Apollonius de Perge, Coniques. *Tome 2.2: Livre IV. Commentaire historique et mathématique, édition et traduction du texte arabe* by Roshdi Rashed

Berlin/New York: Walter de Gruyter, 2009. Pp. xii + 319. ISBN 978–3–11–019938–3. Cloth € 99.95, $140.00

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This book is part of a bigger, and important, project (*Apollonius de Perge, Coniques. Texte grec et arabe établi, traduit et commenté*) involving a commented edition and French translation of Apollonius Arabicus, that is, the seven extant books of Apollonius' *Conica* (the last three of which are preserved only in Arabic), and a new edition and French translation of the Greek text. It is the work of a team of scholars under the leadership of Roshdi Rashed,[1] who, for the first time to my knowledge, studies systematically the 'elementary books', 1–4, in their Arabic guise and compares them to the Greek, Eutocian text, making them also available in a Western language. The book appears in the series Scientia Graeco-Arabica edited by Marwan Rashed, the son of the book's chief editor and a well-known scholar of ancient philosophy and specialist in Alexander of Aphrodisias.[2]

The multi-volume project comprises four volumes in seven:

Volume 1: 1.1: *Livre 1. Commentaire historique et mathématique, édition et traduction du texte arabe* and 1.2: *Livre 1. Édition et traduction du texte grec* respectively by Rashed and by his two partners, Descorps-Foulquier and Federspiel [2008]

[1] The others are Micheline Descorps-Foulquier and Michel Federspiel.

[2] The editor's wife, Françoise Rashed, is another family member participating in the project (*on reste en famille. . .*), being responsible for the diagrams, which, by the way, are not always easy to disentangle due to their size. There also seems to have been no attempt at their collation.

ISSN 1549–4497 (online) ISSN 1549–4470 (print) ISSN 1549–4489 (CD-ROM)
Aestimatio 7 (2010) 29–42

Volume 2.1: *Livres 2 et 3. Commentaire historique et mathématique, édition et traduction du texte arabe* by Rashed (forthcoming)

Volume 2.2: *Livre 4. Commentaire historique et mathématique, édition et traduction du texte arabe* by Rashed [2009a]

Volume 2.3: *Livres 2–4. Édition et traduction du texte grec* by Descorps-Foulquier and Federspiel (forthcoming)

Volume 3: *Livre 5. Commentaire historique et mathématique, édition et traduction du texte arabe* by Rashed [2008].

Volume 4: *Livres 6 et 7. Commentaire historique et mathématique, édition et traduction du texte arabe* by Rashed [2009b].

It is still a work in progress, to be finished during 2010; and it promises to fulfill a longstanding *desideratum*, that of a reliable edition and translation of the complete Arabic *Conics*, supplementing Toomer's still fundamental two-volume edition and English translation of books 5–7 in Banū Mūsā's version [1990].

Book 4 of the *Conics*, the object of this review, belongs, together with the first three books, to the 'elementary' part of the treatise. It deals with the greatest number of points at which conic sections, including the double section, can meet one another and the circumference of a circle. On this the Greek and Arabic texts agree, though, as shown by Rashed, there are otherwise extensive differences between the two. Neither the Greek nor the Arabic text is fully systematic in its exposition (Rashed 'corrects' this in his analysis), though the latter comes closer to that goal.

The text established by Rashed is based on the collation of four manuscripts out of the nine discussed in chapter 3 of volume 1 of the edition ('Histoire des textes').[3] These manuscripts were copied in the 11th and 13th centuries and include one, the earliest, copied by ibn al-Haytham in 1024. Rashed has established a *stemma* in volume 1 on the basis of 'the study of the manuscripts, their history, [and] the accidents of transcription—omissions, additions, language

[3] This contradicts the claim made in the same place: 'Il nous est en effet parvenu sept manuscrits de la traduction' [218]. It is also not clear what the 27 mss listed under 'sigla' in the volume under review exactly are [xi].

faults, mathematical errors, geometrical diagrams' [2008, 232]. This vacuous generality, however, applies generally to all collations worthy of the name. In its disarming vagueness and the lack of any specific procedural details it is, to say the least, utterly disappointing.

