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GUIDOBALDO DAL MONTE AND THE ARCHIMEDEAN REVIVAL

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RIASSUNTO

Questo saggio esamina il ruolo di Guidobaldo dal Monte all'interno del rinascimento di studi matematici in Italia nella seconda metà del '500. Le sue posizioni vengono confrontate brevemente con quelle di Giovanni Battista Benedetti e soprattutto di Federico Commandino. Mentre Benedetti sviluppa un atteggiamento fortemente critico di Aristotele e della filosofia in generale, e Commandino mostra di concepire il rinascimento matematico come una profonda riforma del sapere e ristrutturazione della gerarchia tra le varie discipline, dal Monte si limita a promuovere matematica e soprattutto meccanica con scopi molto più limitati; obiettivi filosofici e critica anti-aristotelica rimangono al di fuori della portata della sua azione. Queste osservazioni mostrano l'esistenza di una ampia gamma di posizioni nell'ambito del *revival* archimedeo in Italia e della stessa scuola matematica urbinate: nonostante alcuni innegabili punti di contatto, i progetti culturali rintracciabili nelle opere di Commandino e dal Monte sono profondamente diversi.

1. Introduction

Historical categorizations help us to capture important features of an age, a community or an individual, and guide us in the advancement of our researches. New perceptions and data, however, prove invariably richer than our schematizations and constitute a constant challenge to the established understanding. Within the Renaissance of mathematical studies in late sixteenth-century Italy,

the Marquis dal Monte's work presents features calling into question our views about philosophy and the mathematical disciplines, theoretical as well as practical. A closer analysis of his contribution to and location within the Archimedean revival is long overdue.

The late Charles Schmitt has warned us against the uncritical usage of terms like «Aristotelianism» for interpreters as diverse as Jacopo Zabarella, Cesare Cremonini, and Andrea Cesalpino. Likewise, Paolo Galluzzi has emphasized the wide range of connotations linked to the notion of «Platonism» for scholars such as Francesco Barozzi, Jacopo Mazzoni, and Galileo.[1] It is now time to consider the humanist renaissance of mathematical studies, and the Archimedean revival associated with it, as less of a coherent movement than we have done thus far. Within its fold we can identify a multiplicity of roots and aims which have to be spelt out if we want to reach a more satisfactory understanding of its nature. A theme occurring frequently in the sixteenth-century literature is the intellectual fascination with the rigour and certainty of mathematics. In addition to such abstract features, one often finds references to the practical utility of mathematics in fields as diverse as navigation and the military art. An important factor in the rise of the mathematical disciplines can be identified in the interest of mathematical practitioners, and especially of military men, in self-promotion: thus intellectual dignity of the discipline and social dignity of its practitioners would be mutually supportive. Still a different justification for the mathematical renaissance can be found in the educational purposes of prominent intellectuals, such as Philipp Melanchthon among the German Protestants and Cristophorus Clavius among the Jesuits. The last aspect I wish to mention in this brief survey is the growing dissatisfaction of larger numbers of scholars with the traditional organization of knowledge as well as the hierarchy relations among disciplines. Although these themes are clearly related, in this paper I shall focus primarily on a few topics related to the last of them.

The Archimedean revival is associated with the mathematization of nature in a form perceived by several sixteenth-century mathematicians and philosophers as a challenge to orthodox Aristotelianism and especially to the science of motion. At Turin the

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[1] C. B. SCHMITT, *Aristotle and the Renaissance*, Cambridge, Mass., Harvard University Press, 1983; P. GALLUZZI, «Il Platonismo nel tardo Cinquecento e la filosofia di Galileo», in P. ZAMBELLI, ed., *Ricerche sulla cultura dell'Italia moderna*, Bari, Laterza, 1973, pp. 37-79.

court mathematician Giovanni Battista Benedetti in *Diversarum Speculationum Liber* used the Archimedean hydrostatic principle against Aristotle's theory that speed of fall is proportional to weight. His earlier publication *Demonstratio Proportionum Motuum Localium contra Aristotelem et Omnes Philosophos* leaves little doubt as to his targets. Benedetti's mathematization of the science of motion tackled a number of philosophical issues involving the existence of the void, the notion of levity, and, at least indirectly, the distinction between substance and accident.[2]

There is a broader sense in which the renaissance of mathematics and the investigation of nature by means of the *scientiae mediae* posed a challenge to the Aristotelian teaching. In logic it is possible to trace an extensive debate on the status of mathematical demonstrations. In astronomy the appearance of new comets and of the 1572 and 1604 novae struck a major blow to the notion of the incorruptibility of the heavens. And, to be sure, the list could continue with such crucial issues as the cosmic upheaval associated by many with Copernicanism.[3]

These observations reveal the depth and range of the philosophical implications related to the renaissance of mathematical studies. The protagonists of this renaissance and even of the slightly smaller movement associated with the Archimedean revival, however, held widely different views on these matters. Indeed, it seems that besides their shared interest in the mathematician from Syracuse and the importance of their own discipline, one can find little else in common among them. The Marquis dal Monte, for

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[2] On different perceptions of Archimedes see W. R. LAIRD, «Archimedes among the Humanists», *Isis*, *82*, 1991, pp. 628-638. Benedetti tried to provide a mathematical theory of resistance to motion (see below). A broad discussion of the problem of accidents is in N. KOERTGE, «Galileo and the Problem of Accidents», *Journal of the History of Ideas*, *38*, 1977, pp. 277-318, and W. A. WALLACE, *Galileo and his sources*, Princeton, Princeton University Press, 1984, pp. 38, 242, 254, 260-263, 278-280, 287, 291, 304-305, 318-319, 330-333, 339, 342.

[3] On the *scientiae mediae* see R. D. MCKIRAHAM, Jr., «Aristotle's subordinate sciences», *British Journal for the History of Science*, *11*, 1978, pp. 197-220. P. L. ROSE, «*Certitudo Mathematicarum* from Leonardo to Galileo», *Atti del Simposio Internazionale di Storia della Scienza*, Firenze, Giunti Barbera, 1975, ed. C. Maccagni, pp. 43-49. G. C. GIACOBBE, «Il *Commentarium de certitudine mathematicarum disciplinarum* di Alessandro Piccolomini», *Physis*, *14*, 1972, pp. 162-193; «Francesco Barozzi e la *Quaestio de certitudine mathematicarum*», ib., pp. 357-374; «La riflessione metamatematica di Pietro Catena», *Physis*, *15*, 1973, pp. 178-196; *Alle radici della Rivoluzione Scientifica: Le opere di Pietro Catena sui rapporti tra matematica e logica*, Pisa, Domus Galileiana, 1981. A. CARUGO, «Giuseppe Moleto: Mathematics and the Aristotelian Theory of Science at Padua in the Second Half of the 16th Century», in L. OLIVIERI (ed.), *Aristotelismo Veneto e Scienza Moderna*, 2 vols., Padova, Antenore, 1983, vol. 1, pp. 509-517. On the novae see section (4) below.

example, was a leading figure in the promotion of the mathematical disciplines, in the revival of Greek mathematics, and in acting as patron to young Galileo. However, he hardly ever criticized Aristotle even when the Philosopher's teaching appeared to be contradicted by recent mathematical findings. Though occupying a marginal position in dal Monte's writings, Aristotle seems to have been more important than a citation index would suggest.

Guidobaldo's conservative attitude emerges convincingly with respect to the «radical» Benedetti, and also in comparison to the father of the Urbino school of mathematicians, Federico Commandino. Different preoccupations can be detected in the dedicatory letters in some of their major works, especially Commandino's 1558 and Dal Monte's 1588 edition and paraphrasis, respectively, of Archimedes. The former defended the fundamental role of mathematics as a precondition for sound philosophizing. The latter seemed to conceive mathematics within a space already set and confined by «sound» philosophy. Thus besides the shared admiration for Archimedes, the fascination with rigour, the satisfaction in restoring a brilliant demonstration in a corrupt text, it is possible to discern genuinely different projects even within the Urbino school. Despite some undeniable common tracts, the Urbino mathematicians cannot be seen as a monolithic group promoting the same project. This observation calls into question the current classification of sixteenth-century Italian scholars in mechanics in two groups: a Northern group including Tartaglia, Benedetti, and Cardano, with a more practical orientation; and the Urbino school of Commandino, dal Monte, and Baldi, who were particularly interested in classical antiquity and in the rigour of mathematics. Classical antiquity, however, could serve different purposes. If we consider mechanics and, more generally, the mathematical disciplines in relation to the transformation of the map of knowledge, other classifications would seem more fitting. As we are going to see, from my perspective, Commandino had more to share with Clavius than with dal Monte, and in general other associations may have to be established with regard to specific problems, such as the interest in motion or algebra.[4]

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[4] In the introduction to S. DRAKE and I. E. DRABKIN, *Mechanics in 16th-Century Italy*, Madison, University of Wisconsin Press, 1969, Drake referred to a Northern and a central Italian school. Later interpreters, notably C. B. SCHMITT, «A fresh look at mechanics in 16th-century Italy», *Studies in the History and Philosophy of Science*, *1*, 1970, pp. 161-175, esp. p. 168; P. L. ROSE, *The Italian Renaissance of Mathematics*, Geneve, Droz, 1975; E.

In the second section I contrast Benedetti's, Commandino's and dal Monte's aims underlying their respective views of the Archimedean revival. After a brief survey of some of Benedetti's works, I focus on the two leading Urbino mathematicians. Attention is paid to Commandino's dedicatory letters to Cardinal Ranuccio Farnese in the 1558 edition of Archimedes, to Cardinal Alessandro Farnese in the 1565 *De Centro Gravitatis*, and *Prolegomena* in the 1572 Euclid. My tentative conclusion is that although Commandino was not militantly engaged in a philosophical battle, he conceived the renaissance of mathematics as part of a wide restructuring of the map of knowledge and disciplinary hierarchies. I attach particular importance to Commandino's references to philosophical disputes about motion and the void, and to the commentator and critic of Aristotle Johannes Philoponus. The more limited and conservative attitude of dal Monte can be reconstructed primarily from the dedicatory letter to Francesco Maria II in the *Mechanicorum Liber*, the preface to the 1588 *In duos Aequeponderantium Libros Paraphrasis*, and the letter of the same year to the philosopher Federico Bonaventura. The letter is reproduced in the Appendix. Although a passage from it was quoted as a possible indication of the author's Copernicanism, my reading of the entire document in connection with the preface to *Paraphrasis Archimedis* rules out this interpretation.[5]

The third section examines some aspects of dal Monte's views about the science of machines, the distinction between equilibrium and motion, and the issue of mathematical rigour versus the contingency of matter. I consider the relationships with more practice-oriented figures, such as the superintendent to the fortifications of the Republic of Venice, Giulio Savorgnan, and the provveditor to the Arsenal, Giacomo Contarini; the role of Francesco Barocci's workshop of mathematical instruments at Urbino; the observations on motion, inclined planes, and mathematical rigour. It would be erroneous to label dal Monte on

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GAMBA and V. MONTEBELLI, *Le scienze a Urbino nel tardo Rinascimento*, Urbino, QuattroVenti, 1988, refer to the Urbino school. On its social character see M. BIAGIOLI, «The social status of Italian mathematicians, 1450-1600», *History of Science*, 27, 1989, pp. 41-95. See also the useful E. GAMBA, «Saggio bibliografico sull'ambiente scientifico del Ducato di Urbino», *Studia Oliveriana*, *8-9*, 1988-9, pp. 35-67.

