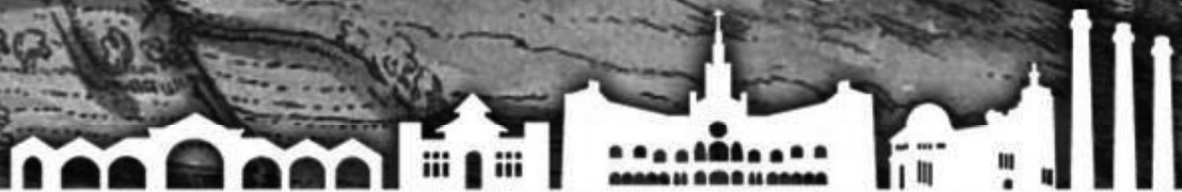


The Circulation of Science and Technology

Proceedings of the
4th International Conference
of the European Society
for the History of Science

BARCELONA, 18-20 November 2010

Hosted by
Societat Catalana d'Història de la Ciència i de la Tècnica



SOCIETAT
CATALANA
D'HISTÒRIA
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FRANCESCO MAUROLICO AND THE RESTORATION OF EUCLID IN THE RENAISSANCE

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Abstract

The first printed edition of the Elements, based on the medieval recensio of Campanus of Novara, appeared in Venice in 1482; some years later, in 1505, Bartolomeo Zamberti published a new (and quite different) translation based on a Greek code. The contemporaneous availability of two Latin editions –we could say two editiones principes– of the Elements, both unsatisfactory for different reasons, gave rise to different reactions among the European mathematicians: some of them embraced the cause of Campanus, some others the cause of Zamberti, and others rejected both Campanus' and Zamberti's redactions. In the last case, the absence of an established, shared and trustworthy Euclidean text, let some mathematicians write 'their' Elements. In this paper I describe the main features of the transmission of the Elements in the early Renaissance Europe and I focus my attention on the figure of the mathematician Francesco Maurolico (1494-1575). Maurolico (<http://www.dm.unipi.it/pages/maurolic/intro.htm>) was very unsatisfied with the available editions of Campanus and Zamberti and in a letter dated 1532 he announced an original publication programme about Euclid's Elements, founded on the following essential points: 'emaculare', or to correct the available editions by mathematical mistakes, 'reddere faciliorem', or to make easier, if possible, the Euclidean proofs; 'coaptare' or to choose every time the best logical architecture, the best proof, the best language between the two editions. In other words, he composed a new text coming from the joining of the two Renaissance traditions with many additions of his own. The Elements "ex traditione Francisci Maurolyci" –which are going to appear in the volume 'Elementa geometriae' of the Edizione Nazionale dell'opera matematica di Francesco Maurolico– were only partially published in 16th century, nevertheless it's possible to detect some influence in Clavio's fundamental recensio of the Elements (1574) and in Borelli's Euclides restitutus (1658).

The first Euclidean project

In 1528, the Sicilian mathematician Francesco Maurolico (1494-1575) lectured on Spherics and Euclid's *Elements* on behalf of the Senate of Messina, his hometown. As he explained in a subsequent dedicatory letter to his patron, dated 1532, the unsatisfactory level of the available editions of the *Elements* convinced himself to prepare a new edition of the Euclidean text.

In the first decades of the Sixteenth century the editions of the *Elements* available to the scholars and known by Maurolico were essentially two: the *editio princeps*, printed in Venice in 1482 by Erhard Ratdolt and based on the medieval version of Campanus from Novara, and the Venetian edition of 1505, based instead on the translation of a greek code, made by the humanist Bartolomeo Zamberti. Maurolico surely knew also the version edited by Jacques Lefevre d'Étaples (Jacobus Faber Stapulensis), printed in Paris in 1516 and followed by numerous reprints and editions. In several documents, unfolded over an extended period of time, Maurolico expressed quite severe criticisms against Campanus and Zamberti. Actually, the medieval *recensio* showed additions, changing of definitions or differences in numbering sometimes questionable, while the translation by Zamberti mercilessly highlighted the very poor geometrical talent of the Venetian humanist. Finally Stapulensis, instead of critically merging the two traditions, simply juxtaposed the two texts, in the vain attempt to balance their shortcomings.

Faced with this situation, Maurolico set out to produce an edition of the *Elements* which was able to collect the best of the known traditions, possibly supplemented by his original contributions, in order to simplify and shorten the Euclidean proofs.