Apollonius speaks explicitly, and generally, of book 4 of the *Conics* in two places, the letter to Eudemus accompanying the dispatch of the first book and the letter to Attalus introducing book 4 itself. The two statements are basically in agreement:

> The fourth book shows in how many ways the sections of a cone intersect with each other and with the circumference of a circle, and contains other things in addition none of which has been written up by our predecessors, that is in how many points the section of a cone or the circumference of a circle and the opposite branches meet the opposite branches. [Taliaferro 1952, 603]

and

> This book treats of the greatest number of points at which sections of a cone can meet one another or meet a circumference of a circle, assuming that these do not completely coincide, and, moreover, the greatest number of points at which a section of a cone or circumference of a circle can meet the opposite sections. Besides these questions, there are more than a few others of a similar character. [Fried 2002, 1][4]

Now, here is the first and shortest of Rashed's many descriptions of the book, in which he improves on Apollonius:

> Dans le quatrième livre des *Coniques*, Apollonius traite du nombre des points communs à une droite variable et à une conique, ainsi que du nombre des points communs à deux coniques quelconques. [v]

Apollonius, of course, does not mention explicitly variable lines and their intersections with given conics. Being a Greek, he could not. Strictly speaking, he never spoke of the intersection of curves with

[4] Rashed does not seem to be aware of this book. The statement appearing in the Arabic edition established by Rashed [116, 117] is essentially the same.

variable lines. This inclination to over-interpretation, sprinkled, however, with numerous sane statements, is not a mere oversight on Rashed's part, as we shall see.

The Arabic text of the *Conics*, which is extant in a number of manuscripts and in at least two translations (to say nothing of the rich tradition of commentaries, abridgments, completions, paraphrases, epitomies,and so forth, which it engendered) by Thābit ibn Qurra and the team of Hilāl ibn Abī Hilāl al-Himṣī and Isḥāq ibn Hunayn, is not just more complete than the Greek text preserved by Eutocius in containing the last extant three books, 5–7; it is also as a rule more reliable at least (but not only) with respect to book 4.[5] If one grants Rashed his editorial *modus operandi* (and this is not as simple as it may sound), then he has shown convincingly the superiority of the Arabic manuscript tradition over the Greek. Still, the question remains: Is this an untainted *manuscript* tradition of the *Conics*?

In his pathbreaking edition and translation of books 5–7 of the *Conica* in 1990, Toomer has shown that in

> almost every instance where *H* [Rashed's main ms.] presents a text different from [that of the other mss used], the reading of *H* makes better sense mathematically. The reason is surely that in these cases ibn al-Haytham changed what he found in his exemplar in order to present a mathematically 'correct' text. *H*, then, represents that bugbear of the textual critic, the 'intelligent scribe'. There can be no doubt that in almost every case where *H* presents a reading 'superior' to that of [the other used mss], the 'inferior' reading is that of the archetype.. . . But, since *H* is certainly descended from that archetype. . . there are a few places where it is at least possible that *H*'s text is more faithful to the original. [1990, 1.lxxxix–xc]

As a result of this troublesome state of affairs, Toomer's wise editorial principles dictated that he

[5] There is, however, a serious problem here because of the weight Rashed gives in his edition to *A* (*H* in Toomer's edition [1990]), the manuscript of 1024, a transcription by ibn al-Haytham which is not an innocent transcription but contains heavy recensional elements that improve the mathematics of the archetype which it allegedly transcribes.

> deliberately [keep] a number of mathematical errors which, in [his] judgment, are to be laid at the door of the Banū Mūsā, the Arabic translator, or possibly the imperfect Greek exemplar from which he was working. Hence, in most cases where *H* offers a mathematically superior reading, [he has] preferred the 'faulty' reading of [the other mss], since, as remarked above, almost all such differences are due to deliberate correction by ibn al-Haytham, and have little weight as textual evidence. [1990, xc]

What all this means, of course, is that somebody like Rashed who relies heavily on *A* (*H* in Toomer) in establishing a critical *manuscript* text is in deep water.[6]

While it is possible that the imperfections in the Greek text of book 4 stem from a corrupt source, the Arabic text, the source of which seems to be a better archetype than that relied upon by Eutocius, seems to be less defective and more systematic in its presentation. This conclusion is, however, marred by Rashed's excessive and uncritical reliance on the manuscript by ibn al-Haytham.