[5] It is unfortunate that so little is known about Commandino's education and views on issues such as novae and comets, Copernicanism, motion, and the void. Hence a more accurate evaluation of his position with respect to those of dal Monte and Clavius – though highly desirable – is premature.

the basis of his general pronouncements and programmatic statements without taking into account some aspects of this practice, since in his experimental study of projectile motion, for example, the Marquis departed significantly from Aristotelian teachings.

The fourth section is devoted to the debates on the location and nature of the 1604 nova. I contrast dal Monte's views with those of Galileo at Padua, Giovanni Antonio Magini at Bologna, Bartolomeo Cristini at Turin, and especially Christophorus Clavius at Rome. Unlike his fellow mathematicians, the Marquis rejected a priori on philosophical grounds the possibility that the heavens could be corruptible. His conservatism on this issue constitutes indirect evidence of his views about the far greater philosophical upheaval associated with Copernicanism.

By setting dal Monte in the context of the mathematicians, philosophers, and technicians in the Duchy of Urbino and in Italy, I hope to provide a richer and more problematic picture of the Archimedean revival in the late sixteenth century. A closer look at the Marquis' works leads to a rethinking of intellectual and social explanations alike.

2. The Archimedean revival and its uses

Niccolò Tartaglia's 1543 Latin edition of the first book of the *Floating Bodies* by Archimedes is traditionally seen as an important moment in the rise of a new way of conceiving motion. Although the Archimedean tract concerned equilibrium rather than motion, the extension of those reasonings to the problem of falling bodies appeared to be fairly direct to some sixteenth-century mathematicians. Within a decade of Tartaglia's edition, his student Giovanni Battista Benedetti tackled the problem of motion in a fashion consciously opposed to the teachings of Aristotle.[6] Although Benedetti repeated his basic intuitions three times in different forms between 1553 and 1555, his reception does not seem to have gone

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[6] Drake and Drabkin, *Mechanics in sixteenth-century Italy* (cit. n. 4), pp. 22; M. Clagett, *Archimedes in the Middle Ages*, vol. 3, Philadenphia, American Philosophical Society, 1978, esp. pp. 530-607.

beyond the immediate circle of his little known friends.[7] In the *Resolutio* and the two versions of the *Demonstratio* Benedetti attacked Aristotle, all his commentators, as well as philosophers in general. In the first version of the *Demonstratio* he claimed that his own reasoning was based on «a mathematical demonstration, not Aristotelian blathering». His specific criticisms focused on the theory of falling bodies. Aristotle believed that velocity of fall is inversely proportional to the density of the medium. Hence in a void, where density is nil, the velocity would be infinite. This absurd conclusion would show that the existence of the void must be rejected. Benedetti objected that the effect of resistance must be subtracted from the speed in the void: the crux in Aristotle's reasoning was the erroneous relation between density and speed leading to infinite velocities, not in the existence of the void. Further Benedetti criticized the theory that speed is proportional to weight and the idea that rectilinear motion cannot be compared to a curved one. Interestingly, in the second version of the *Demonstratio* and later in *Speculationes* we find a mathematical theory of resistance to motion based on the surface of a falling body. In addition, large portions of the *Speculationes* are devoted to a critical examination of the *Quaestiones Mechanicae*. In the Duchy of Urbino Benedetti seems to have been little known, although his work on gnomonics was referred to by Bernardino Baldi, and Alessandro Giorgi mentioned the *Speculationes* in his Italian translation of Hero. The *Speculationes* were also known to the philosopher Jacopo Mazzoni at Pisa, whose *Praeludia* discussed them approvingly while criticizing Aristotle for having paid insufficient attention to mathematics. Another reader of Benedetti was the «consultore» of the Republic of Venice and polymath Paolo Sarpi, who referred to the *Speculationes* on falling

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[7] G. B. BENEDETTI, *Resolutio omnium Euclidis problematum*, Venice, apud Bartholomaeum Caesanum, 1553; *Demonstratio proportionum motuum localium contra Aristotelem et omnes philosophos*, Venice, [apud Bartholomaeum Caesanum], 1554; *Demonstratio* etc., Venice, [apud Bartholomaeum Caesanum], 1554 Idibus Februarii = 1555; reprinted in C. MACCAGNI, *Le speculazioni giovanili «De Motu» di Giovanni Battista Benedetti*, Pisa, Domus Galileiana, 1967. C. MACCAGNI, «Contributi alla bio-bibliografia di Giovanni Battista Benedetti», *Physis*, *9*, 1967, pp. 339-364; the best biography is G. BORDIGA, *Giovanni Battista Benedetti* (con un aggiornamento bibliografico ragionato di Pasquale Ventrice), Venezia, Istituto Veneto di Scienze, Lettere e Arti, 1985. I am setting aside here Jean Taisner's plagiarism of the 1554 *Demonstratio*, in *De Natura Magnetis... Demonstratio proportionum motuum localium, contra Aristotelem et alios philosophos*, Cologne, apud Ioannem Birckmannum, 1562, which appears to have circulated especially outside Italy. *Cultura, scienze e tecniche nella Venezia del Cinquecento*. Atti del convegno internazionale di studi su Giovanni Battista Benedetti e il suo tempo, Venezia, Istituto Veneto di Scienze, Lettere ed Arti, 1987.

bodies in his miscellaneous *Pensieri*.[8] Both Mazzoni and Sarpi were closely associated with Galileo, whose usage of Archimedes against the peripatetics constitutes a major theme in his career from the 1590 *De Motu*.

In the second half of the sixteenth century Benedetti was the most consequent and explicit critic of Aristotle from a mathematical standpoint. By contrast, Federico Commandino's austere and scholarly editions contain frustratingly little commentary, besides strictly philological and technical elucidations, illustrating the editor's general aims and ideas. The reader interested in the reception of Copernicanism, for example, will look in vain in the commentary to Archimedes, *De Arenae Numero*, where the heliocentric theory of Aristarchus is referred to. Likewise, Hero of Alexandria's defence of the existence of the void in the *Spiritalia* is not discussed by Commandino.[9]

Despite this restrained attitude in the commentaries towards taking sides in current debates, some of the dedicatory letters contain important information about mathematics and its location on the map of knowledge. One of the most common themes in several writers of the time is the emphasis on the certainty of mathematics. According to Bernardino Baldi's biography, Commandino devoted

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[8] G. B. BENEDETTI, *Diversarum speculationum liber* , Torino, apud Haeredem Nicolai Bevilacquae, 1585, esp. pp. 151-196; DRAKE and DRABKIN, *Mechanics* (cit. n. 4), pp. 179-223. Letter to Domenico Pisano, on p. 298 discussed by C. MACCAGNI, «Contra Aristotelem et Omnes Philosophos», in L. OLIVIERI (ed.), *Aristotelismo Veneto e Scienza Moderna* (cit. n. 3), vol. 2, pp. 717-727. A more sophisticated view on Aristotle's ideas and on his interpreters is in J. A. WEISHEIPL, *Nature and Motion in the Middle Ages*, Washington D. C., The Catholic University of America Press, 1985, chapter 6.

B. BALDI, *Cronaca de' Matematici*, Urbino, 1707, p. 140. Baldi refers only to G. B. BENEDETTI, *De gnomonum umbrarumque solarium usu liber*, Turin, apud haeredes Nicolai Bevilaquae, 1574. A. GIORGI, *Spiritali di Herone Alessandrino*, Urbino, Bartholomeo e Simone Ragusi, 1592, p. 74*r*. Giorgi mentiones a «lucerna» devised by Benedetti discussed in the *Speculationes* in a letter to Francesco Barbaro, pp. 225-227; the passages concerning motion and the void are ignored. Giorgi, however, included in the preface an account of Aristotle's rejection of the void. J. MAZZONI, *In universam Platonis et Aristotelis Philosopiam Praeludia*, Venice, apud Ioannem Guerilium, 1597, pp. 187ff.; F. PURNELL, «Jacopo Mazzoni and Galileo», *Physis*, *14*, 1972, pp. 273-294. L. SOSIO, «I *Pensieri* di Paolo Sarpi sul Moto», *Studi Veneziani*, *13*, 1971, pp. 315-392, esp. pp. 330-354.

[9] F. COMMANDINO, *Archimedis Opera Nonnulla*, Venice, apud Paulum Manutium, Aldi F., 1558. D. BERTOLONI MELI, «Federico Commandino and His School», *Studies in History and Philosophy of Science*, *20*, 1989, pp. 397-403, esp. p. 399. F. COMMANDINO, *Heronis Alexandrini Spiritalium Liber*, Urbino: [Domenico Frisolino?], 1575. M. BOAS, «Hero's *Pneumatica*. A study of its transmission and influence», *Isis*, *40*, 1949, pp. 38-48. C. B. SCHMITT, «Experimental Evidence for and against a Void: the Sixteenth-Century Arguments», *Isis*, *58*, 1967, pp. 352-366. The *Spiritalia* were published immediately after Commandino's death. E. GRANT, *Much Ado About Nothing. Theories of Space and Vacuum from the Middle Ages to the Scientific Revolution*, Cambridge, Cambridge University Press, 1981.

himself to mathematics after his wife's death, as a psychological anchor of certainty in the turbulence of human affairs. These personal events may be partially responsible for his avoidance of debatable points: Commandino liked the definitive and unquestionable character of a demonstration rather than the tentative and approximate nature of other forms of knowledge. One can still detect the feeling of deep satisfaction in his announcements of having restored a complete treatise with all its demonstrations from a corrupt and lacunal text.[10]

The dedicatory letter to Cardinal Ranuccio Farnese in *Archimedis Opera Nonnulla* contains some passages stressing the certainty of mathematics in contrast to the merely probable character of other disciplines. Commandino's style and notions – not thought the praise of mathematics – are typically Ciceronian:[11]

Mathematical disciplines not only attain understanding by themselves of that which pertains to them, but they even throw a very clear light on the other disciplines, thus rendering them much more accessible to our knowledge. In fact considering natural philosophy[12] (since we begin chiefly from it) we find that even its smallest domains are affected by innumerable difficulties; to find something which is most likely correct has to be declared the outcome of an extraordinary mind and of immense fortune. There was disagreement between not minor philosophers, but between the fathers of philosophy itself, Plato and Aristotle, even whether the world

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[10] The fundamental modern text on Commandino superseding all previous works is P. L. ROSE, *The Italian Renaissance of Mathematics* (cit. n. 4), ch. 9. See also B. BALDI, «Vita di Federico Commandino», *Giornale de' Letterati d'Italia*, *19*, 1714, pp. 140-185. P. D. NAPOLITANI, «Maurolico e Commandino», in P. NASTASI (ed.), *Il Meridione e le scienze*, Palermo, Istituto Gramsci Siciliano e Università di Palermo; Napoli, Istituto Italiano per gli Studi Filosofici, 1988, pp. 281-316.

