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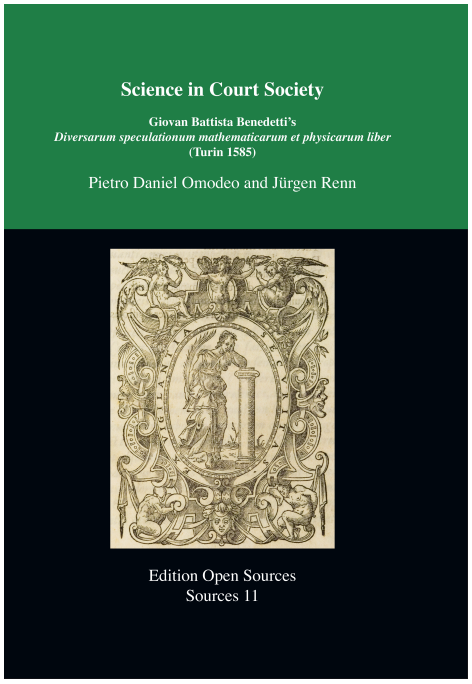
Pietro Daniel Omodeo and Jürgen Renn:

Introduction
DOI: 10.34663/9783945561485-01



In: Pietro Daniel Omodeo and Jürgen Renn: *Science in Court Society : Giovan Battista Benedetti's Diversarum speculationum mathematicarum et physicarum liber (Turin, 1585)*
Online version at https://edition-open-sources.org/sources/11/

ISBN 978-3-945561-16-4, DOI 10.34663/9783945561485-00
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The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available in the Internet at http://dnb.d-nb.de

Introduction

Giovanni Battista Benedetti is today a lesser known figure in the history of early modern science. This relative oblivion is in striking contrast to the fame he enjoyed during his lifetime as a prominent mathematician and mathematical philosopher of Venetian origin and reputable courtier to the Savoy dukes in Turin. Among his admirers, the astronomer Johannes Kepler regarded him as one of the few Italians to significantly contribute to the advancement of mathematics in his time: "The Italians are asleep with the sole exceptions of Commandino and Giovanni Battista Benedetti. And in fact, Clavius is German."[1] For his part, the mathematician of the *Collegio Romano*, Christopher Clavius, extolled Benedetti's scientific merits in the 1589 edition of his reputed commentary of Euclid, *Euclidis Elementorum Lib[ri] XV*. In the dedicatory letter to Carlo Emanuele I of Savoy (*Serenissimo Principi ac Domino D. Carolo Emmanueli Sabaudiae Duci*), he praised "his court mathematician" Benedetti as "very expert in mathematics" (*scientissimus rerum Mathematicarum*).[2] In contrast to the eulogies of the Imperial mathematician Kepler and the most prominent astronomers of the Jesuit order, the Urbino school gathered around the mathematical purist Federico Commandino was rather reluctant to acknowledge his achievements, probably due to rivalry, reciprocal misunderstandings, and different philosophical and cultural choices. Among Commandino's pupils, Guidobaldo Del Monte severely criticized Benedetti's approach to mechanics and his claim to originality, as documented by his manuscript annotations on mathematical issues.[3] Another member of the Urbino school, Bernardino Baldi, gave an extremely negative and reductive portrait of Benedetti in his collection of short biographies of mathematicians from all epochs, *Cronica de matematici*.

> The Venetian Giovanni Battista Benedetti occupied himself with mathematics, a field in which he served the dukes of Savoy. He wrote a book on gnomonics, which dealt with many proofs belonging to this discipline. However, he has been criticized by the most exquisite scholars for not having respected the method and the purity of explanation which mathematics requires and which was respected by the Greek masters and by their followers. He also wrote some light things of no great import.[4]

Such a harsh judgment can only be explained on the basis of a profound enmity held by Commandino's followers against Benedetti. This deserves attention since it also influenced the reception of his work. Therefore, we will offer a reconstruction of Benedetti's

[1] Kepler 1937–2001, 390: "Itali somniant (preter unum Commandinum et Joh[annem] Baptistam Benedictum, Clavius enim Germanus est)."