Thus, Apollonius scholars, who are now required to take into account the Arabic manuscript tradition of the seven extant books of the *Conics,* should always keep handy, near Rashed's text, Toomer's sober edition as a salutary corrective.

We now come to Rashed's historical analysis of the text. It is acutely, distressingly wanting. It is blatantly, and consciously, anachronistic, using concepts and mathematical procedures foreign to Greek mathematics and to the *Conics*; and it does this proudly, stridently, demonstratively, in full awareness of the discrepancy between text and commentary, in the wrong belief that this is the best way to understand the Apollonian text. This is already clear in the introduction to the first volume of the project:[7] 'Dire que les *Coniques* sont un livre de géométrie, c'est enfoncer une porte ouverte' [Rashed et *alii* 2008, vii]. How nice! Thus he writes:

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[6] This has also negative bearings on Rashed's much praised superiority of the Arabic *manuscript* tradition over the Greek.

[7] To limit the length of this review, my examples shall be exemplary, not exhaustive.

> It is enough to glance at this treatise to realize the full absence of any equations of plane curves and of any algebraic concept whatsoever. One could easily verify, for example, something well established long ago, that the concept of *symptoma* is not at all equivalent to that of an equation. [2008, vii]

Eminent historians and mathematicians—Heath and Bourbaki foremost among them—all knew this and yet did not hesitate to read the *Conics* algebraically [2008, vii]. Rashed will follow their glorious example. Since it is abundantly clear what the *Conics* is, geometry, we may as well elucidate it by means of what it is not, algebra. This is precisely Rashed's reasoning. Thus, he says:

> The appeal to the terminology of algebraic geometry [*sic*] runs the risk of displeasing some.... [Apollonius'] is a geometrical theory of conic sections: no algebraic, projective, or differential geometry. And yet, we took the liberty of appealing in our commentaries to algebraic geometry,[8] incurring thus, in full awareness, the reproach of anachronism from the guardians of the temple. [2008, vii]

Why proceed this way? Answer: Because the proper way of reconstructing the past is not only by starting from the present but by keeping it always in sight. *Ipse dixit. Q.E.D.*

This is how Heath and Zeuthen proceeded when appealing to geometric algebra in their elucidation of the *Conics* and this is also the 'historical' methodology of Bourbaki.[9] There is no inconsistency in such an approach, since it represents

> the deliberate choice of a style of writing history, by retrograde elucidation, as practiced by Bourbaki: starting with the present to restitute the past; it is also a matter of didactic concern: addressing one's contemporaries in their mathematical language. [2008, viii]

Still, Rashed's reasons for calling on 'algebraic geometry' (*sic*) as his main historical interpretive tool are different [2008, viii], one being instrumental and the other historiographic.

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[8] Rashed appears occasionally to speak indiscriminately of 'algebraic geometry' and 'geometric algebra'.

[9] Surprisingly, and inconsistently, it seems to me, Rashed rejects the legitimacy of geometric algebra.

Once the historian has established the ancient mathematical text on solid grounds, it is incumbent upon him to use all tools at his disposal to plumb its richness, uncover its underlying structures, verify its results, and check the limits of its internal logic. It is only 'in this manner that what made of this work an inexhaustible source for later mathematics is bound to become manifest' [2008, ix] and explain its great appeal throughout the centuries. Keeping faith with the text, its *mathesis*, its mathematical procedures and concepts, on the other hand, is limiting and runs the risk of issuing into a mere paraphrase. And here comes the unbelievable statement, quoted in the original for its pregnancy and offensive outspokenness:

> Pour lire une oeuvre mathématique ancienne, il nous a donc semblé nécessaire de solliciter l'aide d'une autre mathématique, à laquelle on emprunte les instruments qui pouront en restituer l'essence. Un modèle construit dans une autre langue mathématique permet en effet d'aller plus loin dans l'intelligence du texte, particulièrement lorsque cette langue est celle d'une mathématique plus puissante, mais qui trouve dans l'oeuvre commentée l'une de ses sources historiques. Pour les *Coniques*, c'est la géométrie algébrique élémentaire qui fournit ce modèle. [2008, ix]

It simply could not be said better! Still, as if this were not enough, it is followed by the conceptually self-contradictory statement:

> In short, if the instrumental use of another kind of mathematics seems to us indispensable for commenting an ancient work, it is only because of the diffuse relation of identity and difference which unites the one to the other. That the instrument, the model, is not the object is a truism. They simply do not concern the same *mathesis*. [2008, ix]

So far the instrumental reason for opening widely the welcoming door to anachronistic history.