[11] Commandino, *Archimedis Opera* (cit. n. 9), dedicatory letter of ff. 3, not numbered, f. 1r*: «[Mathematicae disciplinae] non solum per seipsas, id, quod spectant, assequuntur; verum etiam reliquis scientiis clarissimam lucem afferentes, ut earum multo faciliorem cognitionem capiamus, efficiunt. Si enim in naturae obscuritatem (ut ab ea potissimum ordiamur) intuebimur: ne minimam quidem partem reperiemus, non sexcentis obstructam difficultatibus; in qua quid verisimillimum sit, invenire, non mediocris ingenii, et summae felicitatis esse indicandum est. Mundus ipse utrum nunquam non fuerit, an aliquando genitus sit, inter non minorum gentium philosophos, sed philosophiae ipsius parentes Platonem, et Aristotelem summa fuit dissentio. De principiis autem rerum, e quibus omnia oriuntur, quando tres, aut ad summum quatuor philosophi, qui eadem sentirent, inventi sunt? Nam de motu, de inani, de tempore, de elementis ipsis, et eorum natura, variae, atque inter se dissidentes philosophorum sententiae facile ostendunt, physiologiam quibusdam potius coniecturis, quam firmissimis argumentationibus niti; optimeque nobiscum agi, si, quid in ea maxime probabile sit, intelligamus.»

[12] CICERO, *De Oratore*, I, 68: «Philosophia in tris partis est tributa, in naturae obscuritatem, in disserendi subtilitatem, in vitam atque mores». In the following quotation Commandino refers to «ratio disserendi».

always existed or was created at some time. Regarding the principles whence everything originates, when were found three or at most four philosophers in agreement among themselves?[13] For on motion, the void, time, the very elements and their nature, it is easy to exhibit several discordant opinions of philosophers. Natural science relies on some kind of conjectures rather than on firm argumentations; and we act best if we understand what is most probable in it.

This passionate defence of mathematics contains a valuable picture of the relations and hierarchy among disciplines. The reference to motion and the void are of particular concern to us here: can we identify whom Commandino had in mind? Benedetti is certainly a possibility: his *Resolutio* on Euclid seems to have appeared in Venice at the same time when Commandino was there with his Cardinal Ranuccio Farnese. Further, Benedetti took service at Parma as lector of mathematics to the Duke at the same time when Commandino's edition of Archimedes was being published: the Duke of Parma and Piacenza was Ottavio Farnese, brother of Commandino's patron. Moreover, the Urbino mathematician knew Benedetti's teacher Tartaglia, who mentioned their conversations in the dedicatory letter to the second part of the 1556 *General Trattato dei pesi e delle misure*. Tartaglia himself in *La Travagliata Inventione* referred to a new theory of fall different from that proposed by Aristotle.[14]

However, the passage above suggests that Commandino had some philosopher in mind, rather than mathematicians. My conjecture is that among his sources was one of the most radical early critics of Aristotle, Johannes Philoponus, active in Alexandria in the sixth century. His impact on sixteenth-century natural philosophy and Galileo – who mentioned him in the 1590 *De Motu* – has been recently underlined by Charles Schmitt. Philoponus wrote extensive commentaries on several treatises by Aristotle. With regard to the issues under consideration, he attacked several propositions ranging from projectile motion to the alleged impossibility of motion in a vacuum. Philoponus' commentaries to Aristotle are referred to by Commandino in his Euclid edition. Although this edition appeared

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[13] CICERO, *Academicae Quaestiones*, II, *Lucullus*, 36, 117: «Tantum de principiis rerum, e quibus omnia constant, videamus quem probet; est enim inter magnos homines summa dissensio».

[14] N. TARTAGLIA, *La seconda Parte del General Trattato di Numeri, et Misure*, Venezia, Curzio Troiano, 1556, dedicatory letter dated 3 April 1556. N. TARTAGLIA, *La Travagliata Inventione*, Venice, Curzio Troiano, 1551, unpaginated dedicatory letter, transl. in CLAGETT, *Archimedes* (cit. n. 6), pp. 573-575.

several years later, in 1572, it is likely that Commandino was familiar with Philoponus' work from his stay at Padua, where he studied philosophy and medicine for several years about 1540. Indeed, also the other issues mentioned by Commandino, namely whether the world had always existed, time, and the nature of the elements, had come under the scrutiny of Philoponus.[15]

In the 1558 dedicatory letter to Ranuccio Farnese, Commandino forcefully emphasized the «dignitas» and privileged status of mathematics over the other two disciplines constituting theoretical philosophy, namely natural science and metaphysics. This status would descend not from the subject matter, as from the method of demonstration.[16] He then went on to stress the role of mathematics prior to other inquiries:[17]

What about Aristotle, whom philosophers of our age always hold in their hands? What did that excellent man write on logic or natural philosophy, that a stranger in the mathematical disciplines will dare to engage in? Wherefore in my opinion no one will profess philosophy rightly, before having studied and laboured very much indeed in these most noble arts. I see that Galen, prince of the doctors, did not think differently in that tract entitled *Philosophus*.[18]

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[15] F. COMMANDINO, *Euclidis Elementorum Libri XV*, Pesaro, apud Camillum Francischinum, 1572; the initial pages are not numbered and include the *Privilegium*, ff. 1*r**-1*v**; dedicatory letter to the Duke of Urbino, ff. 2*r**-3*r**; *Prolegomena*, ff. 3*v**-7*r** (Philoponus is mentioned on f. 6*r**). See also the Italian translation with the collaboration of Commandino's son in law VALERIO SPACCIOLI, *De gli Elementi d'Euclide Libri Quindici*, Urbino, Domenico Frisolino, 1575, f. 6*r*.* C. B. SCHMITT, «Philoponus' Commentary on Aristotle's *Physica* in the Sixteenth Century», R. SORABJI (ed.), *Philoponus and the Rejection of Aristotelian Science*, London, Duckworth, 1987, pp. 210-230. The useful Appendix contains a list of 16th-century editions of Philoponus. See also R. SORABJI, «John Philoponus», ib., pp. 1-40, esp. pp. 6-14 (on the creation of the universe and motion) and 24-26 (on the fifth element). M. WOLFF, «Philoponus and the Rise of Preclassical Dynamics», ib., pp. 84-120. Other relevant commentators include Avempace, St. Thomas, and John Duns Scotus. On Galileo see moreover Drake and Drabkin, *Mechanics* (cit. n. 4), p. 380. See also WEISHEIPL, *Nature and Motion in the Middle Ages* (cit. n. 8) ch. 6.

[16] COMMANDINO, *Archimedis Opera*, f. 1*v**: «Cum igitur e tribus scientiis, quae vere scientiae appellantur, et physiologia, et prima philosophia in probabilitate versentur, restant mathematicae disciplinae, quae non tam subjecta materia, quam certarum argomentationum, quas in medium afferunt, dignitate, reliquis scientiis iure optime antecellunt.» See P. DEAR, *Mersenne and the Learning of the Schools*, Ithaca, Cornell University Press, 1988, pp. 38-39 for a brief comparison with Clavius.

[17] COMMANDINO, *Archimedis Opera*, f. 1*v**: «Quid Aristoteles? Quem nostrae memoriae philosophi nunquam non in manibus habent. Num quae vir ille summus, vel in disserendi ratione, vel in naturae obscuritate scripsit, hospes in mathematicis disciplinis attingere audebit? Quare mea sententia nemo vere philosophari poterit, nisi idem prius in his nobilissimis artibus plurimum studii, plurimumque operae posuerit. Nec aliter sensisse video Galenum medicorum principem in eo libello, qui Philosophus inscribitur.»

[18] GALEN, *Omnia quae extant in Latinum Sermonem conversa*, Venice, ex tertia Iuntarum

Despite the reference to Aristotle as *vir summus*, Commandino reaffirms here the precedence of mathematics over logic and natural philosophy: the mathematical disciplines are the key to knowledge, theoretical as well as practical, as he proceeds to explain in the letter.[19]

A few years later, in a dedicatory letter to Ranuccio's brother, the influential Cardinal Alessandro Farnese, Commandino presents a slightly different picture of the map of knowledge. This time the emphasis is on the interdependence of the theoretical parts of philosophy and to the relevance of natural science and metaphysics to the solution of mathematical problems:[20]

I hoped that my work would not be disagreable not only to mathematicians, but also to those who find delight in natural philosophy, for many problems most worthy of investigation pertaining to both sciences suggest themselves to the readers. And this should not be considered to be at all strange. In fact in the human body all parts suited to certain functions are related and connected among themselves by divine order, and that extraordinary harmony among them, which the Greeks call «agreement», shines out. Likewise any one of the three philosophies (to use Aristotle's word) exclusively concerned with the truth, although they are governed by their own aims, by itself is somewhat imperfect and cannot be fully understood without the others. Moreover, many extremely difficult problems of mathematicians could in no way be disentangled before the explanation of this matter.

This survey of Commandino's attitudes towards the role of

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editione, 1556, 4 vols., vol. 1, *Isagogici Libri*, f. 6*r*, *Si quis optimus medicus est, eundem esse philosophum* (refers to the utility of astronomy for medicine).

[19] It may worth recalling here the debate on mathematics and syllogistic explored by Giacobbe (cit. n. 3), and Commandino's interest in instruments, documented by Rose, *Italian Renaissance* (cit. n. 4), esp. p. 204. N. Jardine, «Epistemology of the sciences», in Schmitt and Skinner (eds.), *The Cambridge History of Renaissance Philosophy*, Cambridge, Cambridge University Press, 1988, pp. 685-711.