[2] Clavius 1589, ff. *4*r*–*5*r*. The list of Benedetti's admirers also includes the Pisa philosopher Jacopo Mazzoni, the Venetian intellectual leader Paolo Sarpi, and the French scholar Marin Mersenne. See Cappelletti 1966, 262.

[3] See Renn and Damerow 2012 and Renn and Omodeo 2013.

[4] Baldi 1707, 140: "GIO[VANNI] BATTISTA Benedetti veneziano attese alle matematiche, nelle quali servì i Duchi di Savoia. Scrisse un libro di gnomonica, il quale toccò molte cose appartenenti alle dimostrazioni della detta disciplina, se non che viene ripreso da più esquisiti di non haver'osservato quel metodo, e quella purità dell'insegnare, che ricercano le matematiche, et è stato osservato dagl'ottimi Greci, e dagl'imitatori loro. Scrisse anco alcune altre cose leggiere, e di nessun momento." Here and in the subsequent pages, Italian and Latin grammar (e.g., capitalization and punctuation) has been modernized.

cultural environment and the scientific culture of Renaissance Italy in order to understand his work, its roots, and legacy.

Although Benedetti was recognized by his contemporaries, in many respects the theoretical and historical relevance of his work remains obscure. The obscuration of Benedetti is also the result of the prominence of the Urbino school and their bias towards mathematical purism. Moreover, the hagiographic historiography of science sought out the precursors to Galileo and therefore almost naturally adopted the criticism of Benedetti by Galileo's patron Guidobaldo del Monte. Intrinsic factors also played a role in the eclipse of Benedetti's fame, principal among which is the relative rarity of his major work, *Diversarum speculationum mathematicarum et physicarum liber* (Book Including Various Mathematical and Physical Speculations, 1585), not to mention that of most of his earlier publications. Benedetti's fragmentary style is a special difficulty faced by the reader, a defect that was overemphasized by Baldi and denounced by early modern scholars such as Claude-François Milliet Dechales. Dechales dealt with Benedetti's geometry in his *Cursus seu mundus mathematicus* (1690), observing that "the end of his work [the *Diversae speculationes*] comprises many miscellaneous geometrical remarks, some of which are good, in particular with regard to their special concern, but [they are] disordered."[5]

Following historiographic commonplaces and their nineteenth-century crystallization, recent historians of science have tended to neglect Benedetti's work due to the lack of extensive translations of his writings into modern languages, with the exception of the excerpts included in Drake and Drabkin, *Mechanics in Sixteenth-Century Italy* (1969). This anthology isolated passages that were exclusively devoted to what the editors saw, in hindsight, as the most relevant contributions for the progress of mechanics. Due to its selective nature, this publication did little justice to the complexity and richness of Benedetti's stature in the history of science. In fact, isolating certain results elides recognition of the multilayered architecture of a book such as the *Diversae speculationes*, which is characteristic of Renaissance science. Benedetti's showcase of mathematical erudition and scholarship is thus omitted and obscured. Drake and Drabkin's selection could only yield a reductive and rather misleading image of Benedetti as a scientist and thinker. As we will argue, entire paragraphs or chapters expunged from Drake and Drabkin's translation, for instance those concerning philosophy and cosmology, are relevant for an understanding of the author's general conception of mechanics and physics. From a historical viewpoint, it is hardly possible to trace disciplinary boundaries in the Renaissance that fit those established today. Mechanics was an emerging discipline at the crossroads of mathematics, engineering, and natural philosophy. Hence, a reassessment of Benedetti's work in its entirety is necessary not only to understand his personality but also to grasp the scientific culture of his age as the result of interdisciplinary controversies.

This open access edition makes the *Diversarum speculationum mathematicarum et physicarum liber* accessible to a large scholarly readership. Benedetti's volume is a major contribution to Renaissance science, especially due to its insights into mechanics, the mathematization of (or geometrical approach to) natural investigation, and the connection of celestial and terrestrial dynamics in a post-Copernican perspective. The first edition of this work was an elegant folio, which included heterogeneous writings on technical and philosophical issues as well as on mathematics and physics. Benedetti presented them as short treatises (*tractatus*) or letters (*epistolae*) addressed to gentlemen, courtiers, scholars, engineers, and practitioners of different arts. The volume was printed by Niccolò Bevilac-