Now, what is Rashed's 'historiographic' reason for writing the kind of history that he does? It is, in a nutshell, the need to unveil the historical *fortuna* of the text or texts studied, the attempt to see in it or them what its or their successors found in those texts, how they used them, and what they inspired them to achieve. Again, Rashed says it best:

> Starting with the IXth century, one discerns in the study of the *Conics* an extension of some of its chapters, as well as their application to the most diverse domains, and their essential contribution to the creation of elementary algebraic geometry. To convince oneself that this is indeed the case, it suffices to read the *Algebra* of al Khayyām, *The Equations* of Sharaf al-Din al Tūsi, the *Geometry* of Descartes, the *Tripartite Dissertation* of Fermat. Neglecting the context of the successors leads inevitably to the mutilation of the studied work's history. *Even when they transform its meaning, the successors allow the historian, in effect, to grasp the work with increased clarity and profundity. This endeavor has indeed been ours.* [2008, x (my emphasis)]

The real challenge of the historian consists in using all the means at his disposal, philological, historical, mathematical

> to bring to the further progress of historical research, pushing it a little farther than the achievements of his eminent predecessors (especially E. Halley, I. H. Heiberg, P. Ver Eecke). [2008, x]

So, we have it now from the horse's mouth: proper historical study of past mathematics comes from illuminating it with the blinding light of latter-day results somehow stemming from it.

These views, needless to say, color also the book under review, in which Rashed establishes an authoritative Arabic text[10] and a faithful French translation, a lasting contribution to Apollonius studies, to which, alas, he adds numerous mathematico-historical commentaries, practically all of them contaminated by anachronism. His text differs from the Eutocian Greek text in both trivial and substantive matters. As I already said, with the publication of this book, any student of book 4 of the *Conics* has at his disposal a welcome and necessary addition to the preserved Greek text, ultimately stemming from another, and better, manuscript tradition than that available to Eutocius. Sadly, this is served in the framework of an unacceptable historical approach.

[10] But, remember A, the problematic al-Haytham ms. and the heavy role that it plays in Rashed's edition.

To grasp Apollonius' approach, Rashed's commentary is often couched

> in algebraic language, occasionally appealing [even] to projective concepts. These concepts are, of course, foreign to Apollonius, even though they find in the *Conics* one of their historical roots. One does not, therefore, leave the historical ground, when he distances himself deliberately from the geometrical language of Apollonius, in order to see a little farther and more profoundly. [vii]

This is a *non sequitur*, since not even Rashed can have it both ways, though he tries very hard. Thus, his brand of eating the cake and keeping it too, enables him to reach the conclusion that Apollonius, with his methods, managed to deal only with less than half of all possible cases of intersecting conics, something established by means of 'another mathematics than that of Apollonius' [viii]. This is by choice the model provided by projective geometry, a model permitting the unification of the study of conics and the considerable simplification of the analytical approach in order to save the complicated calculations required by the latter, though it too could have been used, were it not (unlike the projective model!?) too distant from 'the spirit of the fourth book' [viii].