[20] F. Commandino, *Liber de Centro Gravitatis Solidorum*, Bologna, ex officina Alexandri Benacii, 1565, dedicatory letter, 3 not numbered folii, f. 2*r**: «Quem meum laborem non mathematicis solum, verum iis etiam, qui naturae obscuritate delectantur, non iniucundam fore speravi: multa enim προβλήματα cognitione dignissima, quae ad utramque scientiam attinent, sese legentibus obtulissent. Neque id ulli mirandum videri debet. Ut enim in corporibus nostris omnia membra, ex quibus certa quaedam officia nascuntur, divino quodam ordine inter se implicata, et colligata sunt: in iisque admirabilis illa conspiratio, quam σύμπνοιαν graeci vocant, elucescit, ita tres illae Philosophiae (ut Aristotelis verbo utar) quae veritatem solam propositam habent, licet quibusdam quasi finibus suis regantur: tamen earum unaquaeque per se ipsam quodammodo imperfecta est: neque altera sine alterius auxilio plane comprehendi potest. Complures praeterea mathematicorum nodi ante hac explicatu difficillimi nullo negotio expediti essent».

mathematics in relation to other disciplines, and especially to philosophy, leads to some tentative conclusions. Despite his caution in the commentaries of his austere and authoritative editions, the Urbino mathematician consciously challenged a system of knowledge in which mathematics was not placed at least at the same level as other disciplines. One can detect a shift of emphasis from 1558, when mathematics is given pride of place, to 1565, when the interdependence among disciplines becomes the central theme. The situation in the universities was probably one of his concerns, as he complained in the dedicatory letter to the 1572 Euclid.[21] However, Commandino did not like to engage in the battle in a fashion similar to that of the Copernican Benedetti. From my reading he appears to have held positions similar to those later endorsed by Clavius. In a passage from the *Modus quo disciplinae mathematicae in scholis Societatis possent promoveri*, of the 1580s, for example, the Jesuit stated: «It is useful that the pupils should understand that [the mathematical disciplines] are useful and necessary for rightly understanding the rest of philosophy».[22] Although Commandino's texts were certainly well known to Clavius, I am not suggesting here that the Urbino mathematician was his only or principal source.[23] In addition, it is conceivable that the analogies in their views may have

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[21] COMMANDINO, *Euclidis Libri* (cit. n. 15), f. 2*r**: «Exulat iam, publicisque fere exclusum est gymnasiis nobile hoc, et pulcherrimum matheseos studium.» It is worth mentioning that in the *Prolegomena*, f. 3*v**, Commandino placed mathematics in an intermediate position as regards nobility between natural and «divine» science. A different – and in my view untenable – interpretation of Commandino is in E. I. RAMBALDI, «John Dee and Federico Commandino: An English and an Italian Interpretation of Euclid during the Renaissance», *Rivista di Storia della Filosofia*, *44*, 1989, pp. 211-247.

[22] *Monumenta paedagogica Societatis Jesu quae primam Rationem Studiorum anno 1586 praecessere*, Madrid, 1901, quoted and transl. in A. C. CROMBIE, «Mathematics and Platonism in the sixteenth-century Italian Universities», Y. MAEYAMA and W. G. SALTZER (eds.), *Prismata*, Wiesbaden, Steiner, 1977, pp. 63-94, on pp. 65-66; P. DEAR, «Jesuit mathematical science and the reconstitution of experience in the early seventeenth century», *Studies in History and Philosophy of Science*, *18*, 1987, pp. 133-175. P. DEAR, *Mersenne* (cit. n. 16), pp. 44-46. Further material relevant to this tentative thesis can be found in C. CLAVIUS, *Euclidis Elementorum Libri XV*, Rome: apud Vincentium Accoltum, 1574, *Prolegomena* (pages are not numbered), esp. the section «Nobilitas atque praestantia scientiarum mathematicarum». F. A. HOMANN, «Christopher Clavius and the Renaissance of Euclidean Geometry», *Archivium Historicum Societatis Jesu*, *52*, 1983, pp. 233-246. A general background on the following discussion is in W. A. WALLACE, *Galileo and his sources* (cit. n. 2), pp. 157-165; W. A. WALLACE, «Traditional Natural Philosophy», in C. B. SCHMITT and Q. SKINNER (eds.), *The Cambridge History of Renaissance Philosophy* (cit. n. 19), pp. 201-235. P. ROSSI, *I Filosofi e le Macchine. 1550-1700*, Milano, Feltrinelli, 1962.

[23] E. KNOBLOCH, «Christoph Clavius. Ein Namen- und Schriftenverzeichnis zu seinen *Opera Mathematica*», *Bollettino di Storia di Scienze Matematiche*, *10*, 1990, pp. 135-189, contains an useful index of Clavius' *Opera*. In this regard probably Francesco Maurolyco deserves closer scrutiny.

stemmed partly from different concerns; they may involve psychological factors, Jesuit educational policies, intellectual reform plans, and social motivations. If my interpretation is correct, within the movement associated with the Archimedean revival, Commandino would occupy a distant position from that of his pupil Guidobaldo dal Monte.

In *Mechanicorum Liber* and *Archimedis Paraphrasis* dal Monte presented himself as a scholar in mechanics rather than as a pure mathematician. This difference with respect to Commandino allowed the Marquis to find in Aristotle a source and a «noble ancestor», since the *Quaestiones Mechanicae* were then attributed to the Philosopher and constituted the most ancient surviving tract on the subject.[24] Guidobaldo exploited this ploy repeatedly. Although Archimedes is the unchallenged prince of mechanicians, Aristotle is by no means criticized, as the following passage from the dedicatory letter to Francesco Maria II in *Mechanicorum Liber* shows:[25]

> Let us rather follow Aristotle, the leader of the philosophers, whose burning love for mechanics is sufficiently proved by the very acute *Questions of Mechanics* which he gave to posterity. In this achievement he greatly surpassed Plato.

Here dal Monte's concern was to rebuke those who despised mechanics. Among them he included Plato, who wanted to guard «the secret misteries of philosophy» without divulging them through mechanics. In *Archimedis Paraphrasis* Guidobaldo attempted a reconciliation between Aristotle and Archimedes:[26]

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[24] The *Quaestiones Mechanicae* are now attributed to the immediate circle of Aristotle. M. Nussbaum, (ed.), G. E. L. Owen, *Logic, Science, and Dialectic*, Ithaca, Cornell University Press, 1986, ch. 18, «Aristotelian Mechanics». P. L. Rose and S. Drake, «The Pseudo-Aristotelian Questions of Mechanics in Renaissance Culture», *Studies in the Renaissance*, *17*, 1971, pp. 65-104. Aristotle left no significant work on mathematics. However see T. Heath, *Mathematis in Aristotle*, Oxford, Oxford University Press, 1979. On the disciplinary difference between Commandino and dal Monte see *Mechanicorum Liber*, dedicatory letter, transl, in Drake and Drabkin, *Mechanics in Sixteenth-Century Italy* (cit. n. 4), p. 245: «And yet in his endless concern with the elucidation of other parts of mathematics, [Commandino] either left mechanics completely untreated or touched on it just casually.» W. R. Laird, «The scope of Renaissance mechanics», *Osiris*, Second Series, vol. 2, 1986, pp. 43-68.

[25] G. dal Monte, *Mechanicorum Liber*, Pesaro, apud Hieronymum Concordiam, 1577, dedicatory letter; I have slightly amended the transl. in S. Drake and I. E. Drabkin, *Mechanics in Sixteenth-Century Italy* (cit. n. 4), p. 243.

[26] G. dal Monte, *In duos Aequeponderantium Libros Paraphrasis*, Pesaro, apud Hieronymum Concordiam, 1588, p. 4, transl by P. L. Rose, *The Italian Renaissance of Mathematics* (cit. n. 4), p. 234.

At the beginning of the *Mechanica* Aristotle publishes many things highly necessary for the understanding of mechanics. Following him, Archimedes made more explicit and plain the principles of mechanics. Nor does Aristotle stand diminished by this, for he explained well the causes of the problems that he discussed... That Archimedes seems to have followed Aristotle is clear not only for the reasons already stated, but also because if we consider the postulates of Archimedes, we will find that Archimedes put them in the place of those mechanical principles expounded by Aristotle.

My concern here is not to examine the accuracy of Guidobaldo's association of the *Quaestiones*, where considerations on motion recur often, with the strictly statical Archimedean approach. Rather, I wish to emphasize how mechanics allowed dal Monte to adopt a strategy not available to the pure mathematician Commandino. Even taking this disciplinary asymmetry into account, however, one finds in dal Monte other passages suggesting a reverence for Aristotle and an attitude towards the relationships between mathematics and philosophy in contrast with those of Commandino. In *Paraphrasis Archimedis*, for example, the Marquis endorsed a disciplinary division of competences, itself an Aristotelian element:[27]

Professors of mathematics and philosophy agree on this, because when they treat topics relating to philosophy, they extol Aristotle with praise. But those who aim to discuss mathematics immediately raise the praise of Archimedes.

In this passage dal Monte adopts a different tone from that which we find in Commandino's dedicatory letters to *De centro gravitatis* and especially to the 1558 edition of Archimedes. These works, it is worth emphasizing, were addressed to very similar audiences and belong to the same literary genres. In dal Monte one can detect an underlying Aristotelian orthodoxy which is not challenged by mathematics. Before seeing in a dramatic way the results of this attitude in the study of the reception of the 1604 nova, it is useful to discuss here his 1588 letter to the Urbino philosopher Federico Bonaventura.

Bonaventura was active at the Urbino court as philosopher and diplomat. His interests were broadly speaking philological and his works reveal a remarkable display of erudition. The occasion of the

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[27] G. DAL MONTE, *Paraphrasis Archimedis* (cit. n. 26), p. 5, transl. in P. L. ROSE, *The Italian Renaissance of Mathematics* (cit. n. 4), p. 235.

correspondence with dal Monte seems to have arisen from Bonaventura's interest in tides, an interest testified also by his correspondence with the bibliophile Gian Vincenzo Pinelli at Padua.[28] Guidobaldo's letter contains a criticism of Andrea Cesalpino's theory that tides are due to the motion of the earth; the same motion would be responsible for the phenomenon of trepidation, which was commonly attributed to the heavens. This letter, which is reproduced in the Appendix, contains a famous line in which Guidobaldo endorses the idea that the earth does move. A satisfactory interpretation requires that attention be paid to the whole passage. The Marquis is exhorting Bonaventura to publish the first two books of his work, which would provide the occasion for Guidobaldo to quote it – probably in relation to the criticism of Cesalpino – for the following reason:[29]

> I have a whim that the earth does move, and this because of Aristotle. But these are matters about which (as you know better than me) one ought to think carefully before publishing, and I would not let them out without having in advance the consent of the best philosophers.