The guidelines of this first Euclidean project, which appears to be regardless of any literary integrity of the text or any philological respect, reveal instead a clear orientation to its mathematical restoration, a tendency which is after all shared by all the editions of the Classics that Maurolico was able to complete; it is not a chance that the titles of these works are always followed by the quote «*ex traditione Maurolyci*», which connotes the works of Maurolico rather than that of any author treated¹. As P. L. Rose has written, «to Maurolico's mind ... there was nothing wrong with correcting classical treatises, as long as it be done by an expert mathematician. Nonetheless, Maurolico was certainly the most radical of Renaissance mathematicians in this respect».²

Announced in 1532 and developed, at least partly, in the following decade, the programme of restoration of the *Elements* would remain unfinished, but in the second half of the Sixties it picked up again, taking the form of an abridged edition of the *Elements*.

In this contribution we provide a brief description of the extant texts (§2) and, after analysing their most relevant mathematical features (§3), we try to trace the evolution of the Euclidean project by the Sicilian mathematician (§4), highlighting the problems that are still open (§5).

The extant Euclidean texts

The collection of Maurolican writings related to the *Elements* includes documents of various kinds: printed editions, holograph drafts, re-readings, compendia and numerous related fragments. A chronological ordering of the survived material leads, in the first instance, to classify the writings into two major groups: the texts written during the years 1532-1541 and the compendia of the years 1563-1567.

The various autographic writings dating back to the decade 1532-1541 witness a real dedication spent by the author in the construction of a new edition of the *Elements*. In fact, we have the following texts:

- a draft containing the first ten propositions from Book II, retained in the Ms. San Pantaleo 115 of the *Biblioteca Nazionale* of Rome, ff. 21r-22v, dated January 21, 1532;
- the drafts of Book V (November 5, 1534) and Books VII, VIII, IX (November 9, 14 and 19, 1534, respectively), corresponding to the folia 1r-39v of Ms. San Pantaleo 116;
- the draft of Book X (August, 1541), retained in the same code (ff. 40r-107v).

At present, we do not have any news concerning the missing drafts of Books I-IV, VI, XI-XII.

The extant texts are written with care and show just a few erasures. Maurolico's attention is focused on the proofs, since definitions and postulates are completely absent. Propositions, although numbered in the margin, are lacking in the statements. In this group of writings, the edition of Books XIII-XV of the *Elements* must also be considered, drawn at least in its essentials in 1532 and published posthumously (1575) in the miscellaneous volume titled *Opuscula Mathematica*; it is the only printed document provided by Maurolico about his plan of restoration of Euclid.

The second group of Euclidean writings consists of the following texts:

¹ Concerning Maurolico and the restoration (*restitutio*) of the Classics, see the papers by P.D. NAPOLITANI, Maurolico e Commandino, in *Il Meridione e le scienze*, edited by P. NASTASI, Palermo 1988, 281-316; Le edizioni dei Classici: Commandino e Maurolico, in *Torquato Tasso e l'Università*, edited by W. MORETTI e L. PEPE, Olschki, Florence 1997, 119-141.

² P.L. ROSE, *The Italian Renaissance of Mathematics*, Genève, Droz, 1975, 166.

- the compendia of Books XI and XII of the *Elements*, dated December 3, 1563 (ff.34v-39v of Ms. San Pantaleo 115)
- the compendia of Books I-X, written from January 28 to March 11, 1567 (ff. 2r-43r of Ms. Lat. 7463 of *Bibliothèque Nationale de France* in Paris).

The previous drafts appear fairly accurate on the whole, presenting few corrections and some additions in the margin. The only exception is the draft of Book X, characterized by successive additions and re-workings.

Maurolico interpreter of Euclid

1. The re-readings of the Thirties-Forties

The aforementioned dedicatory letter of 1532, which accompanies the printed edition of Books XIII-XV of the *Elements* (1575), ends with the promise of a global edition of the Euclidean work inspired by specific criteria: *emaculare*, that is to clean and correct the numerous errors of the printed editions, *reddere faciliorem*, that is to simplify and shorten, where possible, the Euclidean proofs; *coaptare*, i.e., each time choosing, among the known editions, the most streamlined logical architecture, the most convincing proof, the most suitable terminology. It is not excluded, in particular cases, that the existing proofs would be replaced by new Maurolican proofs.

The drafts of Books V and VII-X of the *Elements* dating from 1534 to 1541, perfectly fit into this program, because they are a critical re-fusion of the Greek tradition with the Arab-Latin one, supplemented as necessary by the original contributions of Maurolico, who added, shortened and in case omitted proofs. To better understand what is meant by this statement, we see a little closer the Maurolican reworking of the theory of proportions, i.e. Book V of the *Elements*, starting from a brief description of the versions provided by Campanus and Zamberti.