[5] Ventrice 1985, 188: "in fine sui operis multa habet miscellanea geometrica, quorum nonnulla ad sectiones praesertim pertinentia bona sunt, sed inordinata."

qua's heir (*apud haeredem Nicolai Bevilacquae*), who was the owner of the main printing house in Turin, which was directly supported by the dukes of Savoy. The *Diversae speculationes* appeared in a series of prestigious volumes aimed at celebrating the magnificence of the court and the capital, including the works of the court historian Emanuele Filiberto Pingone: *Augusta Taurinorum* (1577), on Turin, *Inclytorum Saxoniae Sabaudiaeque principum arbor gentilitia* (1581), on the genealogy of the ruling family, and *Sindon evangelica* (1581), on Christ's shroud, which had been recently transferred from Chambéry to Turin. The *Diversae speculationes* exhibits the same celebratory intention. The volume aimed to make the quality of the court mathematician's research and skills publicly appreciable. It also bore witness to the intensity of the cultural debates going on in Turin, and connected this city with other centers of learning, especially Venice.[6] Its miscellaneous and epistolary form was suitable for displaying the variety of the author's interests and for praising his patrons, friends, and colleagues by naming them as dedicatees or addressees of the different sections and letters.

The structure of the *Diversae speculationes*—its occasional and fragmentary character, its celebratory purpose, and the epistolary display of a network of personal connections—mirrors the socio-cultural embedment of Benedetti's work. We regard it as exemplary of "science in court society." As Norbert Elias has pointed out, the *höfische Gesellschaft*, or court society, is a particular social configuration (*gesellschaftliche Figuration*) characteristic of the transitional phase to an industrial and capitalist Europe, which we conventionally refer to as the early modern period.[7] During the Renaissance and the Ancien Régime, the court was (or became) a hegemonic center from which powerful elites mediated between the ruler and the socio-political environment. Benedetti's activities as a court mathematician exemplify such a function. In his role he was expected to interact with the upper classes and respect aristocratic etiquette, and to act as the Savoy "expert" on a wide range of pedagogical and technical issues linked to his profile as a mathematician and mathematical philosopher. He was required to teach geometry to the offspring of the ducal family, to supervise engineering and architecture projects, to produce instruments or machines for practical purposes, warfare, and recreation (such as fountains, sundials, or nautical instruments). He had to adhere to shared court values, norms, and behaviors, primarily those linked to honor and prestige. These courtly principles are reflected in the epistemic values permeating his scientific production, for instance in the value of scientific disinterestedness that marks his theoretical approach to practical as well as to speculative problems. In a hierarchical and aristocratic society, his theoretical attitude marked at once the continuity and the distance between his role as a court mathematician and those involved in practical activities. Moreover, the primacy of courtly interests over those of science as a purely scholarly endeavor (as it was pursued at universities and academies) is evident from Benedetti's networking strategies, which were aimed at not so much exchange with other scholars as at giving advice to a wide range of people, beginning with the ruling elites of the country. In other words, he was not primarily concerned with establishing a réseau, as was typical for the Republic of Letters. As we will show, he did not regard himself and his activity as part of a learned network but rather as the center of courtly interaction. This center-periphery structuring of his network mirrors—in two senses—the "knowledge economy" his work is embedded in. Sociologically, the central-

[6] Cecchini and Roero 2004.

[7] As Norbert Elias put it (Elias [1969] 2002, 73): "Durch das Bemühen um die Struktur der höfischen Gesellschaft und damit um das Verständnis einer der letzten großen nicht-bürgerlichen Figurationen des Abendlandes eröffnet man sich also mittelbar zugleich einen Zugang zum erweiterten Verständnis der eigenen berufsbürgerlich-städtischen-industriellen Gesellschaft."

izing character of court society is reproduced in scientific policies through Benedetti's function as a technocrat; epistemologically, the fluid style and fragmentary form of the *Diversae speculationes* is an expression of the expert-advice character of his scientific work. Thus, in order to properly understand his work, we deem it necessary not only to investigate the technical and theoretical dimensions of Benedetti's science, but also to analyze evidence concerning the ties between these dimensions and the social and cultural environment.