Although dal Monte was writing to a philosopher sympathetic to Aristotle and may have been overpolite, the difference in tone with Commandino and especially Benedetti is very noticeable. Indeed, despite the considerations on the addressee, I believe that Guidobaldo's statements can be taken at face value. The hierarchical order of disciplines, or at least the principle of non-interference between them, is in agreement with other statements of his discussed in this essay. At this point one may wonder who were the philosophers Guidobaldo had in mind: I restrict my research to two names. One was Bonaventura himself, as Guidobaldo stated below in the same letter. The other, more interesting figure, was Jacopo

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[28] Urbino, Biblioteca Universitaria, Fondo Comune, busta 93, fasc. 5, f. 127, Pinelli to Bonaventura, 7 October 1594. Pinelli included a list of authors on tides not mentioned by Bonaventura (the list does not appear to have survived). In the same letter Pinelli refers to a silver pen ordered to Simone Barocci. G. MAZZUCCHELLI, *Gli Scrittori d'Italia*, vol. 2, part III, Brescia, 1762, mentions the work *De Aestu Maris* by Bonaventura. On Bonaventura see *Dizionario Biografico degli Italiani* and the more balanced account in *Dictionary of Scientific Biographies*. P. GUALDO, *Vita Ioannis Vincentii Pinelli*, Augsburg, 1607.

[29] G. dal Monte to Federico Bonaventura, 8 December 1588, see Appendix. A. CESALPINO, *Paripateticorum Quaestionum Libri Quinque*, Venice, apud Iuntas, 1571, f. 59-61. C. COLOMBERO, «Il pensiero filosofico di Andrea Cesalpino», *Rivista Critica di Storia della Filosofia, 33*, 1977, pp. 269-284.

Mazzoni, who was to be invoked by dal Monte in 1604 in connection with the nova.

The specific theory about the motion of the earth endorsed by dal Monte can be identified from the reference to Aristotle and from some manuscripts annotations recently published. In the preface to *Archimedis Paraphrasis*, significantly dating from the same year as the letter, Guidobaldo mentions the centre of the earth and of the universe referring to *De Caelo*. In the relevant passage Aristotle claims that the centre of the earth coincides with the centre of the universe, and that heavy bodies tend to the centre of the universe; thus it is only somewhat incidentally that they also tend to the centre of the earth, since the two centres coincide. It is easy from these premisses to infer that the displacement of a weight on the surface of the earth would change its centre of gravity; hence the earth would move in order for its centre of gravity to coincide again with the centre of the universe. This inference is not drawn in *Archimedis Paraphrasis*, but can be found in a manuscript preserved at the Bibliothèque Nationale, Paris.[30] Similar theories were put forward by a host of scholars ranging from John Buridan and Albert of Saxony in the fourteenth century, to Paolo Sarpi.[31] Guidobaldo's views about the motion of the earth are emblematic of his attitude: Aristotle and Archimedes are brought together and complement each other.

Which conclusions can be drawn from this survey of three protagonists of the Archimedean revival? First, besides their shared admiration for Archimedes, it is possible to identify a wide range of attitudes to the restoration of Greek mathematics. Despite their «courtier gestalt», Benedetti was militantly engaged against the philosophers; Commandino saw mathematics as a crucial factor in the reshaping of the map of knowledge and of disciplinary hierarchies; dal Monte preferred to emphasize the division of competences between disciplines, so that his mathematics would not challenge unduly other fields, especially philosophy. It is also useful to compare their attitudes to the medieval tradition associated with Jordanus Nemorarius and to Tartaglia. The Marquis and,

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[30] G. DAL MONTE, *Archimedis Paraphrasis* (cit. n. 26), p. 11. ARISTOTLE, *De Caelo*, II, 14. The manuscript is G. DAL MONTE, *Meditatiunculae de rebus mathematicis*, Bibliothèque Nationale, Paris, Fonds Latin 10246, f. 54*r*, published by E. GAMBA, *Le Scienze a Urbino nel Tardo Rinascimento* (cit. n. 4), p. 184.

[31] P. DUHEM, *Le systeme du Monde*, Paris, Hermann, 1958, vol. 9, chapter 18. L. SOSIO, «I *Pensieri* di Paolo Sarpi» (cit. n. 8), p. 384, «Pensiero» 499.

surprisingly, Benedetti were highly dismissive of these «lower mathematicians». Commandino, however, seems to have held different views, probably as a consequence of his stronger interests in disciplines other than mechanics. In 1558 he published *Iordani Planisphaerium* (Venice: Aldus), and we have already seen that he knew Tartaglia personally; Commandino also urged his friend Tommaso Leonardi to contact the Brescia mathematician for a problem involving the cubed root of a binomial. Further, Commandino was highly interested in non-Greek mathematics, as one can evince from his projects of publishing works by Leonardo Fibonacci, Luca Pacioli, and appreciation of the Bologna algebraist Rafael Bombelli.[32] Justifications for these different views cannot be easily ascribed to a single factor, either social or intellectual. A recent work has tried to characterise the Urbino school as «conservative» as a result of the high social status of its members. Although this interpretation may be plausible in the case of dal Monte, Benedetti and Commandino do not fit into this scheme. Concerning Commandino, I believe that his reference to Philoponus suggests that we may have to pay more attention to the years he spent at Padua as a student of philosophy and medicine. Those years, together with those spent at the lively Roman courts, were probably decisive in forging a relatively sophisticated and critical approach to philosophy. Significantly, it seems that Commandino studied at the University of Padua for about a decade, while dal Monte spent only one year there.[33]

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[32] BENEDETTI, *Speculationes* (cit. n. 8), pp. 147-148, transl. in DRAKE and DRABKIN, *Mechanics* (cit. n. 4), pp. 174-175; DAL MONTE, *Archimedis Paraphrasis* (cit. n. 26), pp. 18-19, transl. in ROSE, *Italian Renaissance* (cit. n. 4), pp. 235-236; see also ib., p. 208 and P. L. ROSE, «Plusieurs manuscrits autographes de Federico Commandino a la Bibliothèque Nationale de Paris», *Revue d'Histoire des Sciences*, *24*, 1971, pp. 299-307, esp. p. 307. A different reading of Commandino is in Biagioli, «Social Status» (cit. n. 4), esp. pp. 57-67; for the expression «courtier gestalt» in relation to the Urbino school see p. 60. Biagioli claims that the Urbino school's disdain of fellow mathematicians not proficient in Greek, philology, and the *belle lettere*, represents «a strategy for the preservation of social distinctions» (p. 61).

[33] ROSE, *Italian Renaissance* (cit. n. 4), p. 187; GAMBA and MONTEBELLI, *Le scienze a Urbino* (cit. n. 4), p. 17. B. BALDI, «Vita di Federico Commandino» (cit. n. 10). Commandino later took his degree at Ferrara. On the situation at the universities see C. B. SCHMITT, *The Aristotelian tradition and Renaissance universities*, London, Variorum Reprints, 1984. J. GASCOIGNE, «A Reappraisal of the role of universities in the scientific revolution», in D. LINDBERG and R. S. WESTMAN, *Reappraisals of the Scientific Revolution*, Cambridge, Cambridge University Press, 1990, pp. 207-260.

3. Earthly machines and the science of motion

This section presents a picture – by no means exhaustive – of dal Monte's work and shows that the labelling of the Marquis as *tout court* «Aristotelian» cannot be accepted without qualifications. His practice in mechanics led him to endorse positions different from those of the Philosopher and to debate problems independently of classic philosophical concerns. I start from the role of machines and precision instruments; then I consider the problem of accidents and the science of motion; lastly I raise the issue whether concerns derived from Greek mathematics were suitable to the study of nature.

In the dedicatory letter to Francesco Maria II in *Mechanicorum Liber*, dal Monte stated that «mechanics can no longer be called mechanics when it is abstracted and separated from machines.» The union of theory and practice was a relatively common theme in that period, and the opening line of the dedicatory letter stresses precisely this aspect:[34] «There are two qualities, Illustrious Prince, that are usually very effective in adding to men's power, namely, utility and nobility.» Nobility was guaranteed by the subject matter and the certainty of its demonstrations, «as Aristotle on occasion asserts», whilst utility was clearly linked to the science of machines. However, some contemporary readers found difficulties precisely on this point.

Around 1580 the superintendent to the fortifications of the Republic of Venice, Count Giulio Savorgnan, commissioned an Italian translation of the *Mechanicorum Liber* to Filippo Pigafetta. They belonged to a circle including the erudite Gian Vincenzo Pinelli and the provveditore to the Venetian arsenal Giacomo Contarini. The dichotomy between theory and practice emerged as an important issue in the debates between this composite group and the Marquis. In a number of letters probably occasioned by the Italian translation of the book, Savorgnan and Contarini objected that dal Monte's theorems on pulleys were contradicted by their own experiences. Pressed by less theoretically-minded friends, Guidobaldo had to provide several explanations. First, he claimed that instruments had to be small, thus contradicting to some extent the conclusions in the first question of the *Quaestiones Mechanicae* («Why are larger balances more accurate than smaller?»). Pulleys, he explained, are best made of brass, with very thin iron axes, and must

[34] Quotations from Drake and Drabkin, *Mechanics* (cit. n. 4), pp. 241 and 245.

be well built, so that they do not shake and can be turned with a breath. Secondly, dal Monte drew a distinction between the force making equilibrium to a weight and the force capable of moving it. This distinction was present in the 1577 Latin edition, but it was emphasized precisely in relation to the pulley in a passage added by Pigafetta to the 1581 Italian edition.[35] Pressed further by Contarini, dal Monte had to reiterate his point and provide clear diagrams explaining the arrangements of the pulleys. Considering that a balance meant to prove one of dal Monte's theorems was seen by Pigafetta in Pinelli's hands, one can surmise that, short of dispatching his own instruments, little could convince the group around Padua and Venice.[36] Thus, the machines Guidobaldo had in mind in his preface turned out to be very different indeed from the Venetian war machines: dal Monte's were precision instruments built with a clear theoretical aim in mind, no doubt under his own supervision, by the Urbino instrument maker Simone Barocci. The Venetians, by contrast, had more practical concerns and went as far as proposing purely empirical rules for the pulley, for example, without taking theoretical considerations into account.[37]

These observations on the «practical» and «theoretical» machines employed in the arsenal or in Pinelli's library, respectively, lead us to the relations between theory and practice. In the case of equilibrium Guidobaldo felt confident that the difficulty arising from the contingency and irregularity of matter could be overcome. Passing on to motion, however, his confidence vanished. From the important correspondence with Galileo on the isochronism of pendular oscillations it appears that the problem of experimental practice was discussed in some detail. Unfortunately dal Monte's letters are not extant, but their contents can be partially inferred from Galileo's reply. We know, for example, that the Marquis probably tried to

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[35] DRAKE and DRABKIN, *Mechanics* (cit. n. 4), pp. 300 and 308.

