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– FOCUS –

Circulation of Renaissance and early modern scientific traditions in the Americas

edited by Sebastián Molina-Betancur

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Introduction
The New World and the new science

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Abstract
Traditional historical reconstructions regarding the circulation and production of knowledge in the Spanish colonies in the New World have focused on their participation in the birth of Early Modern Science in Europe. Although recent studies have revised this approach by examining how knowledge production in the Americas contributed to the development of seventeenth-century Spanish scientific culture, this focus section intends to enlarge the scope of this revisionist approach by considering study cases that show that the circulation of knowledge informed the development of local contexts in the Americas. This introduction depicts this panorama by considering it in the light of the iconography produced by Europeans after the discovery of the New World.

Keywords
colonial science, centre-periphery model, scientific revolution, Spanish Black Legend

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In the print entitled "America" of the *Nova Reperta* series, (Fig. 1) Giovanni Stradano depicts Vespucci's contact with the Americas as the gest of an almost mythological navigator who brought civilised Europe into contact with a savage, unknown New World. In this print Stradano reproduces the narratives of explorers and *conquistadores* which circulated in Europe regarding the nature of the Americas and its inhabitants.[1] Exotic animals and plants, rudimentary weaponry, nudity, matriliny and cannibalism are depicted in this engraving, thus affirming the superiority of European civilisation, represented in the plate by a Vespucci armed only with Christian tradition, astronomical knowledge and scientific instruments.[2] In Stradano's vision, the encounter between European explorers, navigators and *conquistadores* with the Americas, its nature and inhabitants, entailed a civilising mission that used European science and Christianity as tools to inform and shape the colonisation of the New World.

Regretfully, by reproducing the so-called centre-periphery model and a stagnated conception of the Scientific Revolution, historical narratives about the earliest development of colonial science in the Americas have inherited Stradano's perspective.[3] Following George Basalla's interpretation of the dissemination of European science, the historiography regarding the colonial science in the New World has focused either on the particular ways in which European science was appropriated in the Americas or on the contributions of the latter to the birth of Early Modern Science in Europe. In this scenario, just like Stradano's engraving, the peripheral American context has been depicted as passive, merely receiving the elements of the European scientific culture in the form of curricular activities in the newly created universities and colleges, and as a part of the European imperial policies for administering and ruling the New World's territories.[4] Likewise, as the dissemination of knowledge to and from the New World happened in the same period as the Scientific Revolution and the subsequent birth of Early Modern Science in Europe, historians have identified the participation of the New World in these events as a result of this global network in which data and information run toward the European centres of knowl-

1 Studies on Stradano's *Nova Reperta* series are in McGinty, "Stradanus (Jan Van der Straet)", 28-78; Van der Sman, "A Fertile Imagination", 99-123; Markey, "Stradano's Allegorical Invention of the Americas".

2 Markey traces the Medicean collections as possible source of Stradano's knowledge of the diverse elements of American material culture. *Ibid*., 419-429.

3 The original formulation of the centre-periphery model is in Basalla, "The Spread of Western Science". Reconstructions of the model are in Bertomeu Sánchez, García-Belmar, Lundgren, et al., "Introduction"; Patiniotis, "Between the Local and the Global".

4 The revisionist version of the centre-periphery model has been largely characterised in thematic numbers on Global History of Science in journals such as *Isis* and *Centaurus*. See, Sivasundaram, "Introduction"; McCook, "Introduction"; Davids, "Introduction"; Antonio Sánchez and Henrique Leitao, "Artisanal culture".

Fig. 1 – Stradanus, *Allegory of America* (1587-89), The Metropolitan Museum of Art, New York.

edge production.[5] While this perspective has allowed to examine the emergence of the complex, global scientific networks that propitiated the Scientific Revolution and the way in which the New World participated in it, it is based on a conception of the Scientific revolution as a historical phenomenon that has been ruled out in the literature since the 1990s.[6]

Building upon a rather contextualist approach and the criticism of these historical categories, historians such as Arndt Brendecke and Maria Portuondo have pointed out how Spanish imperial policies for the administration and ruling of the New World's territory

5 In the case of the Spanish Atlantic World, this narrative has largely contributed to defend the participation of Spain in the Scientific Revolution and to criticise the *Black Legend* of Spanish Science. An exemplary case of the use of the New World's scientific production in this sense is Víctor Navarro Brotons & William Eamon (eds.) *Beyond the Black Legend*. A reconstruction of the recent uses of this approach is in Juan Pimentel and Pardo-Tomás, "And yet, we were modern".

6 The criticism of the utility of the "Scientific Revolution" as a historiographic category mostly emerged after Cunningham's and William's *De-centring the "big picture"*. An account of the historiographic trend emerging after their publication is in Teich, *The Scientific Revolution Revisited*, 83-100.

developed an instrumental conception of scientific knowledge and an institutional framework of circulation of information. As these historians have demonstrated, in order to control their new overseas possessions, the Spanish monarchs framed networks that controlled the industry of knowledge and information production, whose centres were at the royal institutions in Spain (the *Casa de la Contratación* and the *Consejo de Indias*) and were administered in the New World by the viceregal courts.[7] In this scenario, the information that explorers, navigators, *encomenderos*, religious orders, and *vecinos* gathered in situ was used to construct an image of the New World for the royal court in Madrid. This approach has created a historiographic trend that has evidenced the particular ways in which science was transformed *in* the New World and how it helped to shape the development of a local scientific culture.

The purpose of this focus section is to contribute to this revisionist agenda by examining specific cases of knowledge production and circulation that took place out of the institutional framework that this revisionist approach has amply described. In their essays, the authors of this dossier examine particular historical cases in which knowledge about the New World's nature and its inhabitants was transformed in the New World itself by agents who produced their works in local contexts, with specific purposes and concerns that were not necessarily connected to the institutional agenda of the Spanish court, universities, and colleges. In other words, the contributions collected here contain evidence to depict how transformations of scientific knowledge in the New World led to important transformations in the New World's societies and culture.

These contributions were first presented and discussed at the workshop *The New World and the New Science* (November 17, 2021), promoted by the Department of Philosophy, Letters, and Communications of the Università degli Studi di Bergamo and the Museo Galileo. We find here different approaches to historical cases of colonial science that allow us to examine the interpretative variations of the Scientific Revolution as a historiographic category. In the first paper, Renée Raphael (University of California, Irvine) examines Capoche's *Relación general de la villa imperial de Potosí* (1585) and Juan Francisco de Hinestrosa's *Relaçion breue y sumaria del descubrimiento … del çerro nuebo potossi* (1596). By comparing the content and form of both *relaciones*, Raphael argues that there were specific manners of knowledge production in mining and metallurgy in Potosí that were evidenced in the inscription of the mining techniques and the theory of metallurgical generation present in these *relaciones*. In the second paper, Sergio Orozco-Echeverri (University of Antioquia-University of Edinburgh) studies the case of a neglected Renaissance genre, the *repertorio de los tiempos*. By examining its development in the Iberian Peninsula during the sixteenth century, Orozco-Echeverri concludes that it was enlarged to include substantial cosmological, chronological, and astronomical features that redefined the genre.

7 Portuondo, *Secret Science*; Brendecke, *Empirical Empire*.

He completes his study by considering how *repertorios* influenced Antonio Sánchez de Cozar's *Tratado de Astronomía y de la Reformación del Tiempo*. In the third paper, Nydia Pineda de Ávila (University of California, San Diego-Fletcher Jones Foundation Fellow in the Huntington-UC Program for the Advancement of the Humanities), leaves aside the heroic reconstructions of the works of the polymath Carlos de Sigüenza y Góngora, examining them as a node in a network of intellectuals, artisans, and artists connected by their religious beliefs and scientific practices. She does so by studying the iconography present in multiple celestial images that she considers visual and textual artefacts of the scientific and religious traditions present in late seventeenth-century New Spain.

Although their contributions were not included in this dossier, I would like to mention Jorge Cañizares Esguerra and Antonio Sánchez, who participated in the workshop with presentations that dealt with Magellan's travel around the globe and the relationship between the legal structure of the Spanish Monarchy and the production of knowledge.

As Juan Pimentel and José Pardo-Tomás have commented, differences in approaches to the problem of the participation of the Spanish World in the Scientific Revolution and the birth of Early Modern Science have been consequences of the multiple historiographic agendas of historians on both sides of the Atlantic. In their opinion, these agendas have been permeated by the degree of penetration of the criticism toward the very notions of Scientific Revolution and Early Modern Science as valid historiographic categories. Thus, while historians working in Spain have been struggling to construct narratives to highlight the participation of Spain in the Scientific Revolution, their American counterparts have used colonial science as an example of the problems of these categories.[8] Taken together, the contributions to this focus section reveal that even this debate has moved forward and that the Grand Narratives are viewed either with a profound criticism or with the indifference with which we remember our old problems.

8 *Ibid.*, 133-134.

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Inscribing mining practice and theory: conceptions of knowledge production and the Iberian state in Capoche's and Hinestrosa's *relaciones*

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Abstract
This contribution uses two narratives composed by practicing miners in Spain's Viceroyalty of Peru to explore period conceptions of the Iberian state's interest in metallurgical knowledge. Luis Capoche's 1585 *Relación general … de Potosí* ("General Relation of Potosí") and Juan Francisco de Hinestrosa's 1596 *Relación breve y sumaria … del descubrimiento … de nuebo Potosí* ("Short relation and summary of the discovery of New Potosí") evince parallels in content and form. While these similarities can be attributed merely to the context of colonial Iberian mining administration, they also point to a horizon of expectations shared by these authors and their intended readers, the viceroy and king. An exploration of the varied ways that Capoche and Hinestrosa marshalled theoretical and practical metallurgical knowledge in their writings enriches previous scholarship that has argued for the Iberian state's interest in and promotion of knowledge production.

Keywords
Luis Capoche, Juan Francisco de Hinestrosa, Potosí, science and the Iberian state, early modern mining

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While historians of early modern science today often celebrate Georg Agricola's 1556 *De re metallica* as the "most famous mining treatise of the sixteenth century," a different geographical locale drew the interest of period actors: the silver mountain of Potosí, located in the Andean highlands of modern Bolivia.[1] Potosí was a site that inspired desire and horror for its technical processes, extravagant silver yields, and labor management practices. This contemporary excitement is evident in the multiple surviving images of Potosí. The town's silver mountain was memorialized by early Spanish visitors, including Pedro Cieza de León, whose 1553 woodcut (Fig. 1) was copied and reprinted in Europe and the Ottoman Empire. The sufferings of indigenous laborers were depicted by the Flemish engraver Theodor de Bry (Fig. 2) and the seventeenth-century Jesuit polymath Athanasius Kircher. Potosí was considered sufficiently important to the seventeenth-century Jesuit missionary Matteo Ricci that he marked it prominently on a world map designed for China's Wanli emperor.[2]

These contemporary visions of Potosí were grounded in technical, economic, and social realities. Potosí produced over half the world's silver from the mid-sixteenth century through the mid-seventeenth century.[3] These production levels were sustained by the patio process, a method of refining silver via mercury amalgamation first implemented in Potosí in the 1570s.[4] This new method of refining required substantial investment in terms of infrastructure and power (wind, horse, and human) to grind and process the silver ore. Its adoption was facilitated by administrative reforms introduced by Viceroy Francisco de Toledo (1515-1582). The institution of a coercive labor regime (*mita*) required indigenous communities to supply draft laborers for rotating terms of service in the area's mines and refineries, which were typically owned and operated by individuals of European descent. Administrative oversight over the production and distribution of raw materials, namely mercury, was designed to ensure that these individuals could afford to adopt the new refining technologies and still make a profit.[5]

These administrative and technological changes transformed Potosí into a cosmopolitan city with a global impact. Potosí's silver output shaped the global trade in silver, affecting not only the economies of Iberia and her near neighbors but also more distant regimes, including that of Ming China. The town, which by 1600 was home to over 100,000 residents, brought individuals from across the globe into proximity. Some, both of Euro-

1 Long, *Openness, Secrecy, Authorship*, 178-182.

2 Lane, *Potosí*, 10, 12, 16, 33, 47. Kircher's depiction is found in Kircher, *Mundus Subterraneus*, II, 209.

3 TePaske, *A New World of Gold and Silver*, 178.

4 Castillo Martos, *Bartolomé de Medina y el siglo XVI: un sevillano lleva la revolución tecnológica a América*; Muro, "Bartolomé de Medina"; Probert, "Bartolomé de Medina: The Patio Process and the Sixteenth Century Silver Crisis"; Bargalló, *Amalgamación*; Bargalló, *Minería*.

5 Lohmann Villena, *Minas de Huancavelica*; Presta, "Compañía del Trajín".

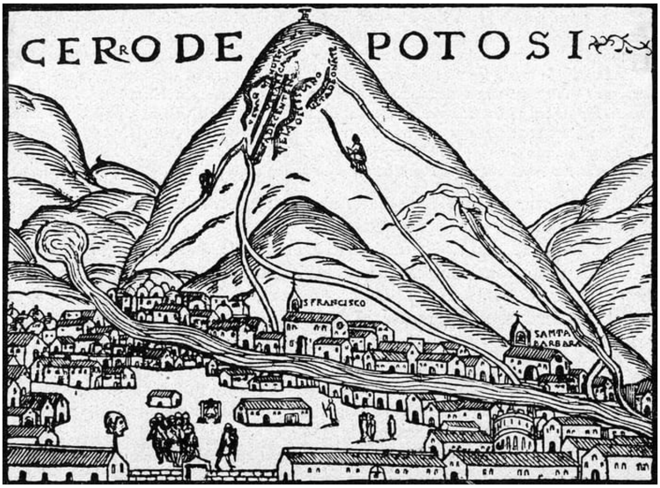

Fig. 1 – "Cerro de Potosí", Pedro de Cieza de León, *Crónica del Peru*, 1553. Image licensed under the Creative Commons Attribution-Share Alike 4.0 International license.

Fig. 2 – Mining in Potosí, engraving from Theodor de Bry, *Historia Americae sive Novi Orbis* (1596). Image licensed under the Creative Commons Attribution-Share Alike 4.0 International license.

pean and indigenous Andean descent, came willingly in the hopes of profiting from the city's rich ores. Iberian officials contracted others, both natives of the Iberian Peninsula and foreigners, for their metallurgical expertise. Others were coerced; these individuals included not only indigenous Andeans but also enslaved Africans, brought to labor in the mines and in the town's mint.

Contemporaries saw in Potosí's ores the promise of future riches through the application of industry, knowledge, and good fortune. Nearby mining sites, both those already in operation and those yet to be discovered, were regarded as tantalizing prospects, whose untapped mineral wealth might equal or surpass that of Potosí. Equally enticing was the possibility that silver yields could be augmented by new technical innovations, and individuals claiming to have developed such mining and refining technologies eagerly presented them to Spanish officials in exchange for protection and reward.

This contribution considers two such individuals whose narrative accounts survive in the Archivo General de Indias in Seville. The first, entitled *Relación general … de Potosí* ("General Relation of Potosí"), was composed by an individual named Luis Capoche, who was born in Seville and was the owner of several mines and refining mills in 1585, when he composed his account. The second is a manuscript dated 1596 and titled *Relación breve y sumaria … del descubrimiento … de nuebo Potosí* ("Short relation and summary of the discovery of New Potosí"). It was penned by Juan Francisco de Hinestrosa, who claimed to have discovered a new silver mine, "New Potosí", whose output, Hinestrosa asserted, would eventually rival that of the famed Potosí.

In their surviving texts, Capoche and Hinestrosa embraced approaches associated with the New Science of early modern Europe. Both authors describe experimental, empirical trials in the context of silver refining and rely on quantitative calculations to bolster their arguments. Hinestrosa, in addition, portrayed his metallurgical knowledge as derived from his reading of scholarly texts, his reliance on experimental methods, and his interactions with indigenous metallugists.

Texts like Capoche's and Hinestrosa's *relaciones* have been employed in recent decades to develop a more inclusive narrative of early modern European science. Such efforts at expansion and recovery of agency have operated at three registers. First, to challenge a traditional focus on elite European actors, scholars have emphasized the role of artisans and artisanal modes of production, including metallurgy, in fueling the embrace of experimental methods.[6] Second, documents like Capoche's and Hinestrosa's *relaciones* prompt a move towards greater geographical inclusivity by revealing the robust culture of scientific

6 This tradition of scholarship is often attributed to Edgar Zilsel, Zilsel, "The Sociological Roots of Science". Important revisions of this thesis include Long, *Openness, Secrecy, Authorship*; Long, "Trading Zones in Early Modern Europe"; Long, "Trading Zones"; Smith, *Body of the Artisan*.

and technical inquiry beyond continental Europe.[7] Finally, Capoche's and Hinestrosa's descriptions of indigenous refining technologies and expertise provide a means of acknowledging and recovering subaltern contributions to early modern knowledge production.[8]

These approaches have shaped previous studies of Capoche and Hinestrosa. Peter Bakewell and many others have employed Capoche's descriptions to recover on-the-ground refining practices in sixteenth-century Potosí, including the transition from indigenous refining techniques to the use of mercury amalgamation.[9] Tristan Platt and Pablo Quisbert relied on Hinestrosa's account to reinterpret the role of indigenous Andeans in the discovery of Potosí.[10] More recently Heidi Scott argued that archival sources like Hinestrosa's provide valuable insight into how early modern geological theories were shaped and deployed on the ground.[11]

This contribution builds on these studies to nuance existing scholarship on the role of the Iberian state in natural and technical knowledge production. Scholars who pioneered the study of science in the early modern Iberian world combatted Spain's Black Legend by demonstrating the significant scientific and technical knowledge inscribed in administrative, archival documents.[12] More recently, scholars have shown how Spain's empire and institutions shaped both the nature of scientific and technical knowledge produced in its realm and the way such knowledge was recorded, disseminated and read. Iberian officials sought to collect knowledge useful for the state and relied on eye-witness reports, experiment, and visual evidence to do so.[13] Rather than promoting the public dissemination of natural knowledge in print, the early modern Iberian state privileged vertical transmission of knowledge, often in secret, between individuals.[14] These studies focused on the recovery of knowledge traditions, whose specific features have tended to be interpreted as shaped by the Iberian state.