Among the studies on Benedetti, Giovanni Bordiga's monograph *Giovanni Battista Benedetti: filosofo e matematico veneziano del secolo XVI* (1926) still stands out as one of the most important references as far as prosopographical information is concerned.[8] The excellent research accomplished by Carlo Maccagni and the proceedings of the conference on Benedetti held in Venice in 1985 at the *Istituto Veneto di Scienze, Lettere ed Arti* investigated many aspects of Benedetti's contribution.[9] In spite of the accuracy of these relatively recent Italian studies, Alexandre Koyré's evaluation of Benedetti's role in the first stages of modern science, in the *Études galiléennes* (1939), has had a more direct influence on his international reception. Koyré emphasized the link between the incipient mathematical science of motion and heliocentrism in Benedetti's speculations. On account of this, Paul Lawrence Rose regarded him as a herald of the "Italian Renaissance of mathematics".[10] Koyré's grand narrative of the Scientific Revolution, which he conceived as a development with a "prologue" (Copernicus) and "epilogue" (Newton) in the heavens, included Benedetti as a precursor to Galileo because of the interconnection of mathematical and physical themes in the former's work. Koyré's main thesis was that classical physics (the mathematical science of nature of Galileo, Descartes, and Newton) emerged as a direct consequence of Copernicus's geokinetic system, which undermined the traditional (Aristotelian and Ptolemaic) worldview. Although Benedetti's relevance as a source for Galileo cannot be denied, scholars now view Koyré's narrative as dubious due to its abstract treatment of the history of science, conceived of as an internal development of ideas. In the years of the Cold War (or shortly before it), this viewpoint embodied the ideological reaction to Marxist or materialist-oriented accounts, which stressed the technological, empirical, and social roots of modern mechanics, as was the case with Leonardo Olschki and Edgar Zilsel.[11] Bendetti's approach to mechanics and post-Copernican astronomy therefore appears to be an appropriate case study for reconsidering this general historical *problematique*, beginning with a reassessment of the relation between mechanics and astronomy in early modernity. This implies a reconsideration of the basic questions of the historiography of science and of historical epistemology, such as the role of material and intellectual factors in the so-called Scientific Revolution.

In this edition of the *Diversae speculationes*, we aim to present Benedetti's achievement in its rich complexity. Benedetti is emblematic both of his time and of the nonlinearity of the historical process of Renaissance science with its multicentric institutions and scientific networks. We will show that the apparently fragmentary nature of his work is expressive of the peculiar character of science in court society and, in spite of this form, it conceals a fundamental unity of his conception of nature and method, both of which rest on geometry. To be sure, Benedetti regarded mechanics as a model, but he enlarged his

[8] Bordiga 1985.

[9] Bordiga 1926, repr. Bordiga 1985, Maccagni 1967b, Maccagni 1967a, Maccagni 1983, and Istituto Veneto di Scienze 1987.

[10] Rose 1975, 154–156.

[11] The cultural-political intentions of Koyré's approach emerge most vividly from his 1943 article on Galileo's Platonism, see Koyré 1943. Lefèvre stresses it in Lefèvre 2001.

perspective to include the most varied fields of investigation in order to concretely demonstrate the fruitfulness of his approach to universal knowledge about astronomy, physics, meteorology, and even literature and ethics.

Overview and Acknowledgments

Our first chapter is devoted to Benedetti's biography and comprises an overview of his publications. We consider the various dimensions of his identity, such as his nobility as both a Venetian patrician and a Savoy aristocrat in the retinue of Emanuele Filiberto and Carlo Emanuele at the Turin court. In particular, we discuss his role as a courtier, the tasks he was entrusted with, and the relations he established in this context. We also deal with his extra-academic education and his attitude towards mathematics, which he initially saw as an intellectual instrument to be used against the "bookish" culture of the universities and the "idle" rhetoric of the humanists. Later he softened the polemical tone that characterizes his early writings. Moreover, since he saw himself as a philosopher, more precisely as a court philosopher to the Dukes of Savoy, a discussion of Benedetti's mathematics cannot be separated from his philosophical project. Benedetti claimed for himself the right to discuss in mathematical terms issues of natural philosophy that traditionally belonged to the rather qualitative and conceptual approach of the peripatetics. The *Diversae speculationes* is an altogether magisterial example of this merging of philosophical and mathematical perspectives.