[36] A. FAVARO, «Due lettere inedite di Guidobaldo del Monte a Giacomo Contarini», *Atti del Reale Istituto Veneto di Scienze, Lettere e Arti, 59*, 1899-1900, II, pp. 303-312. Biblioteca Ambrosiana, Milano, Ms 121 Sup, ff. 4-24; partial transcriptions and translations in A. G. KELLER, «Mathematicians, mechanics, and experimental machines in Northern Italy in the sixteenth century», in M. CROSLAND, *The emergence of science in Western Europe*, London, Macmillan, 1975, pp. 15-34. C. PROMIS, «Biografie d'ingegneri militari italiani dal secolo XIV alla metà del XVIII», *Miscellanea di Storia Italiana, 14*, 1874, pp. 5-858 (see G. Savorgnan). It appears that in the summer of 1579 dal Monte went to Padova; see his letter to Giulio Giordani, Biblioteca Oliveriana, Pesaro, Ms 426, ff. 151-152, dated Pesaro, 14 July 1579, announcing his journey to Padova within ten days.

[37] On the role of instrument makers in the Duchy of Urbino see GAMBA and MONTEBELLI, *Le Scienze a Urbino nel Tardo Rinascimento* (cit. n. 4).

«replicate» Galileian pendular oscillations by displacing a ball from the equilibrium position at the bottom of a bowl. Galileo objected to the abolition of the pendulum and claimed that the surface of the bowl may have been neither smooth, nor «perfettamente circolare». At the end of his reply he expressed his agreement with the Marquis that «when we start to consider matter, the propositions considered in abstract by the geometer begin to be altered because of the contingency of matter; since one cannot assign certain science to such propositions so altered, the mathematician is freed from speculating on them».[38]

According to Guidobaldo, motion was plagued by too many accidental perturbations to become the subject of a true science. In his publications he carefully avoided this issue. It is therefore remarkable that in some manuscript annotations, published for the first time last century, the Marquis discussed an experiment about projectile motion. His analysis deserves close inspection.

Guidobaldo studied the trajectory of a body thrown above the horizontal «whether by sling, or by artillery, or by hand, or by any other instrument», claiming that the path would be similar to the shape assumed by a slack rope suspended below the horizontal, since both curves result from the composition of natural and violent motions. The shape would be similar to the parabola and hyperbola, namely two of the few symmetric curves known at the time. It is noteworthy that the Marquis referred to an *esperienza* «made by taking a ball wet with ink and throwing it along the surface of a table which stands almost perpendicular to the horizontal. Although the ball will bounce along, it will mark some points from which it will be clear that, as it ascends, so also it descends.»[39] In the theoretical discussion of the result dal Monte explained the symmetric shape of the trajectory by having recourse again to the combination of natural and violent motions, though the expression «mixed motion» does not occur. This combination, whereby

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[38] G. GALILEI, *Opere*, ed. by A. Favaro (Firenze, 1890-1909), 20 vols. (hereafter *GOF*), *10*, pp. 97-100, Padova 29 November 1602, esp. p. 100. The entire passage reads: «Perquanto al suo quesito stimo benissimo detto quanto ne dice V.S. Ill.ma, e che quando cominciamo a concernere la materia, per la sua contingenza si cominciano ad alterare le proposizioni in astratto dal geometra considerate; delle quali così perturbate siccome non si può assegnare certa scienza, così dalla loro speculazione è assoluto il matematico.» ARISTOTLE, *Topica*, books I and II. N. KOERTGE, «Galileo and the problem of accidents» (cit. n. 2).

[39] G. LIBRI, *Histoire des Sciences Mathématiques en Italie*, 4 vols. (Paris, 1838-1841), vol. 4, pp. 397-398 (containing other important texts by dal Monte); transl. in ROSE, *The Italian Renaissance of Mathematics* (cit. n. 4), p. 228.

projectile trajectories are nowhere rectilinear, represents an important departure from orthodox Aristotelian teaching, according to which motions do not mix. Possibly the Marquis saw his explanation as contrasting that of the much despised Brescia mathematician Niccolò Tartaglia, according to whom two branches of the trajectory are rectilinear, rather than Aristotle himself.[40]

It is well known that in a passage of *Two New Sciences* Galileo referred to Guidobaldo's observations about the trajectory of a body thrown on an inclined plane and the shape of a suspended thread. Despite the superficial similarity between their discussions, however, fundamental differences should not be overlooked. First, Galileo endorsed parabolas unequivocally, whilst dal Monte considered also hyperbolas. Secondly, even restricting one's attention to parabolas, their components varied for the two mathematicians: Guidobaldo's parabolas resulted from natural motion progressively overtaking violent motion, whilst Galileo's resulted from the composition of uniform rectilinear and uniformly accelerated motions. As far as we know, the Marquis accepted neither the former nor the latter. Thirdly, Galileian parabolas were the central element of a new science, whilst Guidobaldo's experiments have a less defined status and it is doubtful whether in his views they led at all to a *science*. Lastly, dal Monte's inclined plane was almost vertical, whilst Galileo's was almost horizontal. This apparently purely technical detail is indicative of greater differences, since Galileo possessed a theory of the inclined plane, whereas the Marquis had notoriously failed in this issue.[41]

This problem leads us to some brief observations on the usage of Greek and especially Archimedean mathematics in the investigation

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[40] On this issue see DRAKE and DRABKIN, *Mechanics in Sixteenth-Century Italy* (cit. n. 4), pp. 80, 84, 100-104 on Tartaglia; pp. 80, 152, 189, and 234 on Benedetti's critique of Tartaglia's somewhat ambivalent views. See also the discussion on projectile trajectories in B. BALDI, *In Mechanica Aristotelis Problemata Exercitationes* (Mainz, 1621), p. 4; the trajectory is divided into three portions, the first rectilinear due to violent motion, the second curvilinear due to mixed motion, and the third also rectilinear due to natural motion. A. GABBEY, «The case of mechanics: One revolution or many?», in D. LINDBERG and R. WESTMAN (eds.), *Reappraisals of the Scientific Revolution* (cit. n. 33), pp. 493-528.

[41] *GOF*, *8*, pp. 185-186 (*Discorsi*). R. NAYLOR, «The evolution of an experiment: Guidobaldo del Monte e Galileo's *Discorsi* demonstration of the parabolic trajectory», *Physis*, *16*, 1974, pp. 323-346. The author discussed and tried to replicate the experiments; his replication of Galileo's trial is based on an incorrect translation of the relevant passage, since Galileo's inclined plane was closer to the horizontal than to the vertical. Unfortunately this error affects considerably the discussion of the *Two New Sciences* experiment. Is it possible that the experiment with the inclined plane was suggested by Galileo to Guidobaldo rather than the other way round?

of nature. It has become quite common to state that the Marquis was blinded by his admiration for the Greeks to such an extent that he failed to recognize that the theory of the inclined plane provided by Pappus was incorrect, whilst that of Jordanus was right. The matter, though, is more complex. Pappus tried to reduce the inclined plane to the principle of the lever in an ingenious way starting from the assumption that a finite force is required to move a body on a horizontal plane. Guidobaldo endorsed this assumption, even if as a consequence of Pappus' theory an infinite force would be required to raise a body vertically. It will be clear to all those who look at the demonstration by Pappus, however, that Guidobaldo's position was not the result of blind adherence to a Greek model. Rather, it stemmed from the acceptance of common assumptions, from the shared aim of reducing the problem to the balance, and from the attention paid to the formal character of the demonstration. By contrast, the demonstration by Jordanus was incorrect, its general aim was not clearly stated, and the solution implied that no force was required to move a body horizontally. At a time when great emphasis was laid not just on results, but on the certainty and rigour of the method of demonstration as well, one wonders whether it makes sense to evaluate simply the solutions provided by Pappus and Jordanus in isolation from their respective presuppositions and proofs.[42]

This specific problem is linked to the broader question of how preoccupations about rigour affected the practice of mathematicians. Guidobaldo, for example, notoriously claimed that the directions of the weights of a balance are not parallel among themselves, since they converge to the centre of the world. Archimedes ignored this issue in his discussion of the balance. In *On Floating Bodies*, however, he considered the verticals along which heavy bodies fall as converging to the centre of the earth, and this was with all

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[42] JORDANUS NEMORARIUS, *Opusculum de Ponderositate*, Venice, Curtius Troianus, 1565. N. TARTAGLIA, *Quesiti et Inventioni Diverse*, Venice, Curtius Troianus, 1546, eigth book, on the science of weights. DRAKE and DRABKIN, *Mechanics* (cit. n. 4), pp. 111-143. *Archimedis Paraphrasis*, pp. 18-19, transl. in ROSE, *The Italian Renaissance* (cit. n. 4), pp. 235-236. PAPPUS OF ALEXANDRIA, *Mathematicae Collectiones*, Pesaro, apud Hieronymum Concordiam, 1588, pp. 311-312. The relevant passage was inserted by Pigafetta in the Italian translation; the translation in DRAKE and DRABKIN, *Mechanics* (cit. n. 4), pp. 325-326, is wrong (point «H» takes no part in the proof). Concerning Tartaglia and Benedetti see DRAKE and DRABKIN, *Mechanics*, pp. 141-142 and 177-178, respectively. On Guidobaldo and the Greeks see ib., p. 46, and Biagioli, «The social status» (cit. n. 4), p. 65. P. DUHEM, *Les Origines de la Statique*, 2 vols., Paris, Hermann, 1905-6, vol. 1, pp. 182-193.

probability Guidobaldo's source.[43] Thus the Archimedean revival was not by itself leading to the mathematization of new fields. Had dal Monte – or indeed Galileo – tried to study projectile motion in the same way, he would have encountered insurmountable difficulties. However, it was by no means clear up to what extent one could compromise on rigour in order to provide a mathematical solution. The protagonists of the mathematization of nature had to find not simply solutions, but new rules of the game as well.

The observations in this section instantiate my claim about the problematic «labelling» of dal Monte under any rigid classification. No categorization will succeed without taking into account his intellectual horizon and social background, contacts with engineers and instrument makers, views about experiment and the reception of Greek mathematics.