This study takes the opposite approach. Rather than recovering the metallurgical knowledge inscribed in Capoche's and Hinestrosa's *relaciones*, it inquires into Capoche's and Hinestrosa's conceptions of the Iberian state Two approaches serve as methodolog-

7 Cañizares-Esguerra, "On Ignored Global 'Scientific Revolutions'".
8 In the context of Andean metallurgy, see Barragán Romano, "Extractive Economy"; Bigelow, *Mining Language*; Bigelow, "Técnica"; Salazar-Soler, "Álvaro Alonso Barba"; Scott, "Between Potosí and Nuevo Potosí: Mineral Riches and Observations of Nature in the Colonial Andes, ca. 1596-1797".
9 Bakewell, "Technological Change"; Lane, *Potosí*, 46-91.
10 Platt and Quisbert, "Tras las huellas del silencio: Potosí, los Inkas y el virrey Toledo".
11 Scott, "Between Potosí and Nuevo Potosí: Mineral Riches and Observations of Nature in the Colonial Andes, ca. 1596-1797".
12 Portuondo, "Finding 'Science' in the Archives of the Spanish Monarchy".
13 For key examples of these arguments, see Barrera-Osorio, *Experiencing Nature*; Bleichmar, *Visible Empire*; Crawford, *Andean Wonder Drug*; Portuondo, *Secret Science*.
14 Cañizares-Esguerra, "On Ignored Global 'Scientific Revolutions'"; Portuondo, *Secret Science*.

ical inspiration. First, in focusing on Capoche's and Hinestrosa's writings in the context of Iberian administration, it takes up Sebastian Felten and Christine von Oertzen's call to analyze administrative procedures as knowledge processes.[15] It relies particularly on the insights of Arndt Brendecke, who has demonstrated the way that documents providing information ostensibly intended to produce "more knowledge" often served to facilitate political and administrative goals.[16] This contribution builds on but moves in a different direction than Brendecke's through its focus on the perspective of local actors and its insistence that information could simultaneously serve political, administrative, and knowledge-production purposes. In doing so, it builds on current narratives about the history of science in Iberian colonial space that privilege context and networks of knowledge production.[17]

Second, it draws on the methods of historians of the book and archives, who have argued for the importance of situating the content of a text in the context of its production and reception. Capoche's and Hinestrosa's dedication of their treatises to royal officials, it argues, signals their roles as "readers" of Iberian administrative practices and ideals. The appeals each made to natural and technical knowledge can thus be interpreted as evidence of how contemporaries understood the role of natural and technical knowledge in the context of Iberian governance. It approaches Capoche's and Hinestrosa's texts according to Hans Robert Jauss's notion of a "horizon of expectations," the intellectual tradition and assumptions authors shared with readers.[18] Jauss's notion of a "horizon of expectations" invokes a similar shared set of assumptions as has been described by ethnohistorians in speaking of *visitas* as administrative "performances" and the act of "speaking like a state" that Michael Szonyi has applied to military households in Ming Dynasty China who appropriated state discourse in their dealings with the state.[19]

This investigation proceeds in three parts. Part 1 situates Capoche's and Hinestrosa's texts in the context of colonial Andean mining administration. While these efforts at contextualization account for the parallels in Capoche's and Hinestrosa's careers and writings. Part 2 argues that they simultaneously erase the authorial agency of both. It suggests an alternative approach, interpreting their *relaciones* as reflections of a horizon of expectations shared with their intended readers, the viceroy and king. Part 3 explores the varied ways

15 von Oertzen and Felten, "The History of Bureaucratic Knowledge: Global Comparisons, c. 1200-c.1900".

16 Brendecke, *Imperio e información: funciones del saber en el dominio colonial español*.

17 Bauer, *Alchemy of Conquest*.

18 Jauss, "Literary History". Other important works include Iser, *The Act of Reading: A Theory of Aesthetic Response*; Fish, *Is There a Text in This Class? The Authority of Interpretive Communities*; Suleiman and Crosman, *The Reader in the Text: Essays on Audience and Interpretation*; Tomkins, *Reader-Response Criticism: From Formalism to Post-Structuralism*.

19 Guevara-Gil and Salomon, "A 'Personal Visit'"; Szonyi, *Art of Being Governed*.

that Capoche and Hinestrosa marshalled theoretical and practical metallurgical knowledge in their writings as a means of enriching previous scholarship that has argued for the Iberian state's interest in and promotion of knowledge production.

1. Aims and circumstances of production

This section examines the aims and circumstances in which Capoche and Hinestrosa composed their accounts. Their writings were generated in the context of Iberian colonial administration and exhibit striking parallels in form and content. Drawing on the insights of theorists of reader reception, this section argues that Capoche and Hinestrosa shared a horizon of expectations shaped by their quotidian interactions with local and royal officials. As a result, it is possible to read Hinestrosa and Capoche as contemporary "interpreters" or "readers" of the Iberian state.

Capoche and Hinestrosa pursued parallel career trajectories, which they aimed to further through the composition of their *relaciones*. Originally from Seville, Capoche was the owner of various mines and mills in Potosí when he composed his *relación*. The treatise, which was dedicated to the incoming viceroy Fernando Torres y Portugal, is well-known today via a print edition of 1959.[20] Though it remained unpublished in Capoche's lifetime, it appears to have circulated in manuscript in the period. Two separate copies exist in the Archivo General de Indias (AGI) in Seville, Capoche was mentioned as an authority by contemporaries, and his *relación* is thought to have influenced period descriptions of Potosí.[21] While Hinestrosa gives no indication that he encountered Capoche's *relación*, it is possible that a copy was passed to Torres y Portugal's successor to which Hinestrosa was privy.[22]

[20] Capoche, *Relación general*.

[21] These manuscript copies are found in AGI Charcas 134 and numbered 8-9 and 11ª. Subsequent references, unless specified, will be to the published edition of Capoche's text.

[22] Hanke has speculated that Capoche's treatise was brought to Lima shortly after Capoche completed it in August of 1585 and read by the viceroy and the *junta* he assembled to address the question of forced indigenous labor. At least one other copy of Capoche's treatise circulated independently in Peru, as Capoche indicates that he also sent an exemplar to Juan López de Cepeda, former president of the Audiencia de La Plata. By the seventeenth century, at least one of these copies had been sent to Spain, since the official chronicler Antonio de Herrera appears to have relied on Capoche's text in composing sections of his *Historia general de los hechos de los castellanos en las islas y tierra firme del mar Océano* (1601-1615), Capoche, *Relación general*, 64-65. However, even if a copy of Capoche's treatise remained amongst the papers held by the viceregal administration of Hurtado de Mendoza, it is unclear whether Hinestrosa would have been granted access. While Castillo Gómez has emphasized the restrictions on access to municipal and other official archives, Brendecke portrays early modern Iberian archives as open to consultation and the interests of private individuals, Castillo Gómez, "New Culture of Archives"; Brendecke, "'Arca, Archivillo, Archivo': The Keeping, Use and Status of Historical Documents about the Spanish Conquista".

Hinestrosa and his "New Potosí" are less well known. The information we have about Hinestrosa's life derives from his surviving text. When he wrote it in 1596, he described himself as living in the Xauxa province of Peru with a wife and three children. His self-reported metallurgical expertise included serving as an inspector, assayer, and consultant at various gold and silver mines in the Andes. He addressed his account to King Philip II and aimed to secure recognition for his discovery of "New Potosí", a metallurgical site he predicted would rival Potosí's output. Today the site, like Hinestrosa, has fallen into obscurity. His account also seems to have received little recognition from contemporaries or period historians. His *relación* is found in the AGI, bound in the same *legajo* as the copies of Capoche's treatise.[23] While it clearly was sent from Peru to the Iberian Peninsula, there is no evidence from readers' marks, additional copies, or references by contemporaries that it was circulated or read.

The composition and dedication of their texts to royal officials reflects the practices and aims of Iberian governance in this period. Capoche and Hinestrosa composed their *relaciones* in periods of administrative transition. Capoche's *relación* was dedicated to and intended in anticipation of the arrival of the seventh viceroy of Peru, Fernando de Torres y Portugal, who served from 1584 to 1589. Torres y Portugal was succeeded by García Hurtado de Mendoza, whose term as viceroy ended the same year that Hinestrosa completed his *relación*.

Mining administration was a central concern for both these viceroys, who advocated for and instituted new policies on behalf of the silver refining industry. To bolster production, Torres y Portugal urged the king to halve the percentage of silver that refiners were required to hand over to the crown. He also convened a council (*junta*) to reconsider and reinforce incentives granted by his predecessors to ensure a large indigenous labor force in Potosí, including the right to work mines for personal benefit outside the work week (*kapcha*) and to sell raw silver ores for profit (*rescate*). Concerned that the pool of *mita* laborers was declining, Hurtado de Mendoza ordered an administrative inspection of Potosí and issued new ordinances to regulate the assignment and pay of *mitayos*, the interactions between mine- and mill-owners and *mitayos*, and the rights of indigenous laborers to mine and refine ores on their own time.[24]

Efforts to boost silver production extended beyond viceregal administration of the *mita*. The perception that Potosí's ores were nearing exhaustion encouraged some individuals to seek out new sources of silver and improvements in refining technologies. Difficulties refining Potosí's *negrillos*, silver ores with high sulfide content, led Hurtado de Mendoza to write to the crown in 1595 advocating the subsidizing of other mining

23 Hinestrosa, "Relaçion breve y sumaria", AGI Charcas 134, numbered 12.
24 Cole, *Potosí Mita*, 62-63.

centers in the area.[25] Individual miners and refiners sought solutions for these and other technical difficulties, and they brought proposals for new refining techniques and mining apparatus to Potosí's municipal council, the viceregal administration, and the Council of Indies.[26] Recurring problems ensuring an adequate supply of mercury incentivized officials and private individuals to seek alternative administrative arrangements for Huancavelica and prompted attempts to develop new methods of refining mercury.[27]

This administrative context accounts for many of the striking parallels in form and content of Capoche's and Hinestrosa's treatises. Capoche described his text as offering an account of the *asiento* and *cerro*, the state of its mines, the quality of its metals, and "other particulars" regarding its *gobierno*. This information was conveyed, according to Capoche, by "referring to some things that have happened."[28] This enterprise, of "referring to some things that have happened," involved a variety of types of information and presentation styles. Capoche described the geography of the town and her mountain, narrated the discovery of Potosí's and nearby ore deposits, and addressed aspects of mining administration, including indigenous labor and contributions to the royal treasury. He interspersed his textual narrative with extracts of documents penned by others addressing the practice of *rescate*. He also included non-textual elements, including lists and tallies. His *relación*, for example, contains lists of Potosí's veins, the names of individuals who owned mines situated along them, and the *mitayos* (indigenous laborers) assigned to them. He also included descriptive lists of *ingenios* (refining mills) and their owners.

Hinestrosa's surviving manuscript incorporates many similar elements. He offered a textual narration that described his activities as a miner, his discovery of New Potosí, and his own theory of metallic ores. Like Capoche, Hinestrosa includes multiple lists: of the veins of New Potosí and their characteristics; of the discoverers of these veins; and of individuals who staked claims to them as owners. Hinestrosa also transcribed the writings

25 *Ibid*., 63. On Potosí's ore chemistry, Bargalló, *Amalgamación*, 227-228; Guerrero, *Silver by Fire*, 26-32; Lane, *Potosí*, 22-26. On the racial implications of this terminology, Bigelow, *Mining Language*, 229-293.

26 For this phenomenon in relation to the Iberian state and empirical practice, see Barrera-Osorio, *Experiencing Nature*, 56-80. On petitions originating in Potosí and local collaborations between individuals of European descent and indigenous Andeans, see Bigelow, "Técnica". On the bureaucratic practices and ideals in which these proposals were generated and received, see Raphael, "In Pursuit of 'Useful' Knowledge: Documenting Technical Innovation in Sixteenth-Century Potosí".

27 Lohmann Villena, *Minas de Huancavelica*, 110-130; Presta, "Compañía del Trajín".

28 "haciendo esta relación de lo que este asiento y cerro, del estado en que están sus minas con todas las de la provincia, y ley de los metales, y otros particulares tocantes a su gobierno, refiriendo algunas cosas que han sucedido para que mejor se entienda la dificultad que tienen los negocios de esta nueva tierra, que ha sido mi principal intento", Capoche, *Relación general*, 72.

of others, copying a letter of support from García Hurtado de Mendoza, the outgoing viceroy of Peru, testifying to Hinestrosa's metallurgical expertise.[29]

Both Hinestrosa and Capoche styled their accounts as *relaciones*, an early modern Iberian genre whose fluid nature tends to defy categorization. The late sixteenth century saw a concerted effort on the part of the Iberian crown to collect local information for improved governance, which scholars identify as the origin of the genre of the *relación*. To facilitate this endeavor, the crown issued directives to collect information regarding the natural environment and peoples of the Americas, which culminated in the 1577 *relaciones geográficas e históricas de Indias*.[30] According to Walter Mignolo, the genre of the *relación* includes directives, questionnaires, and accounts generated in the course of Iberian administration and other writings whose content was shaped by these official directives.[31] María Portuondo has offered a more expansive definition of *relación*. According to her, *relaciones* comprised "accounts of personal experiences in the New World … personal memoirs, letters, chronicles, replies to official questionnaires, and even personal interviews with travelers from distant lands."[32]

Hinestrosa's and Capoche's *relaciones* were penned in the context of the Iberian knowledge-production regime, which bestowed favor in return for meritorious service. In his composition, Hinestrosa argued that his discovery of New Potosí and previous service to the viceroy were acts of service to the crown that merited the granting of specific privileges as royal favors, including the assignment of indigenous laborers to the new site. Like Hinestrosa, Capoche presented his treatise as a service to the incoming viceroy, one that would facilitate an understanding (*se entienda*) of local affairs (*negocios*).[33]

Other details suggest that Capoche's *relación* was commissioned by representatives of the incoming viceroy. In his text, Capoche expressed a desire to shape viceregal policy on issues that affected him as a mine- and mill-owner. Capoche negated contemporaries' depictions of a mining industry in ruins, favored private over state control of quicksilver production and distribution, and opposed the awarding of privileges for new refining methods. With respect to labor policies, Capoche opposed the enslavement of indigenous Andeans, yet objected to the current policy allowing *mitayos* to collect, refine, and subsequently sell ores gathered on the side (*rescate*) for their personal profit.[34] These pronouncements on policy can be read in dialogue with Capoche's references to his interactions with Pedro de Córdova Mesía, who visited Potosí in anticipation of Torres y Portugal's tenure

29 Hinestrosa, "Relaçion breve y sumaria", 4v.
30 Álvarez Peláez, *Conquista*.
31 Mignolo, "Cartas crónicas y relaciones del descubrimiento y la conquista", 72.
32 Portuondo, "Secret Science: Spanish Cosmography and the New World", 85.
33 "me pareció dar principio en servir a Vuestra Excelencia haciendo esta relación … suplico reciba este pequeño servicio no considerando lo poco que es sino a la voluntad con que lo ofrezco, la cual tengo dedicada al servicio de Vuestra Excelencia", Capoche, *Relación general*, 72.
34 *Ibid.*, 57-61.

in Peru. Following the viceroy's arrival, Córdova Mesía participated in debates regarding the treatment of indigenous Andeans and the administration of Potosí. Though he did not mention Capoche by name, during these discussions, Córdova Mesía acknowledged his receipt of various *relaciones* composed by "experts."[35]

2. Hinestrosa and Capoche as "readers" of the Iberian state

Administrative practice and genre can account for the strong parallels observed in their lives and texts. This section argues that that such explanations assign agency above and outside Hinestrosa and Capoche as local actors and authors. It demonstrates the benefit of an alternative approach, namely the employment of Hinestrosa's and Capoche's *relaciones* to recover common assumptions regarding the Iberian state's valuation of metallurgical knowledge.

Attributing the parallels between Capoche and Hinestrosa to administrative practice or genre focuses our gaze on the intended readers and institutions to which their treatises were directed. Arguments that the state and its institutions shaped their writings inadevertently assign agency to their intended recipients. This approach interprets Capoche's and Hinestrosa's *relaciones* as expressions of the interests of the Iberian state not of Capoche and Hinestrosa as individuals.

Explanations based on conventions of genre similarly obscure Capoche's and Hinestrosa's agency. In seeking to identify how Hinestrosa and Capoche came to know what comprised a *relacion*, one might note that early modern petitioners often wrote with the help of others. Capoche, for example, is known to have received assistance from the Mercederian friar Nicolás Venegas de los Ríos, who was the copyist of one of the surviving manuscripts of his text.[36] Yet such explanations displace authorial decision-making onto other individuals or the disembodied nature of genre conventions themselves. They make it difficult to view Capoche and Hinestrosa as writers who purposefully selected the form and content of their treatises to appeal to their intended readers.

An alternative mechanism to account for the similarities between Hinestrosa's and Capoche's *relaciones* derives from the insights of theorists of reader reception. According to this explanation, Capoche's and Hinestrosa's interactions with municipal and royal officials in Andean mining centers led them to a shared understanding of administrative practices and its associated values. In the terminology employed by theorists of reader reception, these interactions provided Hinestrosa and Capoche with a "horizon of expectations," a set of assumptions regarding the type of information, both in terms of content and form, that was sought by administrative officials. The two authors then styled their *relaciones* to conform to their perceptions of their readers' expectations.

35 *Ibid.*, 64-65.
36 *Ibid.*, 50n32.