Chapter 2 is a reconstruction of the cultural life of Renaissance Turin, the town in which Benedetti spent his mature years and where he composed his major work. His achievement was embedded in the cultural ferment of the new capital of Savoy, a place of ambitious town planning and civil reforms. It was a time in which the arts, literature, and philosophy received a new impetus. Editorial projects were launched; the university was reopened and illustrious scholars were attracted there. The dukes' religious politics was informed by a sense of pragmatism, which is mirrored in the fluctuating relations between the ruling family, the Jesuits, and Rome. Benedetti's secular attitude towards science and philosophy mirrors the cultural politics of his patrons. In addition we discuss his involvement in various scientific debates divided into courtly conversations, academic controversies, and controversies going beyond the settings of the court and the university. Among such extra-academic public controversies, the most important was Benedetti's public defense of the reliability of astronomical calculation against a polemist, Benedetto Altavilla, who indirectly attacked his and others' astrological practice. Newly discovered documents show that Benedetti's successor as court mathematician, Bartolomeo Cristini, continued that polemic after Benedetti's death. Cristini discredited Benedetti's use of astronomical tables to cast horoscopes, in order to ingratiate himself with the dukes and successfully start a career at court. We trust that this chapter offers new insights into the scientific culture of the Renaissance by bringing Turin into focus, a cultural centre that has so far escaped in-depth consideration by historians of early modern science.

In chapter 3 we offer an overview of the structure of the *Diversae speculationes*. We introduce Benedetti's mathematical sections in general terms, focusing on his geometrical demonstrations for the solutions of problems of arithmetic—which were the result of his private teaching of mathematics to the Savoy prince—his sketchy annotations on the theory of proportions based Book 5 of Euclid's *Elements*, and his considerations on linear perspective aimed at supporting the work of painters and architects. The sections on physics, mechanics, and natural philosophy are not discussed in this chapter as they re-

ceive special treatment in other chapters. The last part of the *Diversae speculationes* was a miscellanea of scientific letters. We discuss them vis-à-vis their significance as a mirror of Benedetti's social capital. His epistles were mostly directed to aristocrats, beginning with his patrons, other courtiers, and diplomats, especially those from Venice. He also corresponded with professors, artists, engineers, and practitioners, some of whom lived north of the Alps. His network was markedly a center-periphery one, in which the court expert shared his views on the most varied topics with others seeking his advice or opinion. Thus, it was not a scholarly network implemented for the sake of exchange and the advancement of knowledge. Rather than a networking activity establishing a Republic of Letters, Benedetti's correspondence reflected court-society centralism.

Chapter 4 addresses Benedetti's epistemology on the basis of passages regarding the certitude of mathematics and his effective use of mathematics in physics. His role as an early champion of what would later become known as "physico-mathematics" is understood here against the background of the philosophy of mathematics in the Renaissance. Moreover, we deem the modal epistemology underlying his science of particular interest: his treatment of nature in mathematical terms did not imply the necessary or deterministic nature of physical processes. Rather, he embraced an ontology and an epistemology of contingency that constituted a bridge between medieval scholastic views on nature and the mathematical physics of the time of Galileo and Descartes. We dedicate an excursus to the vision of nature as the realm of contingency in the period extending from the medieval science of weights to seventeenth century mechanics, and ascribe to Benedetti a central position in this intellectual process.

Chapter 5 deals with the field in which Benedetti has received the most credit from historians: mechanics. Actually, Benedetti himself emphasized the importance of his contribution to mechanics as what would secure his fame in posterity. We summarize his theories on equilibrium and his critical reworking of earlier theories such as those developed by Jordanus Nemorarius and Niccolò Tartaglia. We consider Guidobaldo Del Monte's negative reaction to Benedetti's mechanics in detail, as well as the weaknesses and strengths of both authors. We regard this pluralism of clashing and integrating views as revealing the complex paths of discovery undertaken by students of mechanics in a period of the utmost relevance to its modern systematization. Moreover, the subterranean conflict of views and approaches between Benedetti and Del Monte affected Galileo's work. His mechanics drew from both authors, although he did not acknowledge Benedetti explicitly due to circumstances and opportunity.