4. The nova of 1604

In October 1604 a new celestial phenomenon appeared in the constellation of Sagittarius and soon became the object of attention of astronomers throughout Europe. Right from the start mathematicians and philosophers saw it as yet another challenge to Aristotelian teaching: Since astronomical observations of the star revealed no sensible parallax, the belief in the immutability of the heavens was threatened. Previous novae and comets, such as those observed by Tycho Brahe in 1572 and 1577, respectively, had already instigated considerable debates. Despite the opposition of philosophers, by the beginning of the seventeenth century several mathematicians could take for granted that the heavens were corruptible. I select only a few cases in the rich network of correspondents covering many Italian cities. This survey serves mainly the purpose of comparison with the situation in the Duchy of Urbino. Reports from Padua, Bologna, Turin, and Rome follow a similar pattern indicating debates and controversies, besides of course hosts of astrological prognostications.

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[43] The problem recurs repeatedly in *On Floating Bodies*, book 1, esp. prop. 2. See the brief discussion in E. J. Dijksterhuis, *Archimedes. With a new bibliographic essay by Wilbur R. Knorr*, Princeton, Princeton University Press, 1987, pp. 373-379. Guidobaldo's discussion in the section on the balance in *Mechanicorum Liber* is translated in Drake and Drabkin, *Mechanics* (cit. n. 4), pp. 262ff. See also Bertoloni Meli, «Federico Commandino» (cit. n. 9).

One of the first to observe the nova at Padua was the Milanese Baldassarre Capra, who detected it on 10 October. In 1604-5 the professor of mathematics of the university, Galileo Galilei, was teaching the *Theoricae Planetarum*; in addition he delivered three public lectures on the new star. Although only a few fragments of the text of Galileo's lectures are extant, at least part of the intellectual atmosphere can be reconstructed by other documents. According to a later report by Vincenzo Viviani, for example, it appears that the philosopher Cesare Cremonini was violently opposed to Galileo's theory.[44] The main surviving document is the *Dialogo de Cecco di Ronchitti da Bruzene in perpuosito della stella nuova* (Padua: Pietro Paolo Tozzi, 1605), written in Paduan dialect by Galileo himself and his disciple, the Benedictin Father Girolamo Spinelli. In the *Dialogo* two farmers, Matteo and Natale, argue about the *Discorso intorno alla stella nuova* by Antonio Lorenzini (Padua: Pasquati, 1605). Matteo has not read the book, but on being told its contents by Natale, he marvels that its author is a philosopher: in fact philosophy, he explains, has nothing to do with the science of measures, a subject on which mathematicians are far more authoritative. These opening lines outline immediately the disputed matter between the two communities.[45]

The situation at Bologna has been little explored; our main source is the correspondence of the astronomer and professor of mathematics Giovanni Antonio Magini. Magini acted as an important link between Tycho's son in law Franz Tengnagel at Prague and Christophorus Clavius at Rome. Such epistolar exchanges, involving observational data as well as opinions about the nature of the star, reinforced the shared belief about its location. Although we have no work by Magini on the topic, we know from a letter of Bartolomeo Cristini at Turin that the Bologna astronomer held the heavens to be corruptible. Once again the report by Cristini, who was Giovanni Battista Benedetti's successor, reveals

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[44] A. FAVARO, *Galileo Galilei e lo studio di Padova*, 2 vols., Firenze, 1883; reprinted Padova, 1966, vol. 1, pp. 213-236, esp. p. 218. C. B. SCHMITT, «Cesare Cremonini: un aristotelico al tempo di Galilei», *Centro Tedesco di Studi Veneziani, Quaderni, 16* (Venice, 1980), pp. 3-21.

[45] *GOF*, 2, pp. 267-334, esp. pp. 275-284 (fragments of lectures) and pp. 307-334 (*Dialogo de Cecco di Ronchitti*). G. RIGHINI, «Galileo e la stella Nova», in Maeyama and Saltzer (eds.), *Prismata* (cit. n. 22), pp. 329-337. See also *Dialogo sopra i due massimi sistemi*, in *GOF*, 7, pp. 301-347.

the existence of a controversy with the local philosophers who defended Aristotle.[46]

An interesting document of the Roman debates has been published in the last few years by Ugo Baldini. On 23 December 1604 the Jesuit Odon van Maelcote gave a public lecture at the Collegio Romano in which he took sides against the philosophers. The speaker represented the opinion of the Jesuit mathematicians and especially of Father Clavius. The lecture was probably intended for publication, as suggested by the presence of printed diagrams accompanying the text of the lectures.[47]

Before proceeding, it is worth paying attention to the writings of the dean of astronomers operating in Italy at that time, Christophorus Clavius. Between 1572 and 1574 Clavius had observed the «Brahe» nova and in the following editions of his *Commentarium* he had authoritatively argued in favour of the celestial nature of the new star. Virtually his entire analysis was based on the 1572 nova and was in print well before the seventeenth century. The 1604 nova was relegated at the end of the relevant section in later editions and was dealt with in a couple of lines. His typically systematic and well argued reasoning relying on observations from places as distant as Sicily and Germany, Spain and Italy, left little unanswered. After having surveyed the opinions of those who denied that the star was new, or who believed it to be a comet, Clavius proceeded to a refutation of their arguments: although he publicly refused to discuss the physical nature of the star and its philosophical implications, he decidedly claimed that its location was in the heavens. Clavius also quoted portions of a letter by the Sicilian mathematician Francesco Maurolyco concerning the

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[46] A. FAVARO, *Carteggio inedito di Ticone Brahe, Giovanni Keplero, e di altri celebri astronomi e matematici dei secoli XVI e XVII con Giovanni Antonio Magini*, Bologna, Zanichelli, 1886, pp. 283-285, Clavio to Magini, 18 November 1604. The letter of Cristini of 26 February 1605, pp. 298-303, indicates a similar pattern at Turin, p. 298: «Redditae mihi fuerunt tuae sextae diei, sub 18a huius cum in coeto virorum doctorum essem, et loquemur de stella nova, quare admodum mihi gratae fuerunt, et tanto magis, quod etiam de eadem stella tuae agerent, unde confirmabatur alterationem aliquam in aethere dari, contra Aristotelem, quod nullo modo docti illi concedere volebant.»

[47] U. BALDINI, «La nova del 1604 e i matematici e filosofi del Collegio Romano: note su un testo inedito», *Annali dell'Istituto e Museo di Storia della Scienza di Firenze*, *6*, fasc. 2, 1981, pp. 63-98. On the Roman situation see also S. RICCI, «Federico Cesi e la *Nova* del 1604. La teoria della fluidità del cielo e un opuscolo dimenticato di Joannes van Heeck». *Atti della Accademia Nazionale dei Lincei*, 1988, serie ottava, *Rendiconti*, Classe di Scienze Morali, Storiche e Filologiche, *43*, fasc. 5-6, pp. 111-133.

position of the star. Like Clavius, also Maurolyco believed that the 1572 nova was located in the heavens.[48]

We move now to the Duchy of Urbino. The Marquis dal Monte resided then in his fief of Monte Baroccio, a village a few miles from Pesaro. Guidobaldo was in correspondence with Pier Matteo Giordani (1556-1636) in Pesaro, a friend with interests in the mathematical disciplines. Giordani's contact in Rome was the Pesaro historian Homero Tortora (1550-1624), author of a *Historia di Francia* (Venice, 1619). The correspondence with Giordani is one of the most important documents we possess on dal Monte's views about the relationships between mathematics and philosophy, and deserves greater attention that it has thus far received. A close analysis of its contents highlights Guidobaldo's strategy and sheds new light on his personality.[49]

I focus on four letters to Giordani, dated between November 1604 and January 1605. On 23 November the Marquis expressed the wish that the measure of the parallax may determine the position of the new celestial object, and went on to say that he had observed the nova once, but bad wheather prevented him from repeating the observation.[50]

Guidobaldo enclosed also a tract by the philosopher Jacopo Mazzoni on a comet which had appeared in 1596. Mazzoni's essay is a display of courtly erudition: his analysis covered the historical record, discussed elementary notions of astronomy and optics, and referred to several recent texts including Clavius' *Commentarium*. Mazzoni defended without great convinction the view that comets

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[48] C. CLAVIUS, *Commentarium in Sphaeram Ioannis de Sacro Bosco*, Mainz, 1611, in *Opera Mathematica*, 5 vols., Mainz, 1611-1612, vol. 3, pp. 103-105. The same reasoning can be found in the third edition of the *Commentarium*, Rome, 1585, pp. 191-195, concerning only the 1572 nova. U. BALDINI, «Christoph Clavius and the scientific scene in Rome», G. V. COYNE, M. A. HOSKIN, O. PEDERSEN (eds.), *Gregorian Reform of the Calendar*, Vatican City, 1983, pp. 137-169. A. C. CROMBIE, «Mathematics and Platonism in the sixteenth-century Italian Universities» (cit. n. 22). C. DORIS HELLMAN, «Maurolyco's 'lost' essay on the new star of 1572», *Isis*, *51*, 1960, pp. 322-336, contains an edition of the essay. On the 1572 nova see also BENEDETTI, *Speculationes* (cit. n. 8), pp. 371-374, letter to Annibale Raimondi.

[49] In the Vatican Library is preserved a copy of an essay by Guidobaldo *De Stella Magorum* (Ms Urb. Lat. 1743, parte Ia, ff. 65-69). An annotation on the left top corner tells us about the author and the year, 1604. It is highly probable that the topic of the tract was stimulated by the nova of the same year. The Marquis, however, did not discuss mathematical issues, but raised questions such as «qualis fuerit; quando primum visa: ubi, quomodo ex ea natum esse Christum Magi cognoverint» (f. 65*r*). The essay was possibly addressed to a Churchman of the Duchy.