One avenue through which Capoche and Hinestrosa developed this shared set of expectations was via personal interactions with royal officials that directly shaped the composition of their *relaciones*. In his text, Capoche credited Córdova Mesía with influencing the subjects he chose to address. Córdova Mesía, he indicated, incentivized him to treat the subject of *tasas* (tribute), the "most serious subject" of this kingdom.[37] Capoche lauded Córdova Mesía's "advantageous and clear understanding," which, he proclaimed, gave him insight into the viceroy's concerns and interests.[38]

The relationship Capoche describes between himself and Córdova Mesía parallels Hinestrosa's own interactions with viceroy García Hurtado de Mendoza. Hinestrosa described how Hurtado de Mendoza had dispatched him to offer his expertise at the gold mines of Mataro in Huaylas province and at a set of abandoned silver mines registered by two brothers, Hernán and Lucas Ramírez. Hinestrosa's *relación* also concludes with a declaration of support from the outgoing viceroy.[39]

Quotidian interactions with officials in the context of their mining and refining operations also likely led Hinestrosa and Capoche to develop a parallel sense of what type of information interested administrators. Archival documents held today in Potosí contain the records of a lawsuit brought against Capoche in 1593 regarding payments he owed in connection with his refining mills. In 1596, Capoche's refining mills were surveyed as part of an official administrative inspection carried out by the visiting judge (*visitador*) Alonso Vázquez Dávila.[40] Capoche's *Relación* indicates his familiarity with other administrative practices no doubt known to Hinestrosa as well. These included the act of registering mines and the petitioning for royal privileges and protections for new refining methods.

The notion of a horizon of expectations shaped by interactions with royal officials facilitates analysis of Capoche's and Hinestrosa's *relaciones* in two ways. First, it suggests a plausible origin of attributes of these documents that seem to derive from metallurgical practice and administration, including tables and lists of veins, refining mills, and their corresponding owners and assigned *mitayos*. Both Hinestrosa and Capoche, for example, included lists of the discoverers of silver veins and of mine and mill owners (Fig. 3, Fig. 4). These lists follow

37 "La materia más grave que hay en este reino es la de las tasas … Conozco que era menester otro ingenio que el mío para tratarlo y si a esto hubiera de tener consideración, mil causas había para dejarlo de hacer por mi rudeza", Capoche, 180.

38 "Y excúsame el haberme hecho merced que tuviera este cuidado el muy ilustre señor don Pedro de Córdoba Mesía cuando vino a esta villa, para poder dar razón a Vuestra Excelencia, por vista de ojos, del estado de sus cosas. Y con su aventajado y claro entendimiento lo llevó tan comprendido y sondado el golfo de sus negocios y gobierno", Capoche, 180-181.

39 Hinestrosa, "Relaçion breve y sumaria", ff. 3v-4r, 5v-6r, Scott, "Between Potosí and Nuevo Potosí: Mineral Riches and Observations of Nature in the Colonial Andes, ca. 1596-1797".

40 See Capoche, *Relación general*, 45-46. These records are found in the Archivo Nacional de Bolivia (ANB) Minas 18 and the Bibliothèque Nacionale de France (BNF) Ms. Esp. num. 175, ff. 220-220v.

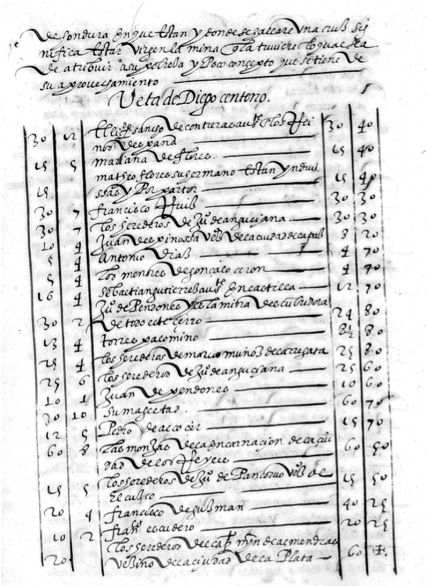

Fig. 3 – Capoche's table indicating distribution of mines along one vein of Potosí's *cerro ricco* and the number of *mitayos* assigned to each, España, Ministerio de Cultura y Deporte, Archivo General de Indias, CHARCAS 134, copy labeled "11a", f. 5v.

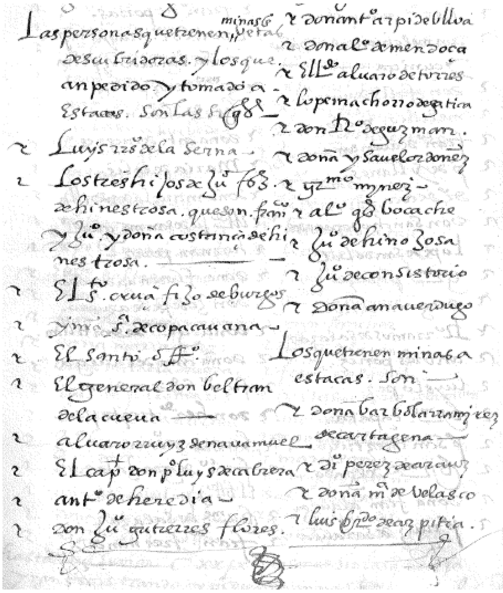

Fig. 4 – Hinestrosa's list of discoverers of silver veins in New Potosí, Hinestrosa, "Relaçion breve y sumaria", España, Ministerio de Cultura y Deporte, Archivo General de Indias, CHARCAS 134, ff. 22v-23r.

a format similar to contemporary administrative documents associated with accounting, financial administration, and the surveying of indigenous populations (Fig. 5, Fig. 6).

Second, it provides a mechanism that assigns agency to Hinestrosa and Capoche in their appropriation of the practices and aims of the Iberian state. This framework emphasizes Hinestrosa's and Capoche's roles as thinking authors who developed their own interpretations of the values and expectations of royal officials. It facilitates a reading of their texts as intentional efforts to appeal to these expectations.

3. *Speaking to the state about natural and technical knowledge*

Whereas scholars have often employed texts like Hinestrosa's and Capoche's as windows into local knowledge, the previous conclusions suggest the utility of a different approach. Rather than using their texts to reconstruct on-the-ground technical practice and metallurgical theory, this section focuses on the role Hinestrosa and Capoche assigned to technical and natural knowledge in the context of their goals as authors aiming to shape the

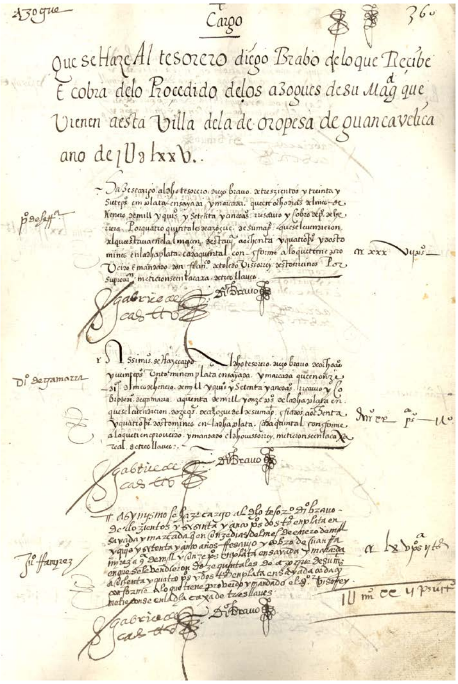

Fig. 5 – Quicksilver accounts, CNM, CR 16, 360r.

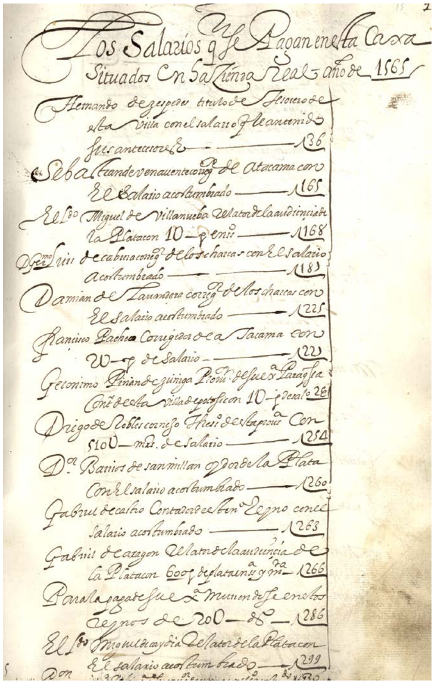

Fig. 6 – Accounts of administrative salaries, CNM, CR 3, 15r.

response of their intended readers. This approach enriches and nuances claims for the Iberian state's interest in and promotion of natural and technical knowledge. Such studies have attributed to the Iberian state these scientific and technical interests on the basis of centrally generated directives to collect such information and the presence in archives of petitions and treatises generated locally. Capoche's and Hinestrosa's texts offer an alternative approach, one directed at the recovery of contemporary, local understandings – what we might term "readings" – of the state's interest in such knowledge.

To bolster his claims that New Potosí would one day rival Potosí's silver yields, Hinestrosa offered details of his metallurgical practice and the theoretical understanding that undergirded it. Hinestrosa described how the mountain's veins, except one, all ran east to west. This orientation, he argued, was a sure sign of the richness of their ores, a fact he had come to know via experience and "discourses."[41] Hinestrosa's confidence in the future

[41] "y metiendome en la consideraçion de las vetas y de los discursos q llevavan que son con el sol todas eçepto una sola y la mas caudalusa de ellas q esta sola la atraviesa el sol por que corre norte a sur", Hinestrosa, "Relaçion breve y sumaria", ff. 8v-9r.

productivity of New Potosí, moreover, rested on a "certain and established rule," which he had formulated that claimed that the richness of surface ores betrayed a poverty in deeper ores found underground and vice versa.[42]

This attention to metallurgical theory simultaneously served to underscore Hinestrosa's credibility as an author. Throughout his *relación*, Hinestrosa stressed the theoretical and practical foundations of his knowledge and emphasized its origins in text, personal experience, and the expertise of indigenous Andean metallurgists. His "certain and established rule," he claimed, revealed the presence of rich, deeper ores, but these ores often could only be accessed through the appropriation of indigenous refining methods.[43] In another section, Hinestrosa described how Potosí defied his general rule in possessing both rich surface and deeper ores, though the former had initially been overlooked even by "some Germans."[44] With this remark, Hinestrosa implicitly positioned himself as more capable than even German metallurgists, a group widely recognized in the period as having superior metallurgical knowledge.[45]

Hinestrosa's presentation style in this section may have been intended to further his claims for authorial credibility. He set his discussion of Potosí and the Germans apart from the main body of his text by labeling it an "example" (Fig. 7). Citation of an "example" calls to mind the early modern practice of commonplacing, the collection and citation of examples, both textual and based on experience, to buttress one's arguments.[46] "Examples" were also employed in certain textual genres that crossed learned-practical divides, such as texts of practical mathematics. Hinestrosa's decision to render this part of his discussion as an "example" may have been a deliberate attempt to bolster his own authority by demonstrating his familiarity with these learned practices and genres.

42 "Y asi tengo por rregla çierta y averiguada que las minas fijas an de ser pobres de ley ençima de la tierra y si van encapadas por de baxo de quemazones y de tierra son mejores", Hinestrosa, "Relaçion breve y sumaria", ff. 14v.

43 "pero a devido pocas vetas destas por que no an hecho caso dellas que si los indios no siguieran con guayras las de potosi no se descubriera su rriqueza y asi sean de yr conoçiendo los paninos de las piedras en que estan y sus caxas y las malezas con que se crian y como corren y la quemazon que llevan", Hinestrosa, "Relaçion breve y sumaria", ff. 15r.

44 "Y labra treynta años que vi en ellas unos alemanes que los ensayaron por azogue y no tan solamente no les sacaron punta de plata pero los metalles y sus malezas les comio el azogue y provaron a hazer hornos de fundiçion con fuelles y rreberberaçiones y tanpoco les acudio cosa alguna y esto fue causa estar estas misturas dichas en su fuerça y punto. Y solos los indios a fuerça de soroches de plomo y fundiendolos tres y quatro vezes … con las guayras les sacava la plata", *ibid.*, 17r.

45 Herzog, "Merchants and Citizens", 146-147.

46 Moss, *Printed Commonplace-Books and the Structuring of Renaissance Thought*, 101-214. On commonplacing in early modern natural philosophy and the incorporation of examples drawn from real-world experience, Blair, "Humanist Methods".

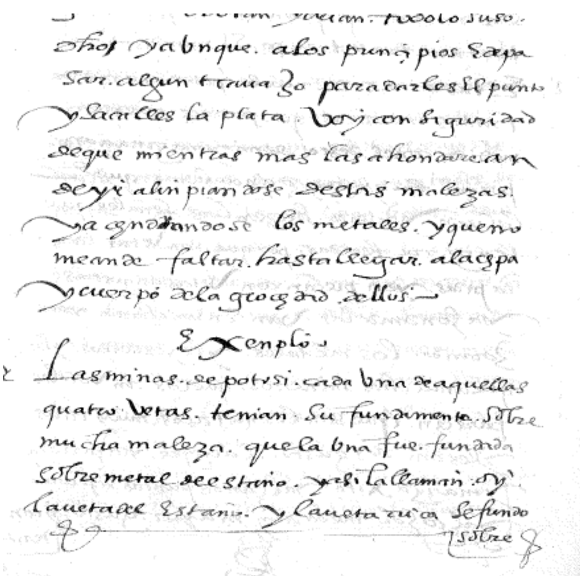
[illegible] todo lo suso-
dichos y aunque. a los principios [illegible]
san algun [illegible] para darles el punto
y sacalles la plata. voy con seguridad
de que mientras mas las ahondaren
de [illegible] destas malezas.
ya [illegible] los metales. y que no
me an de faltar. hasta llegar. ala [illegible]
y cuerpo de la [illegible] dellos –
Exenplo.
Las minas de potosi. cada una de aquellas
quatro vetas. tenian su fundamento sobre
mucha maleza. que la una fue fundada
sobre metal de estaño. y asi la llaman oy
la veta del estaño. y la veta rica se fundo
sobre

Fig. 7 – Hinestrosa's "example", Hinestrosa, "Relaçion breve y sumaria", España, Ministerio de Cultura y Deporte, Archivo General de Indias, CHARCAS 134, ff. 16v-17r.

Hinestrosa's presentation reveals a particular understanding of the Iberian state's relationship to natural and technical knowledge. Hinestrosa sought to convince his intended reader of his reliability as an author by emphasizing his superior metallurgical knowledge. Hinestrosa's claim for authorial credibility rested on the assumption that his intended reader associated credibility and authority with the acquisition of knowledge. Underlying Hinestrosa's argument is the idea that royal officials valued natural knowledge obtained via the reading of texts and verified by practical experience. For Hinestrosa, officials already recognized the value of technical and theoretical knowledge. His task, as he saw it, was to convince his reader that he possessed this knowledge and applied it correctly to the case of New Potosí.

Capoche similarly devoted large portions of his *relación* to detailed descriptions of technical information related to mining and refining, though he focused more on practical details than theoretical knowledge claims. The first section of the two-part work focuses almost exclusively on metallurgical practice. After offering a description of Potosí and its discovery, Capoche details the mountain's veins and the infrastructure developed to access its silver ores. He also describes indigenous methods of refining to process Potosí's ores. Capoche begins the second part of his treatise with an extended discussion of the history and technical details of the patio process, the method of refining silver via amalgamation with mercury introduced in Potosí in the 1570s. Elsewhere Capoche addressed other topics related to metallurgical practice, describing nearby mining sites and detailing the dangers indigenous forced laborers faced.

Capoche's reason for including these details differed from Hinestrosa's. Capoche introduced the patio process by emphasizing the importance of understanding the technical details of silver refining. According to Capoche, although it is "very well known" that silver and gold can be refined by quicksilver, "everyone in general ignores the way it is done because it is a "finicky" thing and "used in few parts of the world." He noted that despite it being a "natural effect to discover such a beneficial use," this discovery required "great ingenuity and ability," which he intended to demonstrate to the viceroy through his description of the details of the process.[47] Rather than assuming the viceroy's positive valuation of technical knowledge, Capoche aimed for his *relación* to make that precise argument: he included technical information to make an argument about its importance for *gobierno* (governance). The incoming viceroy, Capoche argued, should value and appreciate this knowledge in the context of his political, legal, and administrative responsibilities.

Like Hinestrosa, Capoche felt compelled to persuade his intended reader of the credibility of his *relación*. Capoche addressed this issue directly in multiple passages of his *relación*. The truths of Peru, Capoche noted, were so strikingly different from those of the Iberian Peninsula for their "singularity" and "the subject of their matter" that "they are not understood except by the exercise of experience." This phenomenon, he noted, "is accustomed to happen in new regimes (*gobiernos*)."[48] He cautioned the viceroy regarding the difficulties of distinguishing between the representations of others. It was possible, Capoche wrote, to represent the affairs (*negocios*) of this land "in so many ways and adulterated." Because the viceroy was "far from his [accustomed] center and place," Capoche noted, "for some time there would be a risk in recognizing and choosing the true [representation]."[49]

Capoche, unlike Hinestrosa, represented his credibility as derived not from his metallurgical knowledge but from the methods he employed in composing his *relación*.

47 "Aunque es cosa muy sabida que con el azogue se saca la plata y oro de los metales, la manera que en esto se tiene todos lo ignoran en general, por ser cosa excquisita y en pocas partes del mundo usada. Por la cual pondré aquí el orden que se tienen en hacer esto, aunque es operación y efecto natural hallar uso tan provechoso, fué de mucho ingenio y habilidad, pues vemos se parte el azogue para sacar tres onzas, y [aun] dos, de plata que haya en un quintal de metal, incorporada y dividida toda la cantidad [de azogue], que bien se puede juzgar en qué forma tan chica está en las cien libras de metal", Capoche, *Relación general*, 122.

48 "son tan diferentes los de acá por la singularidad y sujeto de su materia que no se dejan comprender si no es por la experiencia en su ejercicio mente suele suceder en los nuevos gobiernos", *ibid.*, 72.

49 "sería posible representarlos de tantas maneras y tan adulterados y fuera de su centro y lugar que por algún tiempo hubiese riesgo en conocer y elegir el verdadero", *ibidem*.

