with the Ptolemaic and the 'Persian' tables. An ecclesiastic holding high office in the Byzantine church and in the patriarchal school, Meliteniotes is otherwise distinguished as the author of two theological works (each of them also in three books) and an allegorical poem. The *Tribiblos*, written about 1352, is Meliteniotes's only known venture into astronomy, although in it he expresses the intention — it is doubtful how seriously we should take it — to prepare a critical revision of the Ptolemaic tables corrected according to new observations. We actually possess the autograph manuscript of the *Tribiblos* Vat. gr. 792, in addition to nine later copies dating from the fourteenth to the eighteenth century — testimony to only a modest subsequent readership; but the most interesting part of the *Tribiblos*, then as now, was the third book in which Meliteniotes explained the Persian Tables, and this part circulated much more widely in an adapted form, often ascribed mistakenly to other authors. The *Tribiblos* was an eminently worthwhile candidate for early inclusion in the Corpus des Astronomes Byzantins progressing under the editorship of A. Tihon, and the *editio princeps* now being prepared by R. Leurquin will certainly satisfy the wishes of philologists and historians of science. As well as a critical edition of the Greek text and an accurate literal French translation of Book I, the present first volume gives an introduction concerning Meliteniotes and surveying the manuscripts, and a copious commentary explicating the text and, perhaps most important of all, sorting out Meliteniotes's complicated debts to earlier writers.

For, contrary to the extravagant praises of the treatise that one finds in some surveys of Byzantine literature (Krumbacher went so far as to call it the "umfangreichste und gelehrteste astronomische Werk des Byzantinischen Zeit"), the *Tribiblos* is neither a very deep nor a very original work. Meliteniotes limited his scope to the use of the astronomical tables, excluding any attempt to discuss the underlying theory. The practical purpose of the work is already evident in Book I, which Meliteniotes devotes to a manual of sexagesimal and fractional arithmetic (largely derived without acknowledgement from the thirteenth-century *Quadrivium* of Pachymeres) and a series of chapters on the construction and use of the astrolabe (in which the astrolabe handbooks of John Philoponus and Nicephorus Gregoras are similarly plundered). In many respects the most interesting part of Book I is the introductory historiographical chapter, which weaves out of Josephus, Strabo, and other authorities an account of the origins of the science involving Old Testament personages (Seth, Abraham) as well as the Chaldeans, Egyptians, and Greeks. It is here that Meliteniotes tells us that Ptolemy was born in the town of Ptolemaïs Hermeiou in the Egyptian Thebaid, an assertion — not in itself implausible — that has yet to be traced to any earlier source.

A final evaluation of the remaining two books, which take up in turn Ptolemy's tables (both *Almagest* and *Handy tables*) and the Persian Tables, will have to await the completion of the edition; it is in Book III that we have the most reason to hope for novelties. But the value of editing and studying a text such as the *Tribiblos* should not be measured purely in these terms. Byzantine astronomy, it must be stressed, is a phenomenon of survival and transmission, and the period in question is a rare one in which technical astronomy had a truly integral place in humanistic and cultural life. Until we have at least the principal writings in reliable editions and translations, our judgements concerning them will continue to be little better than hearsay.

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This is the first of a projected three-volume edition and translation, with commentary, of the comprehensive astronomical treatise of Theodoros Meliteniotes (d. 1393), of which hitherto only fragments have been published. This part of the work, Book I, comprises two sections: Chapters 2–10 are on 'logistic', the arithmetical calculations necessary in ancient astronomy, including operations with sexagesimal fractions, extraction of square root, and linear interpolation; Chapters 11–25 describe the construction of an astrolabe and some of its uses, especially for determining the time of day and night. Of the parts yet to be published, Book II deals with astronomical calculations according to the system of Ptolemy's *Almagest* and *Handy tables*, and Book III with the same according to 'Persian astronomy' (for the latter tradition in Byzantium see e.g. David Pingree, *The astronomical works of Gregory Chioniades*, i: *The Zīj al-'Alā'ī* (Amsterdam, 1985), in the same series).

To judge from this part of it, the *Tribiblos* is a didactic work, aimed at practical rather than theoretical instruction. The author, no practising astronomer, but rather a high ecclesiastical official, is competent, but not infallible in his subject. His exposition, although pedantic, is in general clear and illustrated by numerous worked examples. There is little, if any originality in this part, and the editor documents well its reliance on earlier sources (most never named by the author), notably Theodoros Metochites, Georgios Pachymeres, John Philoponus and Nicephoros Gregoras. It is noteworthy, and indicative of the state of astronomy in late Byzantine times, that the author, in spite of his acquaintance with Arabic astronomy through the 'Persian' tradition, nowhere in this part of the work hints that there is anything amiss with the Ptolemaic astronomy of the *Handy tables*, although by his time the errors in the solar and stellar positions derived from those tables amounted to several degrees. Thus in Chap. 11 (p. 192) he is content to use the rising-time tables of the *Almagest*, although Arabic astronomers had demonstrated 500 years earlier that the obliquity of the ecliptic was by now considerably less than that assumed by Ptolemy. Meliteniotes also maintains (p. 204) the Ptolemaic precession-value of 1° in 100 years, although this would lead in his time to a considerable error in the declinations of the fixed stars (contrary to the editor's assertion on p. 390), which is relevant to the uses he makes of the astrolabe.