[50] G. ARRIGHI, «Un grande scienziato Italiano: Guidobaldo dal Monte in alcune carte inedite della Biblioteca Oliveriana di Pesaro», *Atti dell'Accademia Lucchese di Scienze, Lettere ed Arti*, *59*, 1965, pp. 181-199, esp. pp. 193 and 196.

are generated in the sublunar world and tried to explain the lack of parallax by means of optical refraction. His main preoccupation was to refute astrological interpretations and reassure the Grand Duchess Christina of Lorraine, who had commissioned the essay, that she had nothing to fear from the comet. The impression one gets from Mazzoni's tract is that he was not greatly committed to either views about the location of the comet: certainly he was not a priori hostile to the idea that the heavens were corruptible.[51]

Meanwhile from Rome Tortora asked Giordani for Guidobaldo's opinion on the new phenomenon, «because Clavius believes it to be a new star».[52] Giordani's letters are not extant, but from Guidobaldo's reply of 6 December it can be inferred that Giordani had written to Tortora that the Marquis had been unable to observe the star ever. Guidobaldo then went on to praise his friend for this small lie and confirmed that in fact he had observed the star on 11 November and that its celestial coordinates were 18 1/2 degrees in Sagittarius and 12 degrees 15 minutes latitude. However, he forbade Giordani to communicate them to anyone, hoping to detect the star's motion around mid January. If, however, «the comet will stay in the same position, I shall say that having observed it very carefully, and for a long time, I noticed that it was glittering so strongly, that I have never seen a star glittering so much», almost in such a way that «it really seemed to be fire rather than a star». The Marquis then wished to have observations from several locations in order to test an opinion of his that «it is a comet and not a star, because I cannot agree that scholars want to admit the heavens to be corruptible at the first [difficulty]».[53] Guidobaldo clearly wanted to prevent his

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[51] Mazzoni's manuscript «Trattato della cometa» is in Biblioteca Apostolica Vaticana, Ms Urb. Lat. 1363 (partial draft in Vat. Lat. 13252, ff. 38-49), ff. 1-24. Mazzoni was a personal friend of Guidobaldo and had spent some time at Urbino; see P. SERASSI, *La vita di Jacopo Mazzoni, patrizio cesenate*, Roma, 1790. In the correspondence with Galileo, dal Monte expressed the wish to be present at their conversations at Pisa, *GOF, 10*, pp. 45 and 47, dal Monte to Galileo, Monte Baroccio, 8 Dec. 1590 and 21 Febr. 1592, respectively. On 20 January Guidobaldo acknowledged receipt of the tract returned by Giordani and wished Mazzoni were still alive. Indeed, his presence at Urbino would have greatly revitalized the court.

[52] Biblioteca Oliveriana, Pesaro, MS. 415, Homero Tortora to Pier Matteo Giordani, Rome, 24 November 1604, f. 35: «... il Padre Clavio tiene, che sia nuova stella come fu tenuta da alcuni quella di Casiopea», quoted in GAMBA and MONTEBELLI, *Le scienze a Urbino* (cit. n. 4), p. 51.

[53] G. ARRIGHI, «Un grande Scienziato» (cit. n. 50), p. 193-194, dal Monte to Giordani, 6 December 1604: «Se però la cometa starà nel medesimo luogo, dirò ben questo, che havendola io guardata ben bene, et durato un pezzo a vederla, io vedevo, che ella scintillava tanto forte, che non ho mai veduto stella scintillar tanto... che veramente pareva, che fusse

observation from being known in order to secure its «correct» usage, and ignored completely the 1572 nova and a host of other celestial apparitions. The data the Marquis wished to receive must have arrived soon, since at the back of the letter he annotated some «Osservationi da Praga».[54]

On 22 December Tortora provided a brief account of what appears to be the lecture by van Maelcote, emphasizing the opinion of Clavius and the Jesuits. Guidobaldo dal Monte's letters of 31 December 1604 and 20 January 1605, though, show hardly a change of attitude. The Marquis observed that while the mathematicians will agree to call the new phenomenon a star, they will not be able to answer the arguments of the philosophers, «and these arguments ought well to be answered, if it were true that this comet were a star.»[55] Hence Guidobaldo, alone among the mathematicians mentioned in this section, refused to accept the possibility that the heavens were corruptible on philosophical, or better, a priori, grounds.

I wish to conclude with some observations on Copernicanism with regard to dal Monte and Baldi. Unfortunately, direct evidence about the Marquis' opinion on this issue is lacking; his statement about the motion of the earth in the letter to Bonaventura can be safely dismissed in this regard. Indirect evidence, however, seems to me as strong as it could be: dal Monte's views about the nova and the incorruptibility of the heavens lead to the conclusion that his attitude towards the much greater upheaval implied by Copernicanism was that of total rejection. Bernardino Baldi's statements in the *Vita di Copernico* and *Cronaca de' Matematici* about the «falsa opinione» of Copernicus reflected the views of his teacher

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fuoco, e non stella». «Mi chiarirei, di una opinione... per salvar che ella sia cometa, et non stella, che io non posso acconsentire, che persone dotte alla prima vogliano tener' il cielo corruttibile per poter dire che ella sia una stella.»

[54] Ib., p. 194. E. GAMBA, V. MONTEBELLI, *Le scienze a Urbino* (cit. n. 4), p. 50, n. 30, claim that the observations from Tengnagel reached Magini and then were forwarded to Clavius; Archivio Pontificia Università Gregoriana, Roma, ms. 530, c. 206*r*, Magini to Clavius, Bologna 18 December 1604, contains the same coordinates annotated by dal Monte.

[55] Biblioteca Oliveriana, Pesaro, Ms. 415, Tortora to Pier Matteo Giordani, ff. 39-40, Rome, 22 December 1604: «Circa le comete o stelle che si vedono, non so dirle altro, se non che i Gesuiti pur hoggi, hanno con concorso di molti fatto molte dimostrationi seguitando il Padre Clavio che tiene che sia stella, et nell'ottava stella in Sagittario... dicono essere tenuta in Germania per stella, et che ve ne siano lettere, et dimostrationi. Se si darà fuori quello che hoggi hanno fatto sentire i Gesuiti, lo manderò subito a V.S.» For some reason, however, van Maelcote's lecture is dated 23 December. G. ARRIGHI, «Un grande scienziato» (cit. n. 50), p. 195, dal Monte to Giordani: «Le quali ragioni bisognarà pur solverle, se fusse vero che questa cometa fusse stella.»

Guidobaldo as well.[56] The gulf between Galileo and his patron on astronomical matters emphasizes the wide range of positions among the protagonists of the Archimedean revival. Differences did not involve simply this or that theorem, but the *raison d'être* of the renaissance of mathematics.

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[56] B. BALDI, *Cronaca de' Matematici*, Urbino, 1707, p. 120-121; B. BILINSKI, «La Vita di Copernico di Bernardino Baldi dell'anno 1588», *Accademia Polacca delle Scienze*, Conferenze, Fasc. 61 (Wroclaw, 1973); a less correct edition appeared in *Studia Copernicana*, *9*, 1973, pp. 18-21, on p. 20.

APPENDIX

Biblioteca Comunale, Forlí, Ms Autografi Piancastelli 755 (1)[57]

Molto Mag^co^ Sig^re^ mio hon^do^,

V.S. mi fa vergognare con tante cose, per non dir cerimonie, che usa nella sua lettera, ma conosco che lo fa per spronarmi a far qualche cosa. Con tutto ciò io gle ne resto obligatissimo insieme con la scrittura che mi ha mandata, che mi duole di haverli fatto durar questa fatica doppia, cioè di haverla rescritta, e di haverla fatta in buona forma. Io non l'ho ancor potuta leggere, che appena gl'ho data una scorsa così in furia, che non gli posso dir cos'alcuna di fermo, se bene mi è piaciuta infinitamente, ma non so però se V.S. tocca niente contra il quinto capitolo del medesimo terzo libro, dove mi par che quest'huomo non consideri troppo bene quello che dice, perché vuole che la terra habbi il moto della trepidatione, che havendo lei questo moto, dice il Cesalpino che non accade a darlo al cielo, come che'l cielo habbi questo moto ogni sei hore, come vuol che habbi la terra, poi che quest'è causa del flusso del mare. Ma vuole però che questo moto della terra venghi dal cielo. Ma se dal cielo, la terra si doverebbe mover in giro, come il cielo. Ma si vede che attribuisce alla terra il moto della trepidatione per salvar il flusso del mare. Ma è cosa poco da filosofo per salvar il moto del mare indurre nella terra un'altro moto più stravagante, che per salvar questo della terra bisognava trovarne un'altro, e poi un'altro, e così in infinito. Poi che il dire, come egli fa, che il cielo da questo moto alla terra, e non provarlo, è un niente, che sarebbe forsi meglio dire, che il re di Spagna causa questo moto della terra, essendone egli di tanta parte padrone. Non posso patir, che questi che fanno professione di filosofi, mettino certe stravagantie in capo, senza ragione alcuna, che se adducessero qualche ragioncella apparente, sarebbe manco male. / Ho voluto dirgli questo perché non volevo star più a risponderle, ma io veramente non ho ben considerato ogni cosa, che appena ho letto il Cesalpino in quel luogo così alla sfuggita, havend'io molte cose, che mi levano lo studiare. V.S. le considerarà meglio di me. Pesato poi a metter in esecutione il pensier, che tiene di mandar fuori il 1° e 2° libro di grazia

[57] In the transcription I have slightly altered punctuation and capitalization. Contractions are expanded, except in the forms of salute at the opening and at the end. Except from accents, the orthography is reproduced as closely as possible to the original, including antiquated forms.

non manchi di farlo, che so certo, che ne haverà honore, et satisfattione grandissime e di più gli sarà poi un stimolo a finir gl'altri libri. La lo facci adunque, et quanto più presto. Dove la dice di nominare me, non lo facci per niente, che queste poche cose, che io gli ho detto di sopra, dio sa se stanno così. Haverei ben caro, che V.S. mandasse fuori questi due suoi libri, che so che mi serviranno a me per citarlo, et lo farò volentieri, massime che ho un capriccio, che la terra si muova, et questo in via di Aristotele. Ma sono cose, che (come lei sa meglio di me) bisogna prima pensarci bene, e non le lascierei vedere, se prima io non havessi il consenso di primi filosofi. Acciò mi faccino accorger del mio errore, se vi è, perché io da me stesso confesso, che non me ne so accorgere. E quanto più ci penso tanto più mi ci confermo. Tra i primi voglio il suo giuditio stimato da me più forsi (per dir così), di quello, che lei si crede. Io non mancarò di far offitio con quel Cesare da Calmazza per conto di quello, che deve a Mr Tadeo d'Urbino, ma colui è un meschino, che dal tempo di mio padre fu comportato che stesse in Monte Baroccio. E gle ne darò aviso. Il conte Torquato graziosamente mi rese il libro che V.S. mi mandò. Che gle ne bascio le mani, et il medesimo fa mia moglie alla sua signora consorte. E mi comandi. Di Pesaro alli 8 di decembre del 1588.

Di V.S. S^re^ Guidobaldo dei Marchesi dal Monte.

SUMMARY

This essay examines Guidobaldo dal Monte's role within the Renaissance of mathematical studies in Italy in the second half of the sixteenth century. His views are compared with Giovanni Battista Benedetti's and above all with Federico Commandino's. Benedetti develops a strongly critical attitude towards Aristotle and philosophy in general; Commandino conceives the mathematical renaissance as a wide-ranging reform of knowledge and reshaping of disciplinary hierarchies; by contrast, dal Monte promotes mathematics and especially mechanics with far less ambitions aims; philosophy and anti-Aristotelianism remain outside his range. These observations reveal the existence of a wide spectrum of positions within the Archimedean revival in Italy and the very Urbino mathematical school. Despite some undeniable common traits, the cultural projects we find in Commandino's and dal Monte's works differ profoundly.