Capoche offered an account of local commerce in Potosí to demonstrate that the town was both the source of the realm's silver and the kingdom's guarantor. In this section, Capoche offered a textual narration accompanied by quantitative tables to describe how commercial activities in Potosí, including the production of silver, the sale of mercury, the *rescate* market, and the clothing trade, had contributed to the royal treasury.[50] According to Capoche, Potosí's contributions could be understood according to a narrative of rise, decline, and recovery. Potosí's riches, he noted, "withered and wasted away" to such an extreme that what was initially collected in a month in royal fifths could no longer be produced in an entire year. Yet, "with the introduction of refining via mercury amalgamation," which began to "give fruit" in 1574, these returns began "little by little to grow."[51]

In this section, Capoche addressed explicitly his expectation that the viceroy would receive reports contradicting his assessment. He explained that the information he offered conformed to a "*relación general*," which he understood as comprising the "exterior and public part" of governance (*gobierno*). The "interior and secret," he noted, would be revealed as a verbal report (*relación por palabra viva*) and provided by municipal officials (*procuradores*). Capoche also emphasized the reliability of his account in relation to that of Potosí's officials. His own account, he promised, "will be as much and truthful as is necessary, so that what is furnished will be with the rectitude and discretion that is suitable." In contrast, the "interior and secret" would be revealed via the process of administrative review (*visita*), provided "it suffers no detriment."[52]

Capoche underscored the reliability of his account by closing this section with a description of his method and sources. He noted that many witnesses can testify to the riches that have emanated from Potosí. In order to make these riches apparent for the viceroy, Capoche "made an account of what has been placed as fifths in the official archive (*caja*)." This accounting was not a straightforward task, for "the books of the first quintos are not preserved with the clarity of those today, since in the early years the quantity of silver was so great that the king's portion was determined via a steelyard (*por romano*)." The ambiguity of these early records was such, asserted Capoche, that the accuracy of his own account depended on what he had retained in memory of the accounting (*averiguación*) carried out by Viceroy Toledo in 1574.[53] These comments signaled to readers not only Capoche's care in composing his account but also his local reputation. They indicated that Capoche

50 *Ibid.*, 177.

51 "esta riqueza se fué enflaqueciendo y delgazando en tanto extremo que lo que valían los quintos al principio en un mes no valían más en un año. Y desde el beneficio del azogue, que comenzó año setenta y cuatro a dar fruto, tornaron poco a poco a crecer", *ibidem*.

52 *Ibid.*, 176.

53 *Ibid.*, 180. I took this translation of "por romano" from the translation of a verbatim passage in Acosta, *Natural and Moral History of the Indies*, 178.

had composed his *relación* in consultation with official papers held in Potosí's municipal archives, access to which was predicated on a petitioner's good standing with municipal and royal officials.[54]

4. Conclusion

Modern scholars interested in premodern technological knowledge and practice are inexorably drawn to Capoche's and Hinestrosa's *relaciones*. Not only are they individuals with on-the-ground experience in the particulars of colonial Andean mining, but their narratives offer rich details recounting their personal experience in the industry. This contribution deliberately resisted such an approach. It aimed to recover not Capoche's and Hinestrosa's metallurgical knowledge but rather how they understood their intended readers' interest in that knowledge.

While both Capoche and Hinestrosa thought technical knowledge was important to Iberian officials, they differed as to how they understood the administration's valuation of that knowledge. Capoche sought to convince the viceroy that technical knowledge of metallurgical practice was important for viceregal governance. Hinestrosa, on the other hand, believed theoretical knowledge enhanced the credibility of his claims as an author.

The divergent goals underlying each *relación* likely shaped the roles each author assigned to metallurgical knowledge. Because Hinestrosa aimed to persuade the king of the viability of his discovery, he emphasized his metallurgical expertise. Hinestrosa likely believed that it was his experience in mining and refining that would make his claims of New Potosí's richness persuasive. Capoche, in contrast, aimed to convince Torres y Portugal that his account was more credible and truthful than those composed by other individuals in Potosí. While his technical expertise might distinguish him as an author, the credibility of his account had to rest on the methods of composition and the evidence he amassed. By assuring the incoming viceroy of his credibility, Capoche's arguments for the relevance of technical knowledge to governance would then be more persuasive.

These distinctions suggest the value of probing more deeply the Iberian state's role in early modern knowledge production. The presence of natural and technical knowledge in official archives testifies to a widespread appreciation of such knowledge. However, as this analysis has revealed, the agent (or assumed agent) of that appreciation may be less obvious. Tracing an appreciation of the acquisition of knowledge - and assumptions about that appreciation - would likely result in a more nuanced understanding of the relationship between science and the state and how it evolved over the course of the early modern period.

[54] Castillo Gómez, "New Culture of Archives", 554, 558-559.

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Popular science as knowledge: early modern Iberian-American *repertorios de los tiempos*

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Abstract
Iberian *repertorios de los tiempos* stemmed from Medieval almanacs and calendars. During the sixteenth century significant editorial, conceptual and material changes in *repertorios* incorporated astronomy, geography, chronology and natural philosophy. From De Li's *Repertorio* (1492) to Zamorano's *Cronología* (1585), the genre evolved from simple almanacs to more complex cosmological works which circulated throughout the Iberian-American world. This article claims that *repertorios* are a form of syncretic knowledge rather than "popular science" by relying on the concept of "knowledge in transit". Elaborating on this perspective, I present how *repertorios* ended up delivering a worldview from existing materials, a fact so far unnoticed by scholarship. At the same time, *repertorios* should not be considered an exclusively Iberian phenomenon, but the full scope of their nature as a form of syncretic knowledge should include their networks with migrants, indigenous, mestizos, and *criollos* across the Atlantic. In this sense, I try to trace the paths connecting productions in the Americas with Iberian *repertorios.*

Keywords
astrology, cosmography, almanacs, lunarios, knowledge in transit

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1. Introduction

In the history of early modern accounts of the heavens and their influences on Earth, it is usual to divide the theoretical from the practical. Needless to say, historians acknowledge that the division is far from being straightforward, for it only partially maps onto the disciplinary intricacies of astronomy and astrology; neither does this division fit accurately into the practices, institutions, and self-representations of the practitioners of the period. At the same time, the boundaries between theoretical and practical are unclear, especially at the micro-level scale.[1] However, within the spectrum of astrological literature, it is possible to distinguish the almanacs, calendars, and *lunarios*, predominantly containing tables of astronomical and astrological events for a year or a rather short cycle, from treatises dealing with the principles of astrology. [2] Works of the first kind are embedded within the main types of astrological praxis: revolutions, nativities, elections, and interrogations.[3] Because of their practical orientation, these works do not present foundational aspects of astrology, and if they do, the treatment does not go beyond some short definitions. Works of the second kind deal with the principles of astrology and frequently provide extensive and detailed discussions of the connections of astrology with astronomy, optics, natural philosophy, magic, cosmography or theology. Historians of science are most familiar with this second kind of works: Ptolemy's *Tetrabiblos,* Albumasar's *De magnis conjuinctionibus,* Roger Bacon's *Astrologia* or Albertus Magnus' commentaries on Aristotle.

The practical orientation of almanacs, calendars, and *lunarios,* and their wider social circulation in the early modern societies of Europe have made of them pre-eminently, but perhaps unintentionally, forms of popular science or, in the words of Capp, "popular knowledge".[4] This genre of works is read as a vehicle of scientific ideas produced in treatises. In other words, a significant function of this literature is the "popularization" of science or the dissemination of scientific knowledge produced elsewhere.[5] Consequently,

1 The literature on this is vast. See, for example, Pedersen, "The Corpus Astronomicum and the Traditions of Mediaeval Latin Astronomy"; Pedersen, "The Origins of the 'Theorica Planetarum'"; Grant, *Planets, Stars, and Orbs*, 569-617; Grafton, *Cardano's Cosmos*, 22-70; Vernet, *Astrología y Astronomía En El Renacimiento*; Westman, *The Copernican Question*, 25-61; Lanuza-Navarro, "Astrological Literature in Seventeenth-Century Spain"; Rutkin, "Astrology"; Rutkin, *Sapientia Astrologica*, xlii-xlix; Jensen, *Astrology, Almanacs, and the Early Modern English Calendar*.

2 Zinner, *Geschichte Und Bibliographie Der Astronomischen Literatur*; Capp, *English Almanacs, 1500-1800*, 23-66; Curry, *Prophecy and Power: Astrology in Early Modern England*; Grafton, *Cardano's Cosmos*, 71-90; Casali, *Le Spie Del Cielo*; Lanuza-Navarro, "Astrología, Ciencia y Sociedad En La España de Los Asturias", 55-61.

3 Rutkin, *Sapientia Astrologica*, xxx-xxxi; 423-463.

4 Capp, *English Almanacs, 1500-1800*, 21.

5 *Ibid.*, 180.

studying the almanacs, calendars, and *lunarios* has been a thread to navigate through early modern social, political, and religious problems. These studies have provided us with valuable results about the praxis of astrology and its complex and varied connections with knowledge, society, and power in several European scenarios.[6]

Still, when trying to understand the history of astrology *qua* form of knowledge and the evolution of its connections with other disciplines, there is a tendency to privilege the study of treatises over the almanacs and the ephemeral, and there are several reasons for doing so. As mentioned above, the treatises were the most visible places for these debates, and consequently, they are currently more accessible, as Jensen has recently pointed out. In fact, sometimes controversies about astrology presented in treatises started as reactions to pamphlets that are now lost or are hardly accessible to historians for their technical nature or for their invisibility in digital databases.[7] At the same time, astrological treatises were widely read, criticised and sometimes referenced by early modern astronomers, mathematicians, and natural philosophers traditionally identified with the "New Science". Therefore, historians of science have tended to establish smooth connections between the astrological treatises and the "New Science", even if some of these mathematicians, such as Galileo and Kepler, were also notoriously involved in the praxis of astrology.[8] Finally, the local scope of almanacs, calendars, and *lunarios*, that is, the fact that their validation and acceptance depended mostly on their interpretation and engagement with local circumstances and communities – such as local weather patterns, circumscribed territories, parochial religious practises, confined political settings – make of them not the first candidates when trying to account for long-scale transformations in astrology and its connections with early modern natural philosophy, mathematics, cosmography, and theology. In fact, the limited scope and practical-oriented nature of this genre of astrological works seem not to be revealing of the foundational changes that astrology, natural philosophy, mathematics and cosmography underwent in early modern Europe.

6 Just to mention a few, Thomas, *Religion and the Decline of Magic: Studies in Popular Beliefs in Sixteenth and Seventeenth Century England*; Capp, *English Almanacs, 1500-1800*; Curry, *Prophecy and Power: Astrology in Early Modern England*; Delbrugge, "Capitilizing on the Stars"; Casali, *Le Spie Del Cielo*; Lanuza-Navarro, "Astrología, Ciencia y Sociedad En La España de Los Asturias"; Chapman, "Marking Time"; Azzolini, *The Duke and the Stars*; Durán López, "De las seriedades de Urania a las zumbas de Talía"; Jensen, *Astrology, Almanacs, and the Early Modern English Calendar*.

7 Jensen, *Astrology, Almanacs, and the Early Modern English Calendar*, 5-6.

8 Lindberg, *Theories of Vision from Al-Kindi to Kepler*; Funkenstein, *Theology and the Scientific Imagination*; Westfall, *Never at Rest*; Hunter, *Robert Boyle Reconsidered*; Lattis, *Between Copernicus and Galileo*; Westman, *The Copernican Question*; Boner, "Kepler's Living Cosmology: Bridging the Celestial and Terrestrial Realms"; Heilbron, *Galileo*; Henry, *Religion, Magic, and the Origins of Science in Early Modern England*; Copenhaver, *Magic in Western Culture: From Antiquity to the Enlightenment*; Rothman, *The Pursuit of Harmony*.

In this paper, I present the evolution of a specific tradition of almanacs, calendars, and *lunarios,* the Iberian-American *repertorios* or *reportorios de los tiempos*, in a way that challenges some of the previous distinctions and calls for a re-examination of the categories under which we conceptualise this early modern production of the knowledge of the heavens. I argue that a transformation of astronomy, natural philosophy, and astrology of significant relevance for the Iberian-American world took place in a genre of writing largely ignored by historians of science. Evolving from a local tradition of almanacs, the *repertorios de los tiempos* came to encompass the traditional elements for the praxis of astrology and navigation with astronomical, natural philosophical, chronological and cosmographical elements in a way that crystallised in manuscripts and printed works from the early-sixteenth century to the mid-seventeenth century across the Iberian-American world, from Barcelona to Lima. By articulating elements from several traditions and praxes in a way that came to provide a rather consistent approach to the *machina mundi,* Iberian-American *repertorios* should be considered as knowledge rather than as "popular science", at least in two interconnected senses. In the first sense, the practical orientation of *repertorios,* rooted in their astrological origin, prevented them from discussing cosmological or astronomical novelties and then from being considered as knowledge (as opposed to forms of popularisation of knowledge originally produced elsewhere).[9] However, the articulation of diverse intellectual traditions with practical tools, of Renaissance and early modern cosmological views with the attempts to tackle the challenges posed by the emergence of global empires, resulted in *repertorios* in a coherent view of the *machina mundi* which shall be considered a form of knowledge, not a form of communication of knowledge: although the bricks from which this worldview was built came from elsewhere, the resultant construction, as I argue below, is novel and should be considered a form of syncretic knowledge with its historical and epistemological consequences. In the second, interconnected sense, the Iberian *repertorios* and the productions of their readers and respondents in the Americas should be considered knowledge in the sense of Secord's "knowledge in transit". By separating knowledge from its communication, in this case, the early almanacs from Iberian *repertorios* and these from their networks in the Americas, we introduce problematic epistemological breaks that Cooter and Pumpfrey already identified in 1994.[10] Questions such as how knowledge travels, to whom it is available, and how agreements are achieved are fundamental and constitutive of knowledge. In this sense, the knowledge-making process involves communication rather than merely being followed by it.[11]

9 "To label something unequivocally as popular science can be seen as tantamount to saying that 'it is not science' or even a kind of pseudoscience parading as a real thing". Secord, "Knowledge in Transit", 670-671. See also Cooter and Pumpfrey, "Separate Spheres and Public Places".

10 Cooter and Pumpfrey, "Separate Spheres and Public Places".

11 Secord, "Knowledge in Transit". See also, Cooter and Pumpfrey, "Separate Spheres and Public Places"; Bensaude-Vincent, "A Historical Perspective on Science and Its 'Others'"; Topham,

From this perspective, in what follows, I argue that Iberian-American *repertorios* should not be reduced to a form of communication of knowledge produced elsewhere – the astronomical and astrological treatises. In the first part, I explain how by mid-sixteenth century, mathematicians and cosmographers in the Iberian Peninsula enlarged earlier *repertorios,* particularly Li's, by introducing substantial astronomical, cosmological, and chronological sections. The reunion of divergent astronomical and cosmological traditions, such as Sacrobosco's *Sphera* and the *Theorica planetarum,* together with astronomy-oriented chronology articulated a globalising, Catholic world-view spatially organised by mathematics (geometry and geography) and temporally embedded within the teleology of the history of redemption. Prominent Iberian mathematicians such as Jerónimo de Cháves, André do Avelar, and Rodrigo Zamorano composed *repertorios* that circulated extensively. So far, studies on these authors have overlooked these *repertorios,* considering them as minor works produced mostly for financial purposes and therefore unsuited as vehicles of any significant novelty. Next, I consider how the Iberian *repertorios* attracted attentive readers in New Spain, Peru, and, New Granada. I focus on the case of Antonio Sánchez de Cozar. Sánchez, a *mestizo* priest writing in the New Kingdom of Granada, developed an astronomical and chronological treatise, the *Tratado de Astronomía y la Reformaçion del tiempo* (c1.696), a manuscript in which the synthesis of medieval, Renaissance and early modern astronomical ideas with cosmography articulated an original theory of the cosmos. Sánchez did not stop where Iberian mathematicians did in their *repertorios,* and derived astronomical and natural philosophical information from the Bible in order to explain (visually, mechanically, and conceptually) how and why the *machina mundi* shall end after the last judgment. As part of this teleological narrative, Sánchez localises (historically and geographically) himself, the 'New World', and the natives of the Americas with the resources provided by the Iberian cosmographical *repertorios*. Although Sánchez's work seems aligned with the early modern European tradition of astronomical treatises, his *Tratado* elaborates on the *repertorios* in terms of contents, methods, conclusions and aims.

In this way, it appears that a genre of writing, overlooked for being considered adequate only for the popularisation of ideas that were innovatively formulated elsewhere, became, in the new kingdoms of the Americas, an element for the construction of local identities as part of a globalising Christian identity dominated by the narrative of the universal redemption. The construction of these identities, as in the case of Sánchez, involved the transformation of the foundations of astronomy, astrology, and natural philosophy in a treatise, not in another *repertorio,* as part of understanding the place of the 'New World' in the cosmos. Although other American *repertorios* did not further elaborate the astronomical and cosmographical consequences of this genre as Sánchez did, they mobilised math-

"Introduction"; Delbrugge, "Capitilizing on the Stars"; O'Connor, "Reflections on Popular Science in Britain".

ematical and chronological resources for explaining the place of indigenous and *mestizos* in the political and theological history of redemption portrayed in the peninsular works.

2. "Quanto tienes tanto vales, y aun tanto sabes": repertorios *between printers and mathematicians*

In the preface to the "prudent and wise reader", in the *Chronographia, o repertorio de los tiempos* (1548), Jerónimo de Chaves (1523-1574), who would be the first professor of navigation at the *Casa del Contratación* in 1552, complains about the state of liberal arts in his days. In his view, some writers, moved by greed and "corruption", abused the liberal arts and obtained illegitimate fruits. While these arts had been respected since ancient times and their fruits constituted a "common good," some of his contemporaries "pursuing their interests, and charging common people for famous names, offer to the public (with titles that benefit their income and friends) works alien and strange to their profession".[12] Because of this, they downgraded the liberal arts to "mechanical and servile practices".[13] Chaves makes clear that he has in mind the producers of the "*Repertorios* that have hitherto circulated". These *repertorios,* in the view of the young mathematician, deal with matters "frivolous and lacking any natural foundation", being "short of important and necessary things".[14] At the same time, the *Lunarios* are "incorrectly verified": the eclipses are just put at the will of the printer, without specifying "their magnitude or the time of their occurrence".[15] These and other faults, Chaves claims, have been surely noted by the prudent and wise reader.