Book V *ex traditione Campani* differs substantially from the translation by Zamberti in the following points: a different (and controversial) definition of proportionality³, the inversion of two propositions (the 12th and 13th) and the addition –in the medieval recensio– of nine final propositions on the properties of inequalities between ratios. Maurolico does not slavishly follow one or another tradition, but tries to recast them critically. His draft, although free of definitions, clearly shows to adopt the definition of proportionality of the Greek text. The Sicilian mathematician also respects the ‘greek’ sequence of propositions, but does not hesitate to join eight of the nine Campani additions concerning the inequalities between ratios. As regards the lexicon, as a rule Maurolico shows a preference for the one of the Venetian humanist Zamberti, but also partly follows the terminology of Campanus, for example to indicate some manipulations on the proportions.

Finally, when the proofs of the same proposition differ from each other, Maurolico tends to favour the version proposed by Campanus rather than the one by Zamberti, although in few cases opts for a personal solution.

The problem of restoring Greek mathematics, to Maurolico’s mind, becomes the problem of establishing a comprehensive and mathematically reliable text. The Sicilian mathematician does not arise philological scruples, being convinced of the impossibility to really restore the true Euclidean text, so full of mistakes “of scribes and translators that Euclid himself, returned to life, could nor purge their works”.

2. The Elementorum compendia: a reworking of the Elements in arithmetical key

The impression we can get even from a superficial reading of the Euclidean compendia of the Sixties, is that of a clear distinction between the first four books and the next ones. In fact, while the compendia of the books dedicated to plane geometry (I-IV) are not significantly different from the tradition of the *Elements*, the remaining ones are reinterpreted according to a strongly arithmetical perspective.

The previous rigid dichotomy does not regard the compendium of Book II, which has always been interpreted by Maurolico according to this peculiar point of view. Actually, all the Maurolican survived drafts of Book II, including that of 1532, provide arithmetical alternatives to the traditional geometrical proofs of the first ten propositions. However these proofs are not completely original, because they are based, as stated by Maurolico himself in a scholium of Book IX, on the topics of the Campani adnotationes to proposition IX.16, which interpret in a numerical key the first ten propositions of Book II.

On the contrary, starting from the epitome of Book V, i.e. from the theory of proportions between magnitudes, Maurolico distinguishes himself by a highly personal approach, in which the definition of proportionality is the kernel of the theory, favouring the comparison of ratios rather than equimultiples.

³ For a framework of the discussion on the theory of proportion in the early sixteenth century, see E.GIUSTI, *Euclides reformatus. La teoria delle proporzioni nella scuola galileiana*, Turin 1993.

The Sicilian mathematician constructs a general theory of proportions between magnitudes trying to bring the irrational ratios to rational ones, proving that the former can always be 'contained' in an interval bounded by the latter. In this way, the author tries – even if with some weaknesses– to ensure the generality of the theory by actually studying only the properties of rational ratios. It becomes immediately evident that the propositions in Book VII of the *Elements*, dedicated to proportions between numbers (VII.4-19), appear completely redundant to Maurolico, which summarizes them in one proposition only: "It has been proved in Book V everything regards ratios and proportions in general; this also holds for numbers".

Maurolico, however, does not restrict himself to eliminate this group of propositions from the arithmetical books, but he completely re-arranges their logical architecture. It should be noted, indeed, that the arithmetical books especially apply to be rearranged, because they are nearly free from a hierarchical logical-deductive structure, being rather grouped –especially Book VII– in main themes. Let us briefly see how Maurolico alters the structure and contents of the arithmetical books.

The central problems solved in Book VII, according to the Euclidean tradition, are the determination of the greatest common divisor and least common multiple of two and then three integers (VII.1-3, VII.34-36), and moreover the characterization of representatives of a given ratio and reduction to minimum terms (VII.20-22, VII.33). Instead, in the compendium of Book VII, Maurolico maintains the propositions regarding the determination of greatest common divisor and anticipates –from Books VIII and IX, respectively– some properties of plane and solid numbers, and of a geometrical progression. In this context, he inserts the following proposition that relates the algebraic powers to terms in continuous proportion: "The unit, the unknown, its square, its cube and its square-square are in continuous proportion" («*Unitas, radix, quadratus, cubus et secundus quadratus, sunt continue proportionales*», VII.8). This is a reminder of some interest, since Maurolico also left us a brief treatise on algebra⁴ actually closely linked to this result, which allows him to present an equation as the equality of side powers of the unknown⁵ and reduce the traditional six «*regulae algebrae*» to just four.