> By introducing the points at infinity, one can interpret the parabola as the limit case between ellipse and hyperbola, its center and second focus being thrown to infinity. The asymptotic directions of the parabola and the hyperbola are those of chords passing through a point at infinity of the conic, and the asymptotes of the hyperbola are its tangents at infinity. [viii]

What, pray tell, has all this to do with Apollonius? *Nothing.* Strangely, and incomprehensibly, but in character, Rashed agrees:

> These concepts and the structure of the ontology underlying them are surely different than those of Apollonius. For him, in effect, as for all his followers until Desargues, the three conics were distinct and each was approached by its proper methods; parallel lines never meet and there are no points at infinity. Still, it is nevertheless the case that propositions XXX to XL of the third book and their converses in the

> fourth book are one of the historical origins of the writings of Desargues, Pascal, and de la Hire. [viii]

So what? And, by the way, what exactly is, for Rashed, the difference between 'geometrical algebra', which he rejects—

> Heath n'a pas hésité à lire les *Coniques* à la lumière de la géométrie algébrique [!]. Plus encore, il a justifié cette lecture par la fameuse doctrine de « l'algèbre géométrique des Grecs », déjà défendue par Zeuthen et Tannery, *et selon nous historiquement insoutenable* [Rashed *et alii* 2008, viii (my emphasis)]

—and 'algebraic geometry', which he embraces, though, at times, as in the just quoted passage, he seems to conflate and confuse them?

Now, book 4, part of the 'elementary' introduction to the *Conics* comprising books 1–4,[11] is, as we saw, about the relative positions and meetings of two conic sections with one another and with a circumference of a circle and about their common points, be they points of intersection or of tangency. Neither the Greek nor the Arabic text is systematic, though the latter is more so than the former. In his detailed description of the text that he has established and in his analysis, Rashed provides the missing systematization of the 53 propositions (57 in Greek), classifies them logically and mathematically, and analyzes them with all the means at his disposal, including, alas, mathematical concepts and techniques unavailable to Apollonius and his contemporaries. Thus, he speaks of poles and polars, sub-tangents, harmonic divisions and conjugate points, projective and affine transformations, and the like; and uses powerful analytical techniques 'to illuminate the structure' [61] of the Apollonian text,[12] as well as modern algebraic symbolism and techniques to unravel the subtext of the *Conics*. A superficial browsing through the pages of the book should convince any potential sceptic of the accuracy of this assessment.

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[11] Rashed argues convincingly, as far as it goes, for the 'elementariness' of book 4. However, his reasons should be supplemented by Fried's more sensitive and detailed discussion in the second part of his translation of the Greek text [2002, xxi–xxvii].

[12] In this case, the use of a fourth degree equation to study the intersection of two conics in general [61–62].

It is, of course, impossible (and not really necessary) to go with a fine comb through all the offensive mathematical analyses and historically unacceptable statements copiously adorning the book without writing another little book. I shall, therefore, limit myself as I approach the end of this review to a few typical examples drawn from both the book under review and Rashed *et alii* 2008 which introduces the whole enterprise.[13]

In his mathematical analysis of the propositions of the *Conics*, Rashed uses indiscriminately anachronistic concepts and does not hesitate to reformulate the genuine enunciations to fit his discussion [see 19, 25, 49, *et passim*]. Thus, speaking of drawing a tangent to a conic from an external point, he writes the necessary and sufficient condition algebraically and adds:

> The division (A, B, Δ, H) is harmonic. For the parabola, one has a limit case of the harmonic division, since the conjugate of the vertex A in relation to Δ and H is thrown on the diameter to infinite. [10]

His discussion of proposition 4.1, stretching over more than six pages [25–31] is purely analytic and ends in the following statement:

> This analytic commentary—foreign to Apollonius' mathematics—has the advantage of making comprehensible the choice of sections in this proposition. . . .[31]

The trouble is that Apollonius could not have benefitted from this so-called advantage! And yet, many of Rashed's discussions involve such analyses. Another case in point is his *Commentaire analytique des propositions 3 à 7* [38–44]. There are also occasions when Rashed contradicts himself. Here is an example:

> Tout indique dans cette proposition [IV.23] qu'Apollonius, sans avoir la notion du point double, compte le point de contact pour deux points d'intersection. [76]

How, pray tell, is this possible? And:

[13] Since this is, after all, a review of book 4, I shall not deal in detail with the many errors, some mere errors of fact, concerning Rashed's description of book 1 [2008, 49–56] *et passim*.

> On comprend qu'Apollonius... ne considérait pas encore [when proving proposition 4.32] le point de contact comme un point double. [92]

Clearly, then, the dramatic reverse change happened in the interval between the two propositions 4.23 and 4.32, when Apollonius shifted from counting the point of contact as two points (without ever having the concept of a double point!) to not yet considering it a double point! Miracles do happen, after all.