Apart from the general accusation of degrading the liberal arts to the "mechanical and servile" – which would require a separate treatment – Chaves' condemnation of *repertorios* provides insights into at least two important characteristics that defined the manufacture and circulation of early modern Iberian *repertorios*. First, Chaves criticises the production, the producers, and the choice of topics of previous *repertorios*, emphasising the inappropriate role of printers, depicted here as "alien and strangers" to the liberal arts and, to some extent, guilty of their decline. Second, Chaves suggests that the books called *repertorios* cover, in fact, two different but related matters: the *repertorios* (containing frivolous things) and the *lunarios* (incorrectly verified and modified by printers). Interestingly, instead of rejecting *tout court* the genre of *repertorios* and their organisation, Chaves undertook a systematic reform of them that was subsequently followed by cosmographers

12 Chaves, *Chronographia*, 4v.

13 On this pejorative use of "mechanical" see Drake and Drabkin, *Mechanics in Sixteenth-Century Italy*; Micheli, *Le origini del concetto di macchina*; Orozco-Echeverri, "Mechanics in Renaissance Science".

14 Chaves, *Chronographia*, 5r.

15 *Ibidem.*

and mathematicians such as André do Avelar, Rodrigo Zamorano, Vicente de Tornamira, Ambrosio de Gante, Manoel de Figueiredo, and Bartolomé Valentín de la Hera y de la Varra during the second half of the sixteenth century.

The production of early Spanish *repertorios,* that is, of those fabricated during the first half of the sixteenth century, was in fact an enterprise mostly led by printers who saw in the enlargement of almanacs and *lunarios* the possibility of developing more competitive (and more profitable) prints in the flourishing market of the book. While Chaves criticises the nature and extent of these works, his own *repertorio* benefited from the demand already created by the editorial success of Andrés de Li's *Repertorio de los tiempos,* published for the first time in Zaragoza in 1492 and extensively reprinted, modified, and copied during the sixteenth century.[16] As Chaves correctly pointed out, Li's *Repertorio* was the union of two different texts, resulting from the editorial initiative of Pablo Hurus, an influential printer based in Zaragoza.[17] The starting point of Li's *Repertorio* was the editorial success of Bernat de Granollachs *De la nobilissima art e scientia de astrologia,* known as the *Lunario,* printed in Napoli in 1485 by Mattia Moravo in Catalan and Latin.[18]

Granollachs' *Lunario,* as it was usual in medieval and early modern European almanacs, was based on the lunar cycle – hence the name – from which it was established a 19-solar-years cycle setting the parameters for the calculations of the moveable feasts of the liturgical calendar and some matters of potential interests for astrological medicine.[19] The *Lunario* opens with a short introduction noticing that from the most noble art of astrology the master from Barcelona Bernat de Granollachs summarised the conjunctions and oppositions of the Moon between 1485 and 1550.[20] The introduction also includes some remarks on moveable and fixed feast of the liturgical calendar and some basic astronomical definitions such as time, day, and eclipse. Next, the *Lunario* incorporates the tables from 1485 to 1550, one page per year, displaying the time of all new and full moons from January to December, highlighting the dates of Easter, Ascension, Corpus Christi and other moveable feasts. Every year includes the golden number and the corresponding dominical letter (Fig. 1). According to Chabás and Rocca, the *Lunario* saw no less than 60 editions

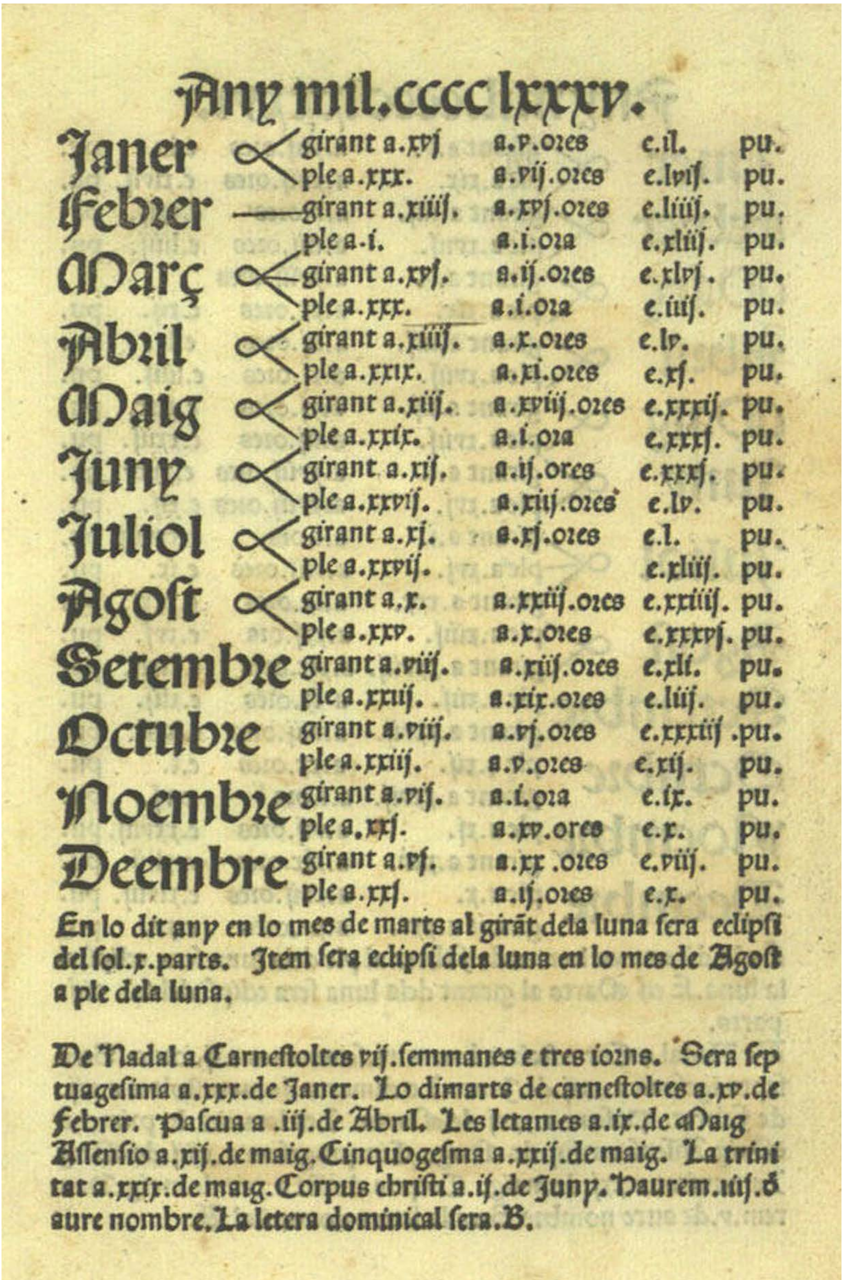
16 On De Li's *Repertorio* and the controversies about its origins see Martos, "La Editio Princeps Del Repertorio de Los Tiempos de Andrés de Li"; Chabás and Roca, "Early Printing of Astronomy"; Delbrugge, "A Critical Edition of Andrés de Li's Repertorio"; Delbrugge, "Capitilizing on the Stars"; Delbrugge, "From Lunar Charts to Li".

17 Delbrugge, "Ties That Bind (and Print)", 41-47.

18 On the controversy concerning the role of Granollachs' *Lunario* in the *Reportorios* see Chabás and Roca, "Early Printing of Astronomy"; Delbrugge, "A Critical Edition of Andrés de Li's Repertorio"; Martos, "La Editio Princeps del Repertorio de Los Tiempos de Andrés de Li".

19 Delbrugge, "Capitilizing on the Stars"; Stern and Burnett, *Time, Astronomy, and Calendars in the Jewish Tradition*; Nothaft, *Scandalous Error*; Rutkin, *Sapientia Astrologica*.

20 Granollachs, *De La Nobilissima Art e Scientia de Astrologia*, f. 1r.



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Abril	girant a.xiiij.	a.x.ores	e.lv.	pu.
	ple a.xxix.	a.xi.ores	e.xj.	pu.
Maig	girant a.xiij.	a.xviij.ores	e.xxxij.	pu.
	ple a.xxix.	a.i.ora	e.xxxj.	pu.
Juny	girant a.xij.	a.ij.ores	e.xxxj.	pu.
	ple a.xxvij.	a.xiij.ores	e.lv.	pu.
Juliol	girant a.xj.	a.xj.ores	e.l.	pu.
	ple a.xxvij.		e.xliij.	pu.
Agost	girant a.x.	a.xxiij.ores	e.xxiiij.	pu.
	ple a.xxv.	a.x.ores	e.xxxvj.	pu.
Setembre	girant a.viij.	a.xiij.ores	e.xli.	pu.
	ple a.xxiij.	a.xix.ores	e.liij.	pu.
Octubre	girant a.viij.	a.vj.ores	e.xxxiij	pu.
	ple a.xxiij.	a.v.ores	e.xij.	pu.
Noembre	girant a.vij.	a.i.ora	e.ix.	pu.
	ple a.xxj.	a.xv.ores	e.x.	pu.
Deembre	girant a.vj.	a.xx .ores	e.viij.	pu.
	ple a.xxj.	a.ij.ores	e.x.	pu.

En lo dit any en lo mes de marts al girāt dela luna sera eclipsi del sol.x.parts. Item sera eclipsi dela luna en lo mes de Agost a ple dela luna.

De Nadal a Carnestoltes vij.semmanes e tres iorns. Sera septuagesima a.xxx.de Janer. Lo dimarts de carnestoltes a.xv.de Febrer. Pascua a .iij.de Abril. Les letanies a.ix.de Maig Assensio a.xij.de maig. Cinquogesma a.xxij.de maig. La trinitat a.xxix.de maig. Corpus christi a.ij.de Juny. Haurem.iiij.de aure nombre. La letera dominical sera.B.

Fig. 1 – Granollachs' calculations for 1485, including remarks on moveable feasts, dominical letter and golden number. Granollachs, Lunario, f. 1v. Biblioteca de Catalunya, public domain.

in 40 years in Spain, France and Italy.[21] In 1488, the *Lunario* was translated into Spanish as *Dela muy noble arte: e sciencia de Astrologia ha seido sacado el presente sumario,* published by Juan Hurus – brother of Pablo – in Zaragoza. According to Li's Prologue to the *Repertorio,* some computational errors in Granollachs' *Lunario* but mostly because the work deals with "times, years, months, weeks, days, hours, planets, signs," he decided to provide some additions so that the reader could know "the origin of the times and why they were named in such a way".[22] The editorial collaboration between Pablo Hurus and Andrés de Li brought to light the first edition of the *Repertorio de los tiempos* in 1492, an edition in which Granollachs' *Lunario* was preceeded by Li's additions. The novelties added by Li included a Prologue explaining the importance of the work; a history of the divisions of times (day, week, month and year); a summary explanation, including illustrations, of the heavens, the astrological signs of the zodiac, and the four elements; a calendar of the year; a medical section with the traditional zodiac man; and a conclusion. As Delbrugge notes, Li's *Repetorio* was an extremely eclectic work "discussing everything from Greek and Roman gods to the proper procedures for bloodletting".[23] In this way, Li's provided mythological, astrological, astronomical, and chronological frameworks to Granollachs' *Lunario,* bringing together medieval and early modern traditions. At the same time and closely connected with the editorial intentions of the work, Li's *Repertorio* integrated a rich visual apparatus which I have analysed elsewhere,[24] summarising and rendering visible the novelties added to the *Lunario*, such as the mythological origins of the names of the months, planets, and signs, and their astrological significance for agriculture and medicine.

Compared to other European almanacs similar in format, content and style to the *Lunario*, particularly to those of English and German origins influenced by the emergence of Protestantism,[25] the editorial transformation of Granollachs' *Lunario* into Li's *Repertorio* - or rather the subsumption of the former under the latter – shows a peculiar move in this genre of astrological literature. While other European traditions of almanacs and calendars kept improving the accuracy of their tables and expanding the range of astrological elements for practical purposes such as calendrics, medicine, geography or even trade, Li's *Repertorio,* in contrast, provided to the reader of almanacs elements of history, astronomy, astrology, cosmology, natural philosophy and medicine that were usually restricted to more technical and theoretical works, such as treatises or university textbooks related to Sacrobosco's *Sphaera* and to the tradition of the *Theorica planetarum*. This does not mean,

[21] Chabás and Roca, "Early Printing of Astronomy", 125.

[22] Li, *Repertorio de Los Tiempos,* a ii, r-v.

[23] Delbrugge, "Capitilizing on the Stars", 302.

[24] Orozco-Echeverri, "Diagrams of the End of the World in a Cosmographical Manuscript Composed in the New Kingdom of Granada (c 1696)".

[25] Chapman, "Marking Time"; Capp, *English Almanacs, 1500-1800*; Casali, *Le Spie Del Cielo*; Zinner, *Geschichte Und Bibliographie Der Astronomischen Literatur*.

however, that Li's *Repertorio* did not include new practical elements as a supplement to Granollachs' *Lunario*; it means, rather, that the core of Li's additions are theoretical in nature and may seem at odds with the somewhat fugacious utility of almanacs and calendars. While the introduction of the printing press made the printing of yearly almanacs cheaper, it also made possible more voluminous almanacs and calendars covering longer periods, such as Granollachs' *Lunario,* and, in this way, more useful a wider range of readers.[26] It is precisely to the readers of these more voluminous almanacs and calendars that Li's and Hurus' *Repertorio* is addressed.

In order to appreciate the nature of Li's additions, let's consider his characterisation of the heaven of Mercury and the context in which it appears. The characterisation of the seven heavens follows the history and meaning of the divisions of times (week, months, years) and connects historical/mythographical elements with astrological/astronomical topics. This provides the historical/theoretical background of the practical information intended to be used by the readers of *repertorios.* Before explaining the nature of heavens, Li's remarks that according to ancient astrologers "planet means wandering thing (*cosa errante*)." But this does not mean that they do not follow any rule, for "as Horatio said, they follow the same rule that they had when they were created".[27] Because of this, the seven planets "correspond to the seven days of the week and in proportion to the seven climates that are seven lines or parts of the world that can be inhabited".[28] Furthermore, these planets have their strenght "in the twelve signs of the sun in the circle of the zodiac". According to the first meaning of heaven (*cielo*), Li explains that planets, stars and signs are "sculpted and impressed" (*esculpidos e impresos*) in heavens; a second meaning, in which heaven (*cielo*) is related to *celo* means "to cover up, to conceal, secret things".[29] The number of these heavens was known by a "demonstrative reason, by the number of the movements of higher bodies." Li explains that from the motion of planets it follows that heavens also move. The characteristics and meaning of these motions are detailed for every planet, headed by an illustration (Fig. 2).

Taking Mercury as an example of Li's additions, the exposition starts (1) with the most general astronomical information: that Mercury, the sixth planet, is embedded within the second heaven; that its 'circle' is consumated in 20 years and that it rules the sixth climate. This basic astronomical information is followed by (2) the mythographical meaning of the planet. Mercury means 'reasoning' and "reasoning is the way to agree between those

[26] Campos Ribeiro, "The Bounded Heavens: Defining the Limits of Astrological Practice in the Iberian Indices"; Delbrugge, "Capitilizing on the Stars"; Lanuza-Navarro, "Astrological Literature in Seventeenth-Century Spain".

[27] Li, *Repertorio de Los Tiempos*, f. b v, r.

[28] *Ibidem*.

[29] *Ibidem*.

Del ſegundo cielo ⁊ de mercurio que es el ſeſto planeta.

El ſegundo cielo es dõde tiene ſu aſſiento mercurio: que es el ſeſto planeta enel circulo ſeſto dela ſphera. ⁊ en ſpacio de veynte años cõſuma ſu circulo. ⁊ es ſeñor del ſeſto clima. Llamaſe mercurio: q̃ tanto q̃ere dezir como razonamiẽto. ⁊ por q̃nto el razonar es medio para cõcordar los q̃ compran y vẽden: llamarõ le los antiguos dios dela mercaduria. ⁊ ahũ le aſſignaron por dios medianero entre los dioſes

Fig. 2 – Li's illustration of the second heaven containing Mercury. Li, *Repertorio,* f. 14. Image from the collections of the Biblioteca Nacional de España. CC BY 4.0

who sell and those who buy".[30] Therefore, the ancients called Mercury the god of trade, the god mediating between different gods: celestial and infernal. That is why Mercury comes from trade (*mercaduría*). As part of the mythographical/philological characterisation, Li explains the illustrative traditions of Mercury: the ancients "depicted it with the head of a dog by his knowledge of all things".[31] Additionally, Mercury is represented with a stick (*verga*) in his hand, which he uses to "cut the snakes and poison: because those who oppose to Mercury are divided by the reasoning of the mediators".[32] The mythographical characteristics are followed by (3) the astrological properties of the planet: Mercury is a masculine planet, of cold and dry nature. It rules over all "men of letters, accountants, painters and draftsmen: and over those who deal with subtle matters." Li explains the influence of the planet over metals, beasts, birds, trees, and plants. The astrological influences of Mercury concludes with its influence over those born under it, emphasising some medical aspects: those born under Mercury will have "a short body, and delicate head, and small and attractive eyes." Finally, the exposition concludes with (4) the geographical and meteorological aspects of Mercury: it is related to the North, its day is Wednesday, its hour the first, and its night that of Saturday.[33] The extent of Li's additions highlights that, apart from offering theoretical elements of astronomy and astrology to the reader, his interests involves providing a more comprehensive, cosmological view of the celestial elements that play a role in the life on Earth. The eighth and ninth heavens are presented in a summary way for they do not contain any planet: the former hosts the signs and its movement, according to Ptolemy, takes 36.000 years; the latter has no planets or stars but completes its movement in 24 hours in a direction contrary to those of all other heavens.[34]

The editorial success of Li's *Repertorio* has been widely noticed.[35] In a census still under construction, I have been able to identify 32 editions printed between 1492 and 1548, when Chaves' *Chronographia o repertorio de los tiempos* appeared.[36] These editions are not

[30] Li, *Repertorio de los tiempos*, f. 14.
[31] *Ibidem*.
[32] *Ibidem*.
[33] *Ibidem*.
[34] Li, *Repertorio de los tiempos*, f. c v, r.
[35] Chabás and Roca, "Early Printing of Astronomy"; Chabás and Goldstein, *A Survey of European Astronomical Tables in the Late Middle Ages*; Delbrugge, "A Critical Edition of Andrés de Li's Repertorio"; Delbrugge, "Capitilizing on the Stars"; Delbrugge, "From Lunar Charts to Li"; Martos, "La Editio Princeps Del Repertorio de Los Tiempos de Andrés de Li"; Albisson, "En Mala Estrella"; Carrió-Cataldi, "El tiempo, el mar, el mundo".
[36] I am currently working on a census of *repertorios* deriving both from Li's *Repertorio* and from Chaves' *Chronographia*. Given the current circumstances, I have not been able to inspect many of them physically. I have relied on digital collections and on indexes of Iberian bibliography such as Navarro-Brotons et al., *Bibliographia Physico-Mathematica Hispanica (1475-1900)*; Lanuza-Navarro, "Astrología, Ciencia y Sociedad En La España de Los Asturias"; Wilkinson

just reprints or updated versions of Li's initial work, but include transformations in the methods of calculation or in mathematical techinques not always evident, such as the edition corrected by Sancho de Salaya (Zaragoza, 1536), chair of astronomy and astrology in the University of Salamanca between 1504 and 1542 and appointed in 1524 to the *Junta de Badajoz* in charge of determing whether the Maluku Islands belonged to Castille or Portugal. Although the purpose of Li's and Hurus' enterprise seemed to profit from the success of Granollachs' *Lunario*, the *Repertorio* acquired a life of its own and inaugurated a genre of writing widely influential in the Iberian-American world. Beyond the traditional genre of almanacs and calendars – to which the tradition of *repertorios* began to run in parallel – the new genre encompassed the lunar tables and the calendric information of the tradition from which it stemmed; but it now included the cosmological, natural-philosophical, astronomical, astrological, mythographical, geographical, and philological sections and remarks that appeared for the first time in Li's 1492 *Repertorio.* In this sense, Li's *Repertorio* presented the reader practical aspects within the framework of an all-comprehensive, articulated view of the cosmos that made of this genre of writing a kind of work surpassing the ephemeral and practical nature of medieval and early modern European almanacs, calendars and *lunarios*.