The editor's introduction provides a short but very well documented summary of the life and other works of Meliteniotes, followed by a detailed account of the surviving manuscripts of this treatise and their interrelationships. Since the editor, following Giovanni Mercati, has demonstrated that the manuscript Vat. gr. 792 is the autograph of Meliteniotes, and thus constitutes the sole basis for the printed text, the interest of this section is purely codicological. The editor has a good grasp of the technical part of the treatise, and provides a facing translation which is on the whole accurate and an adequate exegetical commentary. In the "philosophical" introduction the translation is less sure, and in places quite wrong: to give just one example, pp. 88–89, ἐπὶ κακῷ τῆς κεφαλῆς ("to the perdition of their lives", i.e. resulting in their damnation) is mistranslated "à cause du mal qui est dans leur tête". I cannot comment on the accuracy of the text presented, but it reads well. Concerning the translation I note that there are accidental omissions of short passages on pp. 91, 101, 109 and 203, but only a few actual errors, e.g. p. 102, line 141 ταῖς γραμμικαῖς ἐφόδοις ("geometric methods", not "des méthodes graphiques"); p. 104 line 19 τὸ δύσχρηστον τῶν μοριασμῶν ("the inconvenience of division into [unit] *fractions*", not "par *degré*"); and p. 160 line 115, where κύκλος should be translated "anneau" ("ring"), not "disque".

The commentary is in general helpful and accurate, but needs correcting or supplementing in the following points: p. 311, δύναμις (used for a power of two), never means "area"; p. 315, on the ancient method of extracting the square root, a reference should be added to Theon of Alexandria's example, well treated by Heath, *A history of Greek mathematics*, i, 60–63; on p. 353, Ptolemy's *Planispherium* does not exist only in Latin translation from the Arabic: the Arabic text is extant and indeed has been edited: Christopher Anagnostakis, *The Arabic version of Ptolemy's Planisphaerium* (Ph.D. dissertation, Yale, 1984); p. 365 (second paragraph), the reference must be to Ptolemy's *Geography*, not to his *Handy tables*, since the list of "notable cities" therein contains no "rivers" or "seas".

The production of the book is far from satisfactory. One understands why a work of this kind, with a limited readership and of a highly technical nature, is reproduced from camera-ready copy. But there is no reason these days to use the primitive methodology of typewriter supplemented by manual entry to produce that copy. The result is a Greek text that is both ugly and hard to read (and in which the same symbol is used for both 0 and 70), and a French text in a sans-serif style which is also very hard on the eyes, particularly when one is attempting to compare it with a facing text. Furthermore, little thought has been devoted to the reader's convenience: for instance, the page numbers have been put where there should have been running heads, so that one cannot tell, when opening at an arbitrary page, even what chapter it is in (and some of the chapters are very long). This makes referring to the commentary from the text unnecessarily arduous. I offer these comments in the hope that improvements will be made in future volumes of this treatise and other works in the same series, which is an admirable enterprise deserving of all encouragement.

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JAKI ON COSMOLOGY

Olbers Studies: With Three Unpublished Manuscripts by Olbers. (Pachart History of Astronomy Series, viii.) Stanley L. Jaki (Pachart Publishing House, Tucson, 1991). Pp. 95. $28.

Cosmos in Transition: Studies in the History of Cosmology. (Pachart History of Astronomy Series, v.) Stanley L. Jaki (Pachart Publishing House, Tucson, 1991). Pp. 256. $24.

Wilhelm Olbers (1758–1840) of Bremen was an accomplished physician, a tireless worker in the public interest, and an enthusiastic astronomer who enjoyed fame as the discoverer of the asteroids Pallas and Vesta. In six essays entitled *Olbers studies*, five of which appear in English for the first time, Stanley Jaki pays tribute to this "universal man" whom he ranks with Leonardo da Vinci, Leibniz, Thomas Young, and Thomas Jefferson.

Nowadays, Olbers is known widely because of his discussion in 1823 of the dark night sky problem, known as Olbers's Paradox. Following a method introduced by Edmond Halley, Olbers constructed in an infinite universe imaginary concentric shells of stars out to the limit where visible stars cover the entire sky. Stars beyond this background limit were occulted by stars within the limit. Jaki states (p. 36), "Olbers should have concluded from this that since the number of shells was infinite, the intensity or rather flux density of light had to be infinite at any point in an infinite universe". I know of no astronomer in the history of Olbers's Paradox who came to such an absurd conclusion; Jaki's belief that starlight must be infinitely intense in an infinite universe follows from the mistake of assuming that stars have zero cross-section.

Olbers gave a second reason why the sky should be bright with starlight: in an infinite universe populated with stars, each line of sight ultimately intercepts the surface of a star, and no dark gaps should exist between the stars. Jaki and astronomers who refer to Olbers's Paradox overlook Olbers's very simple and compelling demonstration of the paradox.

Olbers attributed the darkness of the sky at night to the absorption of starlight in interstellar space. And so did the mathematically gifted Swiss astronomer Jean Philippe Loys de Chéseaux who wrote in 1744 on a similar theme. Chéseaux avoided Halley's errors and showed that light from a star-covered sky is 90,000 times more intense than sunlight, and the visible stars numbering 1×10^{46} stretch away to a distance 3×10^{15} light years (in modern units). Jaki omits to mention that Olbers's did not perform such calculations,