In the compendium of Book VIII, Maurolico inserts the propositions excluded from Book VII (that is the propositions mainly related to prime numbers) and the first 27 propositions of Book VIII, concerning the determination and the study of continuous proportions, the characterization of square and cubic numbers, plane and solid numbers.

The compendium of Book IX opens with six propositions devoted to the square and cubic numbers, and after propositions 7-21, which are not confirmed in the Euclidean *Elements*, the epitome concludes with the famous result on perfect numbers: «If as many numbers as we please beginning from a unit continuously be set out in double proportion, until the sum of all becomes first, and if the sum into the last multiplied make some number the product will be perfect» (proposition IX.23 «*ex traditione Maurolyci*», i.e. proposition IX.36 of the *Elements*). Some applications regarding continuous proportions and most of the results related to prime numbers are then removed from the compendium, as well as the treatment of even, odd, even-times even and even-times odd numbers. Therefore, as it is evident, Maurolico deeply modifies the Euclidean arithmetical books, both in content, in methodological approach and logical architecture.

Maurolico and the educational project of the Jesuits

In the late Forties, the Jesuit Jerónimo Doménech, with the help of Ignatius of Loyola and the Viceroy of Sicily Juan de Vega, founded in Messina the Collegium primum ac prototypum with the purpose of creating a model of Jesuit University opened to external students. According to the intent of Doménech, the Collegium had to be the University of Messina, but managed by the Society of Jesus, which had to plan the courses and organize the lectures.

For about five years, i.e. from 1548 to 1553, the Collegium of Messina essentially supplied elementary and secondary teaching. Due to a series of clashes that arose between the Jesuits and the Senate of Messina, the project was not able to definitively take off and the educational activity of the Collegium was considerably reduced but, from 1564, a renewed understanding led to the activation of the Studia superiora, within the framework of the genuine *Ratio studiorum*⁶. The need to realize a new educational system related to the advanced courses, and the intention of involving the local scholars in the educational project, led the Jesuits of Messina to strengthen the relations with Francesco Maurolico.

The terms of the cooperation offered by the old mathematician to the Jesuits, were gradually extended from occasional advices to the development of an ambitious editorial plan for arranging all the sciences in an encyclopedia

⁴ The electronic edition of *Algebra* is available on the website of the *Progetto Maurolico* (www.maurolico.unipi.it)

⁵ Given the scale of algebraic powers, Maurolico considers 'side powers' of an assigned one, the equidistant powers from it.

⁶ On the vicissitudes of the *Collegium primum ac prototypum* of Messina and the role of the Mathematics teaching, see in particular the contributions by R. MOSCHEO, *I Gesuiti e le matematiche nel secolo XVI. Maurolico, Clavio e l'esperienza siciliana*, Messina 1998, and by A. ROMANO, *Il Messanense Collegium Prototypum Societatis Iesu*, in *Gesuiti e università in Europa (secoli XVI - XVIII)*, edited by G.P. BRIZZI, R. GRECI, Bologna 2002, 79-94.

structured in compendia. Such compendia were to be used in the teaching of the Collegium of Messina and, possibly, in every *Collegium* of the Society.

If one considers the chronology of Maurolico's writings, in the second half of the Sixties a significant increase of scientific activity can be registered, mainly oriented to the redaction of epitomes. In particular, in 1567 Maurolico wrote the Euclidean and astronomical compendia, which fell within the basic teaching of the Jesuit Universities (and not only). To be precise, in the early 1567, he completed the compendia of the first ten books of the *Elements* and reworked a text of some years earlier (1563), dedicated to stereometry, transforming it in the compendium of Books XI and XII. To conclude, he then wrote that the old edition of Books XIII-XV – the one dated 1532, to be clear – added to the most recent epitomes, would have finally completed the whole *Elementorum compendia*.

In April 1569, Maurolico vainly tried to advocate at the Superior General of the Society the publication of the compendia, emphasizing their general utility and need⁷.

Unfortunately, the editorial project wrecked and the old mathematician, now seventy years old, had several writings left, ready for publication. The few extant documents, show that in this same period, precisely in 1570, Maurolico invested all his remaining energies in a new editorial operation, probably born from the ashes of the just faded one, which had to end, after many vicissitudes, with the publication of the *Opuscula mathematica*, which occurred in 1575, just few days after his death. Among the published opuscula, we find, surprisingly, the edition of Books XIII-XV of the *Elements*, without any trace of the remaining compendia.