Celebrated Iberian mathematicians such as Jerónimo de Cháves, André do Avelar, and Rodrigo Zamorano contributed to this genre, bringing to it their background in mathematics, geography, navigation and particularly in cosmography that by the sixteenth century was thriving in the Iberian peninsula.[37] In the traditions of almanacs and calendars that flourished in the Americas during the seventeenth and eighteenth centuries, it is possible to differentiate those works belonging to the medieval and early modern traditions of almanacs and calendars (including Granollachs' *Lunario*), such as the *almanaques* and *efemérides* calculated by Carlos de Sigüenza y Góngora (1645-1700) in New Spain or those by Francisco Ruiz Lozano (1607-1677) in Perú, and those belonging to the tradition of *repertorios* such as Enrico Martínez (n.d. -1632) in New Spain, Antonio Sánchez de Cozar (*c.*1676-1696?) in New Granada, and the examples presented in the next section of this paper.[38]

and Ulloa, *Iberian Books*.

37 Sánchez, "La Institucionalización de La Cosmografía Americana"; Sánchez, "Science by Regimento: Standardising Long-Distance Control and New Spaces of Knowledge in Early Modern Portuguese Cosmography"; Portuondo, *Secret Science*; Navarro-Brotons, "Aspects of the History of Cosmography in Spain in the Last Decades of the Sixteenth Century (until 1606)"; Lanuza-Navarro, "Astrología, Ciencia y Sociedad En La España de Los Asturias"; Navarro-Brotons, "The Teaching of the Mathematical Disciplines in Sixteenth-Century Spain"; Esteban Piñeiro, "Los oficios matemáticos en la España del siglo XVI"; Vicente Maroto and Esteban Piñeiro, *Aspectos de La Ciencia*; Pardo Tomás, *Un Lugar Para La Ciencia*.

38 Tappan, "Representaciones de La Tierra"; Lanuza-Navarro, "Astrología, Ciencia y Sociedad En

Li's *Repertorio* inaugurated, then, a variant of astrological literature which embedded the practicalities of *lunarios* and calendrics within wider elements of astronomy, cosmology and natural philosophy, delivering a more comprehensive view of the cosmos and its interactions accessible to readers that typically had no formal education or access to Scholastic textbooks, medieval and early modern astronomical treatises, and medical and natural philosophical literature. A significant transformation of the genre of *repertorios,* already consolidated in the Iberian Peninsula, occurred with the publication of Jerónimo de Chaves' *Chronographia o repertorio de los tiempos, el más copioso y precisso que hasta ahora ha salido a luz* (Seville, 1548), a transformation described elsewhere as the introduction of cosmographical *repertorios*.[39] As we have seen, Chaves was critical of both the accuracy of the calculations of *lunarios* contained in the *repertorios* and of the matters (astronomical, astrological, mythological, natural philosophical and medical) acompanying them. I noticed that Li's *repertorios* already called the attention of the reader of *lunarios* to the fact that the tables of conjunctions and opposition of the Moon – the key to the liturgical and medical calendrics – were just a visible part of a *machina mundi* in which the motion of planets, stars, and signs informed the life on Earth, especially the human body represented in the zodiac man. Emphasising, even more, the importance of time in the conception and understanding of the cosmos, Chaves offered in his *Chronographia* a work in which the mathematical account of time played the central, cohesive role of the world and the humankind. His view of time was not restricted, as in the case of *lunarios,* to the determination of celestial events for astrological events of meteorological or medical significance: in the hands of the young professor of cosmography, time was now extended to embrace a (mathematical) consideration of history, a chronology ruled by astronomy, which set in order the occurrence of events on Earth.[40] In so doing, Chaves integrated into the genre of *repertorios* a prominent practice of historical chronology that goes back to Roger Bacon (1220-1290) and that would became popular in Europe through the works of Joseph Scaliger (1540-1603).[41] Consequently, Chaves' *Chronographia* is divided into four treatises: the first, which sets the framework for the remaining treatises, deals with time. In a way

La España de Los Asturias"; Lanuza Navarro, "Adapting Traditional Ideas for a New Reality"; Suárez, *Astros, Humores y Cometas: Las Obras de Juan Jerónimo Navarro, Joan de Figueroa y Francisco Ruiz Lozano (Lima, 1645-1665)*; Trabulse, *Ciencia y Tecnología En El Nuevo Mundo*, 25-37; Peraza-Rugeley, *Llámenme "El Mexicano": Los Almanaques y Otras Obras de Carlos de Sigüenza y Góngora*; Gruzinski, *Quelle heure est-il là-bas?*; Orozco-Echeverri and Molina-Betancur, "A Mestizo Cosmographer".

39 Orozco-Echeverri and Molina-Betancur, "A Mestizo Cosmographer".

40 Tappan, "Representaciones de La Tierra"; Carrió-Cataldi, "El tiempo, el mar, el mundo"; Orozco-Echeverri and Molina-Betancur, "A Mestizo Cosmographer".

41 Grafton, *Joseph Scaliger. Historical Chronology*; Smoller, *History, Prophecy, and the Stars*; Nothaft, *Dating the Passion*.

similar to previous *repertorios,* Chaves explains the divisions of time (day, week, month, year). The basic astronomical divisions of Li's *Repertorio* are now explained as part of a philosophical discussion of the nature of time that initiates with the definition of eternity, evo, and atom and concludes with the chronological explanation of the mosaic creation in which the distinction between day and night was set by god. Next, Chaves continues with a detailed historical account of the divisions of time at which Li's only hinted in the Prologue of the *Repertorio.* This historical review relies on mythological, historical, and philological analysis. But borrowing from cosmographical works, Chaves offered more techincal, astronomical divisions of time, only then to turn to astrological and chronological considerations of the ages of man, the ages of the world, the catalogue of Caesars and Roman Emperors, the catalogue of Popes, and the catalogue of Kings of Spain.[42] The first treatise concludes stating that "After this sixth age, until our time, 1584 years have passed. From the origin of the world, according to the Hebrews, 5832 years. According to the interpreters, 6777. According to the King *Don* Alfonso 8565 years, and 111 days".[43] This remark not only reveals that the intention behind the chronology is to provide a historical view of human action from the creation to the present. It also acts as context for the second treatise in which Chaves deals with "the world and its parts." In other words, by dealing with the astronomical, astrological, but notably with the chronological and historical aspects in the first part of his work, Chaves set a view of time that underpins the astronomical and cosmological expositions of the second part; the historical, astronomical, and chronological treatment of the calendar in the third part; and the medical astrology and the meteorological considerations of the fourth part.

Chaves' *Chronographia* preserves important elements of the tradition inaugurated by Li's *Repertorio.* For example, the characterisation of the heavens and their planets follows the order of topics – and to a large extent, the same words – set by Li. Chaves further elaborates on the astrological influence of those born under the sign, but even the elements of the illustrations are not too different from the woodcuts of Hurus' edition of Li. However, some other elements, notably those coming from cosmography, offered the reader of *repertorios* the novelties of the century. Chaves incorporates geographical illustrations and detailed visual representations of the elements according to the Aristotelian natural philosophy when dealing with the elements and the sublunar word. Furthermore, Chaves introduced the cross-section of the cosmos or the *figura de la máquina del mundo* that goes back to the visual tradition of Sacrobosco's *Sphaera* (Fig. 3). In this way, the textual tradition of medieval textbooks connects with the popular tradition of the almanacs represented in the *repertorios.* The connection between these traditions is more evident in the visual apparatus of the prominent mathematician and cosmographer Rodrigo Zamorano's

42 Chaves, *Chronographia,* 56r-80v.
43 *Ibid.,* 80v.

Fig. 3 – Chaves' cross-section representing the heavens following the illustrative tradition of Sacrobosco's *Sphaera*. Chaves, *Chronographia*, 112. Universidad Complutense de Madrid, public domain.

Cronología y repertorio de la razón de los tiempos (Seville, 1585). Zamorano's *Cronología* attempted to correct Chaves' calculations after the introduction of the Gregorian calendar that rendered useless all previous *repertorios.* Significantly, Zamorano incorporates cosmological and natural philosophical elements, and introduced both in the visual apparatus and in the characterisation of the heavens the highly-technical astronomical tradition of the *theorica planetarum.* Following the order set by Li, Zamorano presents the astronomical, mythological, and astrological aspects of the heavens, but as just discussed, he introduced more technical elements of cosmography. For example, in the visual representation of the heaven of Mercury, it is possible to appreciate the introduction of the layered orb that accounts for the singular motion of the planet, detailing the epycicles (Fig. 4).

The transformations of the tradition of *repertorios,* involving cosmographical, astronomical and natural philosophical elements, provided a synthesis of elements from divergent disciplines and traditions in a popular format widely accessible to readers in the Old and in the New worlds. It would be a mistake to assume that the *repertorios* were just an enlarged form of almanacs and calendars intended only for practical reasons of calendrics

Fig. 4 – Notice the layered orb coming from the illustrative tradition of the *Novae theoricae planetarum* (top-right) added to the traditional pictoric elements of *repertorios*. Zamorano, *Cronología y repertorio de la razón de los tiempos*, 62. Universidad Complutense de Madrid, public domain.

and medicine. In fact, since Li's *Repertorio,* but notably in Chaves' reform of the genre, the *repertorios de los tiempos* postulated an eclectic but all-comprehensive view of the cosmos and its history, centred around the idea of time that inexorable goes from the creation to the end of the world. In this movement from the beginning to the end, human events – under the influence of stars and depending on their location – hint at the triumph of Christianity, represented by the Spanish Monarchy, and at the redemption of humanity after the last judgment. The practical aspects providing guides for human actions concerning the moveable feasts, agriculture, navigation, and medicine acquire a different dimension in the *repertorios:* they are subsumed under the universal history of redemption, not only under the influence of the stars, as it used to be in the medieval and early modern European traditions of almanacs and calendars. In what follows, we will see how the European invention of the New World and the expansion of Christianity over the new lands constituted a central step in the astronomical chronologies and geographies presented in the *repertorios.*

3. Histories, stars and signs of the New World

In the previous section, I provided arguments to consider that *repertorios de los tiempos* constitute a form of novel, syncretic knowledge, not by announcing ideas never mentioned before, but by providing an all-encompassing view of the *machina mundi* centred around a complex, layered conception of time that borrowed from different traditions, disciplines, and praxes. Compared to other astronomical and astrological literature of the period, including treatises, *repertorios* are centred around a chronological perspective that makes of the history of the world and of the motion of planets consistent and integrative axis. Rather than mere compendia of information, *repertorios* articulated a rather coherent historical and natural philosophical view of the cosmos, underpinned by astronomy, astrology and chronology, in which events led relentlessly to the redemption of humanity. Readers of *repertorios* in the Americas were influenced by this worldview: a synthesis that constituted a key to understanding European elements that were now part of their immediate reality. In this sense, American readers of Iberian *repertorios* attempted to interpret their local histories, genealogies, territories, and traditions within the astronomical and chronological elements represented in the works of Chaves and Zamorano that widely circulated in the New World.[44] In so doing, these American writers enlarged the scope of *repertorios* by including new information and also by developing some astronomical, astrological, natural philosophical, and chronological perspectives. In this sense, indigenous and mestizos borrowed elements from the *repertorios* to understand their own place both in space and in time but also developed the genre in new directions. However, readings of *repertorios* in the New World have followed a top-down approach focusing on how and to what extent local productions replicate Iberian models. Enrico Martínez's *Repertorio de los tiempos y historia natural de nueva España* (Mexico, 1606) has set the standard against which American *repertorios* are read. Considering the European origin and education of its author, however, this *repertorio* can hardly be representative of the readings of indigenous and mestizos, although its value in understanding the European creation of the New World remains beyond doubt.[45]

In this section, I present some elements that challenge this way of reading *repertorios* by reading them as "knowledge in transit", constituting the history of the production of knowledge in the Iberian-American world, not as a form of circulation of peninsular ideas. The American *repertorios* are not imitations of their Iberian sources but contain elements introduced by indigenous and mestizos to produce their own works in which they read

[44] Torre Revello, *El Libro, La Imprenta y El Periodismo En América Durante La Dominación Española*; Rubio, "Prácticas y Actores Del Comercio de Libros En La Nueva Granada".

[45] On the controversial nature of Enrico Martínez's *Repertorio* see Gruzinski, *Quelle heure est-il là-bas?* For a recent treatment of the value of Martinez's *Repertorio* in connection with the New World see Lanuza Navarro, "Adapting Traditional Ideas for a New Reality".

their reality now inevitably including Spanish and European natural, cultural and social elements. At the same time, some indigenous and mestizos readers did not limit their engagement with *repertorios* to practical astrology but embraced their contents as elements of a universal explanation that provided the clues to interpret their locations, backgrounds, and circumstances. From this perspective, the *repertorios* mobilised astronomical, astrological, and cosmological elements for the construction of indigenous and mestizo identities. While this aspect has not been fully considered by historians of science, its importance for the construction of local identities is beginning to appear in recent scholarship in the Iberian-American world.[46]

The *reperdorio delos dienpos* written in náhuatl transcribed, translated, and analysed by López Austin in 1976 constitutes a first example of American *repertorios*.[47] The manuscript seems to date from the sixteenth century and it provides short astrological remarks on the months, from January to December, following the style of peninsular *repertorios.* Interestingly, the *repertorio* opens claiming that "many things are omitted for they lack of interest for the indigenous".[48] There are some mentions to local animals and plants but also to those coming from the Old world that were already incorporated into the Americas. The astrological remarks are limited to characterising "those born in this month shall not be tall, some of them shall be very short. They will be fond of women," reads for those born in January.[49] However, the meteorological and medical aspects receive more consideration. For example, every month explains what to do with plants and trees ("this month is very convenient to dig next to the vines" or "this month is very convenient to plant all the seeds in wet lands, even the melons, quince trees and fruit trees").[50] Concerning medical aspects, the *repertorio* náuhatl incorporates traditional elements of the Aztecs and Mesoamerican cultures, such as the *temazcal* baths and the use of obsidian. The *temazcal* was a type of steam room used for hygienical and ceremonial reasons, particularly by women after birth and by the ruling elites who had private *temazcals* in their houses.[51] In the *repertorio*, the writer recommends the *temazcals* baths in January but warns against them in

46 Cañizares-Esguerra, "New World, New Stars: Patriotic Astrology and the Invention of Indian and Creole Bodies in Colonial Spanish America, 1600-1650"; Spitler, "Nahua Intellectual Responses to the Spanish: The Incorporation of European Ideas into the Central Mexican Calendar"; Rappaport, *The Disappearing Mestizo*; Ramos and Yannakakis, *Indigenous Intellectuals. Knowledge, Power, and Colonial Culture in Mexico and the Andes*; Marroquín Arredondo and Bauer, *Translating Nature. Cross-Cultural Histories of Early Modern Science*; García-Arenal and Pereda, *De Sangre y Leche*.

47 López Austin, "Un Repertorio de Los Tiempos En Idioma Náhuatl".

48 *Ibid.*, 288.

49 *Ibid.*, 193.

50 *Ibid.*, 193, 196.

51 Walsh, *Virtuous Waters: Mineral Springs, Bathing, and Infrastructure in Mexico*, 20-21.

August ("And *temazcals* baths and gluttony are very bad").[52] While this *reportorio* does not elaborate on chronological matters and sketches some astrological remarks, it follows the *repertorios* in style and topics but direct its contents to the indigenous, incorporating local elements that predate the arrival of Spaniards.