Chapter 6 summarizes Benedetti's astronomical work. Although he did not see himself as an astronomer, his contribution is quite interesting. He should be acknowledged for his effort to develop a new mathematical physics in accordance with post-Copernican astronomy. His discussion of astronomical theory against the background of a general philosophical reform was strikingly innovative. His specific polemics on the reliability of astronomical calculation also receive close treatment here. Furthermore, in an appendix Günther Oestmann offers an assessment of Benedetti's astrological calculations on the basis of so-far neglected manuscript sources containing two of his horoscopes.

In chapter 7 we deal with Benedetti's natural philosophy as he presented it in Book 4 of the *Diversae speculationes*. Although he entitled it "Disputations on Some Opinions Held by Aristotle" (*Disputationes de quibusdam placitis Aristotelis*), it was a polemic directed "against" fundamental Aristotelian theses on motion, time, space, matter, and cosmology. This is the section in which Benedetti's commitment to "the system of Aristarchus and Copernicus" most clearly emerges. It is also a fundamental section on the existence of the physical void as the necessary presupposition of any local displacement and on free

fall through different media. We see this book of the *Diversae speculationes* as a major contribution to the Renaissance debate on the foundations of physics, going far beyond the treatment of mechanics and cosmology *strictu sensu*. Hence, we take into consideration Benedetti's definition of space as an "inter-bodily gap" (*intervallum corporeum*), his defense of the possibility of actual infinity in nature against Aristotle's veto, his understanding of time as an absolute frame complementary to space and its place in the philosophical debates of the Renaissance, the revision of the concepts of natural and violent motion, and finally, the surprising conclusion of the "Disputations on Some Opinions Held by Aristotle" with a Copernican note.

This volume is a continuation of an Edition Open Access project aimed at the publication and scholarly reassessment of the fundamental sources of Renaissance mechanics. This project began with Jürgen Renn and Peter Damerow's *Guidobaldo del Monte's Mechanicorum Liber* in 2010. Elio Nenci's open-access publication of Bernardino Baldi's *In mechanica Aristotelis problemata exercitationes* appeared in 2011 and, in 2013, Matteo Valleriani's *Metallurgy, Ballistics and Epistemic Instruments*, including a transcription and an English translation of Nicolò Tartaglia's *Nova scientia*. Ideas that were crucial for the writing of this introduction to Benedetti's *Diversae speculationes* are derived from another volume by Renn and Damerow, *The Equilibrium Controversy: Guidobaldo del Monte's Critical Notes on the Mechanics of Jordanus and Benedetti and their Historical and Conceptual Backgrounds* (2012).

We are very thankful to our colleagues at the Max Planck Institute for the History of Science in Berlin for their insightful remarks and the precious exchanges about early modern science that took place in the many workshops and regular meetings over the past years: Angela Axworthy, Sonja Brentjes, Jochen Büttner, Giulia Giannini, Peter McLaughlin, Matthias Schemmel, Joyce Van Leeuwen, Matteo Valleriani, and many others. We are especially thankful to Antonio Becchi and Elio Nenci for their accurate reading of the manuscript of this book and their expert advice. Rodolfo Garau kindly took pictures of manuscripts and rare books that are preserved in the Biblioteca Nazionale Universitaria di Torino and are published here. Stefan Paul Trzeciok helped us with the translation of several Latin passages. We would like to acknowledge the Collaborative Research Centre "Episteme in Motion" (Freie Universität Berlin), which has constituted an important intellectual framework for this collaboration, and the Deutsche Forschungsgemeinschaft for financing Pietro Daniel Omodeo's research in Berlin for several years as well as a research trip to Turin in 2012. We are grateful to the librarians of the Max Planck Institute for the History of Science for their valuable support with bibliographical research and the digitization of sources, and to Louis Berger, Lindsay Parkhowell, and Charlie Zaharoff for their copyediting work and linguistic support. The last phase of the authors' collaboration on the manuscript of this volume is part of a project based at the Ca' Foscari University of Venice that has received funding from the European's Horizon 2020 Research and Innovation Programme (GA n. 725883 *EarlyModernCosmology*).