The presence of the edition of the only Books XIII-XV and the subsequent exclusion of the compendia of the first twelve books, appears to be very astonishing, given the explicit will of Maurolico to avoid the separation of the compendia. The fact that his will has been disregarded would lead us to think that, unless some sudden rethinking of the author, there may have been some external interference, not yet identified, in the selection of the texts to be published in the *Opuscula*⁸.

Concluding remarks

In 1528 Francesco Maurolico gave lessons on the *Elements*; in the same year, in the preface of his grammar textbook *Grammaticorum rudimentorum libelli sex*, he wrote to be ready to lay out a full scale programme for the renaissance of Greek mathematics. The first step of his ambitious plan was the restoration of the *Elements*, so to have a new edition «*ex traditione Maurolyci*» able to replace the worst printed editions. In the following years he reworked Books XIII-XV and in 1534, over a period of intense arrangement of his writings, he prepared a nearly final version of Book V and arithmetical books. Few years later he devoted himself to writing Book X.

The Maurolican editions of 1530's and 1540's essentially appear to be a critical merging of the traditions by Campanus and Zamberti; nevertheless, sometimes the author does not hesitate to replace Euclidean proofs with more easily intelligible ones (from his point of view, of course) or to add new propositions when he thinks incomplete the Euclidean theory. Although these writings are clearly not based on any kind of philological restoration of Euclid, they are not significantly far from the spirit of the *Elements*.

Unfortunately, at this time we are unable to establish whether the editions of the 'missing' books of the *Elements* –i.e. Books I, III, IV, VI, XI and XII– are lost, nor to categorically exclude that they have never been written. Anyway, we can say, with a certain validity, that the Euclidean edition of the years 1532-1541, although limited to few books, is not, as might appear at first sight, an unused work set aside until a future completion. Maurolico, in fact, considered and used these writings the same way as a real edition of the Euclidean work, far superior to those available concerning what regards mathematical rigour and completeness of treatment. To take an amazing example, in his *Arithmeticonum libri duo* (printed posthumously in 1575 together with *Opuscula Mathematica*) Maurolico sometimes cites Euclidean propositions existing only in his edition «*ex traditione Maurolyci*» of the Thirties.

While the drafts of the Thirties follow in the wake of existing Euclidean traditions, the successive compendia of the Sixties are not only a reasoned synthesis of the *Elements*, because they are completely influenced by a deep arithmetical interpretation of the topics, from the theory of proportions to the relationships between regular polyhedra. Following this peculiar approach, Maurolico often chooses to replace, where possible, geometrical proofs with arithmetical ones. The compendia of the fifteen books of the *Elements* –grouped on the basis of the autograph instructions left by Maurolico– show tracts of deep originality, but at the same time they constitute a very heterogeneous work, as their complex genesis testifies.

⁷ See P.D'ALESSANDRO, P.D.NAPOLITANI I primi contatti fra Maurolico e Clavio: una nuova edizione della lettera di Francesco Maurolico a Francisco Borgia, *Nuncius*, 16 (2001), pp. 511-522.

⁸ In this regard, we would remember that Rosario Moscheo has highlighted the role played by the Jesuit Vincenzo Le Noci in promoting the publishing venture culminated in the print of the *Opuscula* (MOSCHEO, *I Gesuiti e le matematiche...*, p.221 and following). It is plausible that Le Noci may have influenced Maurolico also in the choice of the writings to be published.

The edition of Books XIII-XV, for example, seems to adhere more to the editorial criteria of the Euclidean project of the Thirties, rather than to the style of the compendia of the Sixties.

The Euclidean writings as a whole, set different kind of problems: although the textual tradition is rather poor, the edition of these works has to include partial redactions of the *Elements* «*ex traditione Maurolyci*», compendia written on different periods and many related fragments. The difficulty of placing such different texts into a coherent framework does not only regard the editorial aspect, but also and especially the interpretative one. The crucial points are, first of all, a reliable reconstruction of the two different Euclidean projects undertaken by Maurolico, and a precise evaluation of the actual influence of the Euclidean edition on his scientific production, especially concerning the close relations existing among arithmetical and Euclidean writings.

The first step to reach this aim is the critical edition of the Euclidean texts, which will be published within the National Edition of Maurolico's mathematical works (*Francisci Maurolyci Opera Mathematica*); anyway, a first transcription of such texts is available in the website of the *Progetto Maurolico* (www.maurolico.unipi.it).