Similarly, the *Codex mexicanus,* now in the Bibliothèque national de France, has been widely recognised as "influenced" by *repertorios* and particularly by Chaves' *Chronographia.*[53] A recent article by Lori Diel has provided sound evidence of the way in which the elements presented by Chaves were used by Nahua intellectuals, about 60 years after the fall of Tenochtitlan, to adopt calendric and chronological elements. Using the Aztec pictorial system, the manuscript contains a monthly calendar, calendar wheels, astrological medical charts, an Aztec sacred calendar, comparative numeric systems written in Aztec, Roman, and Arabic scripts, a genealogy of the Tenochca royal dynasty, Annals history of the Aztec Empire (1168-1590), alphabetic text on the Zodiac, and some Biblical visions in which characters wearing indigenous clothes found Jesus on the road to Emmaus.[54] The calendric system starts with an annotation revealing that in 1575 the Friars of Saint Augustine arrived at San Pablo. From this initial date, a wheel calendar is used to establish the dominical letter and their corresponding years (Fig. 5). But more interestingly, the *Codex mexicanus* uses chronological elements to elaborate a genealogy of Aztec kings and a chronicle of the events of the Aztec empire going up to a few years after the Spanish conquest. As Diel noted, the *Mexicanus* historical narrative "mimics the reportorios, which communicate an identity for Spain that is tied to its ancient Roman past and suggest a pagan, but illustrious, foundation for the modern Christian nation. The Codex Mexicanus fashions a corollary identity for Christian New Spain, one that is built upon its own pagan, and equally illustrious, Aztec foundation".[55] In this sense, the background against which the New Christian identity is construed is not dissolved or erased but incorporated into a providentialist view in which the Christianisation of the territory and their people is presented with the elements of the chronology of *repertorios* (Fig. 6).

But Iberian-American *repertorios* not only incorporated local plants, traditions, and kings into the framework of peninsular *repertorios*. Writers in this New World elaborated on the foundations and debated theoretical topics. This is the case of the manuscript entitled *Tratado de astronomía y la reformación del tiempo,* written between 1676 and 1696 by

52 López Austin, "Un Repertorio de Los Tiempos En Idioma Náhuatl", 294.

53 Diel, "The Codex Mexicanus"; López Austin, "Un Repertorio de Los Tiempos En Idioma Náhuatl"; Plas, "Une Source Européenne"; Spitler, "Nahua Intellectual Responses to the Spanish: The Incorporation of European Ideas into the Central Mexican Calendar"; Ramos and Yannakakis, *Indigenous Intellectuals. Knowledge, Power, and Colonial Culture in Mexico and the Andes,* 215.

54 Diel, "The Codex Mexicanus", 435.

55 *Ibid.*, 429.

Fig. 5 – Calendar wheel, *Codex Mexicanus*, 5. Bibliothèque nationale de France, public domain.

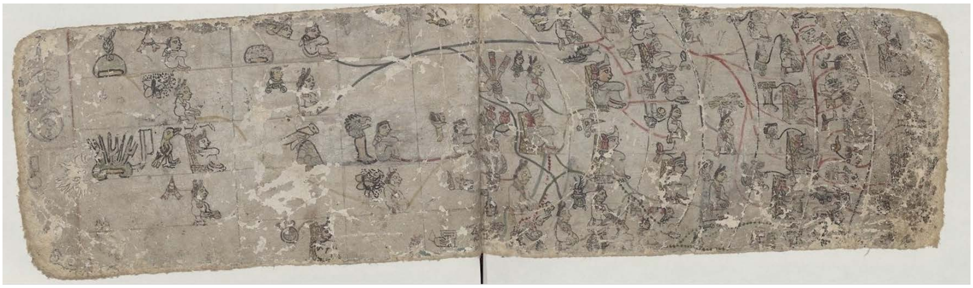

Fig. 6 – Genealogy of the Tenocha royal family, *Codex Mexicanus*, 16-17. Bibliothèque nationale de France, public domain.

Antonio Sánchez de Cozar y Guanientá, a *mestizo* priest, who claims to be a parish priest in Vélez, New Kingdom of Granada.[56] The *Tratado* touches upon topics that were present in Chaves' and Zamorano's *repertorios:* spherical astronomy and *theorica planetarum*, definitions of time, chronology, calendars, astrology; it relies on the typical (first and second

[56] Sánchez de Cozar, "Tratado".

hand) sources: Ptolemy, Macrobius, Clavius, Venegas, Cortés, Zamorano, Pérez de Moya, Copernicus, the Alphonsine and Prutenic tables, to mention a few. It is structured in three "*tratados*": the first dealing with introductory definitions of cosmography and astrology similar to the astronomical sections of *repertorios*; the second deals in some detail with the measurements of time, chronology, and *computus;* and the third with a reform to the calendar, tables of conjunctions, and the table of longitudes of the Spanish world calculated from the city of Vélez. Consequently, Sánchez's *Tratado* is structured around the elements that I presented as constitutive of the cosmographical tradition of *repertorios* introduced by Chaves' *Chronographia,* as I have shown elsewhere.[57]

Sánchez's engagement with the topics coming from Spanish *repertorios* differs from the examples so far presented. In Sánchez, the *machina mundi* relies on the astronomical and astrological elements of *repertorios* to provide a natural philosophical explanation of the two regions of the world (celestial and terrestrial) but this is done in a way that challenges central theoretical tenets of the spheres, the *theorica*, and the Spanish cosmography. The cosmos is formed by celestial spheres in constant interaction by means of pyramidal knots (*ñudos*) where planets are located, not by layered orbs of varying density which, according to the *Hypotheses* of Ptolemy and the *Theorica planetarum,* account for the changing speed observed in the motion of planets. These orbs include one "unknown to the Ancients" (*cielo incógnito*), above the Moon but below Mercury, in which comets circulate (Fig. 7). Furthermore, the motion of the celestial orbs is explained in terms of their "measured heaviness" (*peso medido*), by which all existing things – including the heavens – are directed towards "the central point of gravity". Although the *Tratado* confronts central theoretical aspects of the cosmographical traditions depicted in *repertorios*, it also follows them similarly to the *repertorio* náhuatl and the *Codex Mexicanus:* by incorporating the local perspective and elements of the author in a wider view of time (and history). In Sánchez's case, the teleological sense of history provided by the Christian conception of time represented in the Spanish cosmographical *repertorios* provides a general framework to depict the *machina mundi* as a historical device created by God at the creation that will be locked at the last judgment: when the motion of heavens ceases, the times shall end. At the same time, Sánchez's *Tratado* aims at understanding his own place, and that of the New World, in this history of redemption.

The *Tratado* put forward a reform of astronomy with natural philosophical undertones in which celestial orbs containing pyramidal knots account for the changing position and speed of the seven planets. Although this aspect seems new, Sánchez claims, it is not "if you observe with care".[58] In part, because this structure explains not only how the *machina mundi* works but how it will end, when the stars of Aries fall over the heaven of Saturn,

57 Orozco-Echeverri and Molina-Betancur, "A Mestizo Cosmographer".
58 Sánchez de Cozar, "Tratado", 7v.

according to St John's *Revelations*, bringing the entire system of the heavens to a standstill after the last judgment. Although Spanish astronomers and cosmographers, such as Alejo Venegas and Rodrigo Zamorano, mentioned the last judgment as part of their wider eschatology, only Sánchez's *Tratado,* as far as I am aware, develops in detail mathematical and cosmological arguments accounting for its natural effects. However, Sánchez's reform of astronomy involves not only the transformation of the shape and position of the heavens but also the discovery of another heaven, "so far unknown," in which comets circulate. After observing the "comets" of 1681 and 1682 and calculating the trajectories of these celestial bodies, Sánchez explains that there is a new heaven that was unknown to

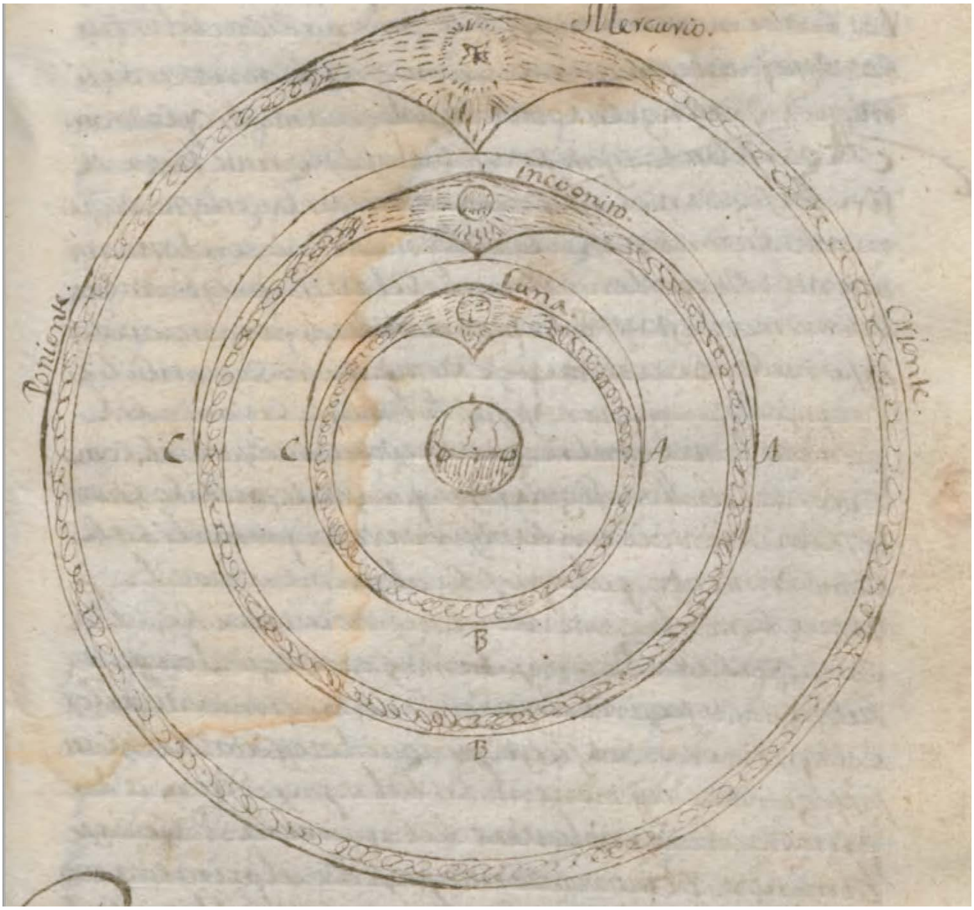

Fig. 7 – Sánchez's heavens of Mercury, the unknown heaven, the Moon and the Earth. The spheres are "free in the air", just in contact through the pyramidal knots. Sánchez, *Tratado,* f. 30v. Biblioteca Nacional de Colombia, public domain.

the ancients and to his contemporary "astrologers", and, therefore this heaven should be called "the unknown".[59] As trivial as the name may seem, the reason for the name involve an important aspect of Sánchez's view of the significance of the event in which a new heaven was discovered by a mestizo in the New World. Ancient mathematicians and modern astrologers do not ignore this heaven by lack of mathematical knowledge or observational skills. On the contrary, Sánchez relies on Ptolemy's and Alfraganus' numbers to calculate the thickness of celestial orbs. The reason is, rather, the *moment* in which this discovery should be made and its meaning, as he explains:

> This second heaven which I named "unknown" for not being hitherto known, was shown to us in such a singular wonder last year of the Lord 1681 after 5502 years from the creation, with such a terrifying and never-seen comet in the shape of the scourge of the Moorish sect of Mohamed, which in my understanding has been the last signal in which our Lord has announced virtue and reserved strength that will accompany the royal house of our Catholic King Charles II against the sectarians. And this has been more clearly revealed with the other smaller comet, which appeared the following year of 1682 in the shape of a sceptre in the sign of Aquarius. This sceptre means that Only one sceptre shall prevail over all sceptres and crowns. The announcement seems to me to favour our Christianity.[60]

Sánchez's introduction of a heaven unknown to the ancients, as well as his rearrangement of the *machina mundi,* are embedded within his interpretation of the history of Christianity as the history of redemption, which in his view includes the natives of the Americas.[61] His "discovery" of these truths unknown to the ancients but also to the modern "astrologers" has a particular meaning in Sánchez's understanding of the temporality of the world.[62] Sánchez presents his own detailed genealogy as a convergence of indigenous rulers or *caciques* and Spanish conquistadors. In a way resembling the *Codex Mexicanus,* Sánchez depicts his own indigenous ancestors, and those ruling in the "nuevo mundo"

59 Sánchez de Cozar, f. 15r-v.

60 *Ibid.*, ff. 24v-25r.

61 For example, Sánchez claims that now, as subjects of the Spanish crown, inhabitants of the "nuevo mundo" are freer than when they ruled themselves: "Because that freedom and dominance lacked the light of the Gospel, while this servitude and vassalage comes with such a light: through the invincible weapons of our Catholic monarchs your predecessors in glorious memory, we were told, by the mercy of the supreme and true god, that after so many thousand years all these nations, so numerous and extended, remained in the sad darkness of God's gentility. But now we enjoy this benefit, and we have more insofar the spiritual is better than the material".Sánchez de Cozar, "Tratado", f. 4v.

62 See Orozco-Echeverri and Molina-Betancur, "A Mestizo Cosmographer"; Orozco-Echeverri, "Diagrams of the End of the World in a Cosmographical Manuscript Composed in the New Kingdom of Granada (c 1696)"; Sánchez de Cozar, "Tratado", ff. 7r; 24r-25v; 27r-29r.

before the arrival of the Spaniards, as nobles and virtuous but lacking of "the light of the Gospel". In this sense, the domination that former *caciques* exercised over their vassals was rejected in favour of the submission to the king of Spain, for "the invincible weapons of our Catholic monarchs" derived from the "supreme and true God." Hence, the submission "of the vassals of this new world" to the true authority of God got "all these nations, so numerous and extended… [from] the sad darkness of God's gentility. But now we enjoy this benefit, and we have more insofar the spiritual is better than the material".[63]

Astronomy and astrology provide Sánchez, as it did in other American *repertorios,* a way to understand his own place in the history of salvation. This includes, as we have seen, the interpretation of comets and of their place in the cosmos as indications of the expansion and final triumph of the Catholic Church that biblical hermeneutics scholars read in the *New Testament.* But the reformation of astronomy has another important consequence: the correct calculation of the true length of the year which, for Sánchez, consists of 365 days, 5 hours and 50 minutes. By restoring the length of the year, Sánchez thinks to have unlocked the key to encompass the historical chronology of the Bible with the information of the natural world that, in his view, allows him to correct the date of the birth of Jesus, the dividing event in human history (and chronology). From correcting the mismatch between the astronomical year and the year of the civil and religious calendar, Sánchez argues in favour of a different use of the leap year not only to correct the Gregorian calendar but also to reinterpret the past based on these recalculations. Central to this correction is the clarification of the position of the Sun and the Moon during the supernatural eclipse that the Gospels reported that occurred during the Passion of Jesus – a remark that also appears in the closing section Sacrobosco's *De Sphaera*.[64] In a complex set of arguments, close to the medieval tradition of the *computus* and resembling Scaliger's scholarship, Sánchez calculates the date of the birth of Jesus on the year 3821 after the creation. The establishment of this date has chronological and calendric consequences. On the one hand, Sánchez re-writes the chronology of the historical events in a way in which the year 3821 after the creation constitutes the centre of history. In so doing, he attempts to show that Jewish chronology is mistaken for missing the last two ages:

1. From the creation to the universal deluge; 2. From the universal deluge to the call of Abraham; 3. From the call of Abraham to Moses; 4. From Moses to the captivity of Jerusalem; 5. From the captivity of Jerusalem to the coming of Jesus; 6. From the coming of Jesus to the end of the world; 7. From the end of the world to eternity. The strength of his arguments is such, he thinks, that it is enough "for the Hebrews to be removed from the mistake in which they have lived showing them the deceit of their misleading account-

[63] Sánchez de Cozar, "Tratado", f. 4v.

[64] For a wider perspective on the significance of this date, see Nothaft, *Dating the Passion*.

ing".[65] While the reformed astronomy explains how the heavens announce the defeat of the Muslim, it also provides arguments to persuade the Jewish of this mistake. In this sense, the calendric reform acquires significance in the history leading towards the universal redemption of mankind.

Sánchez's narrative of the triumph of Christendom incorporates the defeat of the Ottomans and the final conversion of the Jews as historical steps towards establishing a universal Catholic monarchy. By placing in history the astrological and astronomical analysis of celestial objects, knowledge acquires a political and theological dimension that is present in European astrological thinking and has some prominence in the *repertorios.*[66] In fact, underlying the defeat of Ottomans and their faith and the correction of the Jewish chronology, Sánchez understands the occurrence of celestial events as part of an astronomical chronology with religious significance that widely circulated in Spain and the Americas as part of the narrative of a universal (Catholic) monarchy.[67]

4. Conclusion

Iberian *repertorios* arrived in the New World during the consolidation of Spanish rule in the Americas in the sixteenth and seventeenth centuries. But this does not mean, as I argued, that readers in this New World were passively adapting peninsular ideas to their immediate surroundings and local traditions. On the contrary, the American engagement with the astrological, astronomical, and chronological elements of the *repertorios* shall be thought of as part of a wider dynamic of production of knowledge, not as a form of circulation in the Americas of knowledge produced in Europe. Although the European and American authors involved in the production of *repertorios* did not form a *république des lettres,* their works established a conversation spanning at least over a century and a half on the meaning of celestial bodies for understanding the nature of the heavens and their influence in human affairs, relying on a shared set of evolving theoretical and practical resources. The evidence I presented, although limited when compared to the vast amount of works involved in the Iberian-American tradition of *repertorios,* is sufficient to claim that by reading *repertorios* as popular science or as a form of circulation of knowledge, we miss constitutive and central elements of the production of knowledge in the Iberian-American world. First, the path leading from Granollachs and Li to the cosmographical *repertorios* of Chaves and Zamorano consolidates a synthetic form of novel knowledge which avoided discussions of theoretical novelties, following the nature of the astrological literature

65 Sánchez de Cozar, "Tratado", f. 82r.

66 Gruzinski, *Quelle heure est-il là-bas?*; Malcolm, *Useful Enemies. Islam and the Ottoman Empire in Western Political Thought, 1450-1750*.