A few more gems: '...propositions 3.18 and 3.19 put into play the power of a point with respect to conics' [85].

> Apollonius' proof [of proposition 4.51] involves eight particular cases. It is, however possible to give a general demonstration by means of projective concepts. [98–99]

Indeed it is. The proof is given in the appendix entitled 'Théorie projective' [237–252]. There is also another appendix entitled 'Théorie affine' [252–294]. Both of these elegant appendices, incomprehensible to Apollonius, are the work of Christian Houzel. Finally:

> Two parabolas cannot, therefore, be tangent in two points, only in one. In such a case, they can be tangent at a point at infinity, and the line joining the two points is a common diameter of the two parabolas. [108]

No comment.

As intimated above, Rashed has shown, to my satisfaction, that the Arabic manuscript tradition of book 4, as defined by him, is more satisfactory than the Eutocian text preserved *inter alia* in Vaticanus graecus 206. Still, in his ardent desire to emphasize the superiority of the Arabic tradition over the Greek, he occasionally goes overboard, making inaccurate assertions. A few instances should suffice.

Speaking of book 4 in his general introduction to the whole project, while comparing the main Greek ms. of the *Conics*, Vaticanus graecus 206 (V), and one of the Arabic mss that he uses in his edition, Teheran, Milli 3597 (M), Rashed finds fault with the proof of 4.7 in V, which, according to him, unlike M lacks a crucial assumption, namely, 'that the secant be parallel to an asymptote' [2008,14]. This is wrong because 4.6, the assumptions of which are identical to those of 4.7, contains in its protasis the required hypothesis of parallelism.[14] It follows, then, that the next statement about the Greek *manuscript* tradition, based, as it is, on the cited wrong statement, is also wrong.

Comparing 4.20 in M to its corresponding Greek proposition in V, 4.19, Rashed asserts that, unlike the rigorous proof in Arabic, the Greek proof is faulty since it gives the conclusions 'sans avancer les justifications requises' [2008, 5]. Again, this is, strictly speaking, wrong. In this case too, the comparison between V and M is inaccurate. There is, *pace* Rashed, no harmonic division in V, and the assessment of 4.19 in V is not only anachronistic but also inexact. The proofs in question (4.6, 4.7, 4.19, 4.20) in V are real proofs, though less prolix than the corresponding proofs in Arabic. True, they are elliptical, occasionally only alluding to the reasons for the facts without spelling those reasons out explicitly; but, when read in context, they do precisely the job they are supposed to do.[15]

In sum, the great merit of this book, as of the project, of which it is a part, in its entirety, is the scholarly edition and translation of an Arabic text of the *Conics*. This is an important achievement.

In the *avant-propos* to the whole enterprise [2008], x], Rashed enumerates the goals that he set himself in bringing the project to fruition:

- the production of the *editio princeps* of books 1–4 in the Arabic version;
- a new edition of the Greek, Eutocian, version;
- a new edition of books 5–7;
- a French translation of all the books comprising the project; and
- finally, a historical/mathematical commentary on the whole.

[14] See the translation at Fried 2002, 8–9.

[15] See the analysis in Fried 2002, 15. Rashed himself remarks that 'il arrive souvent que l'on ait dans V une demonstration abrégée; c'est ce qu'on observe dans les propositions 4, 5, 8 et 20, entre bien d'autres' [19]. Rashed considers this uncharacteristic of Apollonius. I am not entirely sure. It seems to me rather that Apollonius abbreviated only simple proofs, giving the others in full; and that many of the propositions in book 4 belong to the 'simple' category. That is all.

Judging from the book reviewed here, and with all the reservations stated above, he has accomplished, though not perfectly, most but not all of of his goals. It seems to me that the historical commentary and its accompanying mathematics, as well as the basic assumptions under which they were conceived, are, well, *pardonnez l'expression*, deplorably egregious. For me and my cohorts, the 'guardians of the temple' as he refers to us disparagingly (and we are not as few as Rashed seems to think), this conclusion is, alas, unavoidable.[16]

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[16] I thank Fabio Acerbi, Alain Bernard, and others who extended to me generously their assistance.