67 Pimentel, "The Iberian Vision"; Cañizares-Esguerra, "De La Esfera a Los Dos Planetas: Las Indias Como Planeta Alternativo Desde La Colonia a La Independencia".

at their origin. However, by incorporating different traditions and praxis, cosmographical *repertorios* became a new form of knowledge by producing a novel and complex view of the *machina mundi* and its history out of existing materials (and sometimes without changing them). In this sense, *repertorios* are not manifestations of knowledge produced elsewhere, such as astronomical or astrological treatises, but a specific form of complex knowledge. Second, the popularity of Iberian *repertorios* in the New World transformed the genre when writers from Mexico to Lima introduced their own local circumstances and engaged in discussions on the astronomical, chronological, and historical fundamentals of the genre. When these phenomena are interpreted as the circulation in the New World of knowledge discretely produced elsewhere (in Iberian *repertorios*), American writers of *repertorios* are deprived of agency, and their intellectual production is reduced to a mimicry of European manners in an exotic land whose result is not worthy of the history of science and knowledge but of a cabinet of curiosities. By reading *repertorios* as "knowledge in transit", as a complex dynamic of production of natural knowledge, it is possible to appreciate that knowledge production is not as centralised as colonial dynamics may suggest, and it is richer than a unidirectional influx of information. Furthermore, the reduced number of astronomical or astrological treatises or prints in the Americas – and in the Iberian peninsula when compared with other European places – do not evidence the absence of the production of natural knowledge. On the contrary, the production of natural knowledge took other forms, such as the *repertorios de los tiempos,* that have remained somewhat invisible to historians of science under the label of "popular science".

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The Fabric of the Skies: Carlos de Sigüenza y Góngora and the *Academia Mexicana*

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Abstract
This case study discusses the role of the chair of mathematics and the status of celestial knowledge in the Real Universidad de México in late-seventeenth-century New Spain through the analysis of a chronicle of Marian festivities. *Triumpho Parthenico* (Mexico, 1683) was penned by Carlos de Sigüenza y Góngora (1645-1700), during his professorship in mathematics at the Mexican university. This Mexican-born author, known to Latin American scholars as a baroque polymath and prominent actor in the development of *criollo* identity, has been historically considered a defender of mathematical reasoning and a representative of a shift to modernity in New Spain. This essay argues that Sigüenza and his contemporaries' understanding of celestial knowledge and science is not merely instrumental to local political struggles, but that it should be contextualized within the political, epistemic, and confessional discussions about the origin, mediation and purpose of knowledge in early modern Mexico.

Keywords
Carlos de Sigüenza y Gongora, university, politics, devotion, knowledge, Republic of Letters, New Spain, colonial science

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At dawn of Sunday January 25th 1682, the Real Universidad de Mexico opened its doors to the most important church and civic dignitaries of Mexico City for a celebration dedicated to the Immaculate Conception.[1] The guests crossed the portico and discovered a spectacular exhibition of altars ornamented with sumptuous cloths, tapestries, precious stones, pearls and metals, mirrors, paintings and sculptures. Once inside, their enthralled gazes wandered: silk and velvet drapes reflected by mirrors and crystal recreate celestial light. Multitextured surfaces of silver and gold, inlaid diamonds, rubies, pearls and emeralds from Tyria, Milan, Venice, China, Muzos, Potosí and Zacatecas evoked the divine world's riches. By the entrance, on the wall next to the cloister, the visitors could contemplate a mountain range painted in perspective under a sky of brocaded silk. Walking through the atrium was compared to navigating around a "gulf of beauty".[2] This religious academic spectacle conveyed a cosmographic analogy. Every altar was a world which projected and reflected another. This image of the cosmos, was minutely conveyed by the tenure professor of mathematics (*cathedrático propietario de mathematicas*) of the *Real Universidad de Mexico*, Carlos de Sigüenza y Góngora (Mexico City, 1645-1700): "because of its magnitude, in describing it I had to apply what is observed in cosmography, whose masters give plenty news about the universe, even when they have to reduce it to a small map".[3]

The memory of these festivities was preserved in a volume that extolled the glory of the Virgin: *The Parthenic Triumph* (*Triumpho Parthenico que en glorias de Maria Santissima immaculadamente concebida, celebró la Pontificia, Imperial, y Regia Academia Mexicana*). This work, published in Mexico City by Juan de Ribera, one of the most notorious stationers in seventeenth-century New Spain, was commissioned and financed by the acting rector of the Real Universidad de México, Juan de Narvaez.[4] It included a history of Marian devotion in the university, an ekphrastic description of the baroque festivities mentioned above, and a collection of two poetry jousts hosted by the academic institution in 1682 and 1683. Overall, the work was a highly contrived defense of knowledge and Catholic faith in the *Academia Mexicana*, eponym of the Mexican university since its foundation in 1553. This 1683 statement, undertaken by the tenured professor of mathematics, gives rise to questions concerning the role of mathematics in relation to devotion in that epistemic community.

The status of mathematicians in the New World remains largely unexplored. This essay aims to shed light on this issue through a case study based on Carlos de Sigüenza y Gón-

1 Sigüenza y Gongora, *Triumpho Parthenico,* f. 20v.

2 *Ibid.,* f. 21r.

3 *Ibid.,* f. 23v.: "[...] por su magnitud era necesario practicar en su descripción lo que observa la cosmografía, cuyos profesores dan bastante noticia del universo, aún cuando lo estrechan a un corto mapa".

4 *Ibid.,* ff. Ir-VIIIv. The history of the book production is reconstructed from dedication letter to the reader and licenses of publication.

gora, who was Professor of Mathematics in the Real Universidad de México from 1672 to 1693. Any discussion concerning Sigüenza's significance in the history of early modern science has hitherto been based on his *Libra Astronómica*, a cometary disputation written against a Jesuit missionary on the occasion of the transit of the infamous 1680 comet. This work gave Sigüenza a particular reputation. In the early twentieth century Leonard Irving, historian of New Spain, based in Berkley, California, defined him as one of the most advanced thinkers of his time.[5] José Gaos, Spanish translator of Heidegger exiled in Mexico during the Spanish Civil War, considered Sigüenza as an exception to the leading scholasticism in New Spain.[6] This reputation persisted in those academic circles which worked on the history of science in the Iberian world: surveys and focus works from 1960 to 2000 distinguished Sigüenza's best-known work, *Libra Astronómica*, as the beginning of modern science in the Spanish Americas.[7]

Wider considerations of this author's poetic, historical and propagandistic work have nuanced this perspective. The Mexican polymath is currently associated with the elite of New World writers who enacted baroque aesthetics to express *criollo* subjectivities and displays of power.[8] Sigüenza's poetics, like that of his contemporaries, is broadly construed as an obscure, Latinate, rhetorically ornamented mode of thought that accommodated emblematic world views, neo-scholasticism, "neo-Platonism and hermetic currents", and other intellectual systems, in order to channel political anxieties.[9] Historian Anna More argued that Sigüenza's positioning in the renowned *Libra Astronómica* was not "a sign of scientific modernity for its own sake" but a tool in the formation of an idealized community of intellectual peers with cosmopolitan aspirations.[10] This essay proposes that Sigüenza's programmatic motivations also imply confessional and epistemological convictions which express more widely what astral observation, science and knowledge meant to his local community.

Libra Astronómica, a title which echoes Orazio Grassi's polemic with Galileo Galilei over the 1618 comet, is a fascinating defense of reason against received authority and gives an insight into the status of mathematical sciences in New Spain, including astrology, chronology and astronomy. It is also a work that attests to the reception and appropriation

5 Irving, *Don Carlos de Sigüenza y Góngora*, 23-28.

6 Sigüenza y Góngora, *Libra Astronómica y Philosophica*. See: Gortari, *Historia de la Ciencia en México*, 12, 229.

7 Trabulse, *Historia de la Ciencia en México*, 74-80, 125; Navarro Brotons, "La *Libra Astronómica y Philosophica* de Sigüenza y Góngora"; Navarro Brotons, *La Libra Astronómica y Philosophica de Sigüenza y Góngora Carlos de Sigüenza y Góngora*.

8 More, *Baroque Sovereignty*, 7-10.

9 Buxó, "Triunfo Parténico: Jeroglífico Barroco"; Cañizares-Esguerra, *Nature, Empire and Nation*, 48-56;

10 More, *Cosmopolitanism and Scientific Reason in New Spain*, 118.

of the works of natural philosophers such as Pico della Mirandola, Galileo Galilei, Athanasius Kircher, Pierre Gassendi and Giambattista Riccioli. This work needs to be analyzed on the basis of late-seventeenth-century discussions in New Spain about the limits of astrology in relation to chronology, astronomy and natural philosophy, beyond the mere European context. However, this is not the goal of this essay. Instead, I wish to go back to the institutional context in which such work was written and where science was ultimately conceived as divine knowledge. I will investigate the relationship between celestial knowledge and devotion in the *Academia Mexicana* where Sigüenza participated by exploring the engagement of the chair of mathematics with Marian devotion.

The *Academia Mexicana*: a space of politics, knowledge and devotion

The *Academia Mexicana*, celebrated in Sigüenza's *Parthenic Triumph*, was at once a place of political struggle and an idealized space of learning and devotion related to local pride. The work's title page highlighted its three key attributes: it was Pontifical, Imperial and Royal (*Pontificia, Imperial, Regia*), and therefore in strict allegiance to the Roman Catholic Church and the Spanish Monarchy. Literally, the *Academia Mexicana* referred to the Real Universidad de Mexico founded in 1532 as a central place of prestige where colonial authority and the casta system were negotiated.[11] This institution, dedicated to the formation of civil servants and church officials, was a crucial social crossroad where the most important jurists and theologians of the viceroyalty extended their influence from one socio-political sphere to another. The elected rector, for instance, was frequently also a member of the council (*cabildo*) of the Metropolitan Cathedral and judge (*oidor*) of the High Court (*Real Audiencia*). In university politics there was both an overlap and constant friction between the different governmental spheres as well as with the Franciscan, Augustinian, Dominican and Jesuit orders, who also participated in university governance and teaching. Moreover, this academic and political space was the medium in which locally-born elites, such as Carlos de Sigüenza y Góngora and Juan de Narvaez, the author and commissioner of the Marian festivities, sought for recognition and authority.

The *Academia Mexicana* was also an idealized community connected to history and futurity. The eponym, most likely coined in a neo-Latin dialogue published in Mexico in 1554 by the first Professor of Rhetoric, Francisco Cervantes de Salazar (1514-1575), conveyed a reimagined vision of the university's regimented body through humanist ideals of

[11] Martínez López-Cano, *La universidad novohispana en el siglo de Oro*, 37-38; Gonzalbo Aizpuru, *Historia de la educación en la época* colonial, 72-78; Mengegus and Aguirre, *Los Indios, el sacerdocio y la Universidad en Nueva España*, 56-76; Aguirre Salvador, "Mismas aulas, diferentes destinos". For a helpful overview of the history of universities in the New World: Gonzalez Gonzalez, *Una tipología de las Universidades Hispánicas en el Nuevo Mundo*.

classical education and Christian universality.[12] This intellectual space was bound by oath to the devotion of the Immaculate Conception, like all Catholic universities in the Spanish Monarchy.[13] Therefore, the promotion of the Marian cult was tied into the defense of education and it was a gesture of political allegiance with local implications. Sigüenza compared the *Academia* to a Mexican Athens and to a Marian Attic Garden, where each faculty represented a different colored flower or plant: white lilies for theology, olives for jurisprudence, dark red carnations for cannons, yellow retama for medicine, blue violet for philosophy and, shining among all the other flowers, the rose, which symbolized the Virgin.[14] In this sensual evocation, the Mexican university was praised as a legitimate space of knowledge and devotion.

Sigüenza argued that the Mexican scholarly grounds were worth being integrated into a universal history of education. Knowledge in New Spain, he claimed, had legitimate ancestry in Ancient Mexican schools, whose knowledge had been degraded and buried in the barbarous American soil until it was unearthed with the abundant silver of New Spain.[15] The idea of a forgotten ancient knowledge had been disseminated by Francisco de Gomara in his *General History of the Indies* and echoed by the neo-stoic humanist Justus Lipsius, who included a brief description of Mexican schools in his history of education, which was also a promotion of the Academy of Louvain.[16] Having defended the foundation of the university as a rebirth of reason, Sigüenza then represented the *Academia* as a storehouse, treasury and emporium of erudition and wisdom. He asserted that, albeit younger than European universities, his institution was nonetheless connected with them through love and Marian devotion.[17]

> Most florid Academia Mexicana, storehouse of erudition, treasury of letters, emporium of wisdom and inexhaustible source where erudites drink the sweet nectar of knowledge. Though not as ancient as others in Europe at the time of its foundation, it is coeval to most of them in the affectionate love of the holiest Virgen […][18]

12 Cervantes de Salazar, *Francisci Cervantis Salazari*; Id., *Mexico en 1554*.
13 Palafox y Mendoza et. al., *Estatutos, y constituciones*, 43v.
14 Sigüenza y Gongora, *Triumpho Partenico*, f. 18r; Id., *El Triunfo parténico*, 66.
15 *Ibid.*, f. 4v.: "Nostra Academia in barbara et ante hac inculta regione posita, modo etiam nascens eiusmodi est inchoata principiis, ut brevi credam futurum Novam Hispaniam, ut hactenus argenti copia, ita in posterum sapientium multitudine apud caeteras nationes optime auditurum".
16 *Ibid.*, f. 4; Justus Lipsius, *Lovanium*, 104.
17 For the metaphor of the early modern storehouse of knowledge: Pantin and Peóux, *Magasins de savoirs.*
18 Sigüenza y Gongora, *Triumpho Parthenico*, f. 5r: "Florentissima Academia Mexicana, deposito de la erudicion, erario de las letras, emporio de la sabiduria, y fuente inagotable donde beben los eruditos el nectar suavissimo de las ciencias, aunque menos antigua que aquellas otras de la Europa en el tiempo de su erección, coetania casi a todas en el cordial afecto a la Santissima Virgen [...]".

Sigüenza complained that Mexican Marian love, which should have naturally united his *Academia* with Catholic scholars throughout the world, was not reciprocated by other academies, who also defended the Immaculate Conception. Basically, he was outraged that his scholarly community was not included in the catalogue of the academies defending the cult that had been printed in the "Armamentario serafico", a Franciscan response to the Papal prohibition to use the word "Immaculate" as an attribute of the Conception.[19] He argued that the incomplete catalogue of Marian devotees, printed in Madrid in 1649, was a sign of Mexican scholars' self-inflicted silence.[20] Why should it have been his task as a mathematician to correct this omission?

The chair of mathematics in the Real Universidad de México

On a pragmatic level, Sigüenza's defense of the *Academia Mexicana* was integral to his socio-professional struggles. Appointed chair of mathematics from 1672, throughout his tenure he had progressively constructed a multifaceted identity, seeking legitimacy and authority. He was busy with many audiences and clients. At least from 1673 he was invested in annual lunar prognostics, which provided him with financial income and a heteronym (Juan de Torquemada) in the public sphere.[21] In the early 1680s, he sought patronage by designing and writing a commentary of the triumphal arches for the reception of the new viceroy Thomas de la Cerda, Conde de Paredes.[22] On the occasion of the 1680 comet, shortly after the new governor's arrival, he dedicated a short astronomical pamphlet to the vicereine Maria Luisa Manrique de Lara y Gonzaga.[23] The same year, he also wrote a chronicle of the foundation of the Congregation of Santa Maria de Guadalupe in Queretaro, commissioned by Juan Caballero y Ocio, commissary of the Inquisition, and favorably seen by the University rector in turn, Diego Garcia de Leon Castillo, who was also a Cathedral ecclesiastic, judge in the Inquisition and lawyer in the High Court.[24]

The publication of the *Parthenic Triumph* was directly related to Sigüenza's clientelist

19 Sigüenza y Gongora, *Triunfo Parténico*, 31; Alba and Gutierrez, *Armamentarium seraphicum*; Reeves, *Painting the Heavens*, 142.

20 Sigüenza y Gongora, *Triumpho Parthenico*, f. 5v.

21 Manuscript evidence of Sigüenza's work as an almanac-maker is found in the Inquisition records of the National Archives of Mexico: AGNM, Ramo Inquisición, 670, ff.1, 11r-17v, f. 98r, 165r, 192r-193v, 203r-210r, 211r, 212r-215r, 212r-215r, 216r-v 243r-244v; 271r-272v; 283r-293v; f. 336r-336v, 342r-352v, 349-350r, 356r-358v.

22 Sigüenza y Gongora, *Teatro de Virtudes Políticas*.

23 There is no extant copy of the cometary pamphlet *Manifesto Philosophico contra los cometas*, published in 1680 (dedicated to the Vicereine) but the text is included in Sigüenza, *Libra Astronomica y philosophica*, 8-20.

24 Sigüenza y Gongora, *Glorias de Querétaro*.

relationship with the acting rector of the University, Juan de Narvaez.[25] Born in Mexico City from a wealthy family, Narvaez aspired to enter the cathedral council (*cabildo*).[26] He was doctor in theology, treasurer of the Inquisition court and in 1681 managed to be appointed rector, although he was too young with respect to University statutes.[27] To gain the favor of the viceroy and other dignitaries, he played a fundamental role in the funding and reestablishment of Marian festivities in the university. Some of the previous rectors had also supported the cult: Doctor Antonio Rodriguez de Villegas, rector of the University in 1618, held the festivities for the Immaculate Conception in Mexico before moving to Manila; in 1652, the Mercedarian Juan de Ayrolo y Flores created a donation plan to relaunch the celebrations.[28] The promotion of the rector's program was the tangible condition for Sigüenza's participation in university politics. The result was an extremely articulated construction including not only social but also epistemic commitments.

Understanding the role of the chair of mathematics is a key to unraveling Sigüenza's implication in the Marian festivities. The professorship was established in 1637 by request of the students of the Faculty of Medicine. The university chronicles published in 1645 reported that this appointment was conceived to complement the curriculum of Medicine.[29] The content of the syllabus remains largely unknown. Mathematics was most likely understood as a fluid sphere that comprised the so-called "pure" mathematics, including disciplines such as geometry and arithmetic, and the "mixed" mathematics which comprised astronomy, optics, cosmography, music, architecture, surveying, etc.[30] The works of the first appointed professor, Mercedarian Friar Diego Rodríguez (Atitalac, Mexico, ordained 1613-d.1668), attest to the ongoing work in arithmetic, algebra, geometry, logarithms, horology, hydrology, surveying and eclipse observation for the establishment of longitude in the mid-seventeenth century university. Rodríguez was an open proponent of the Tychonian geo-heliocentric world system and, moreover, his writing contains a great number of references to Nicolas Tartaglia, Peter Apian, Oronce Finé, Andreas Schone, Johannes Toefler, Antonio Magini, Galileo Galilei, Johannes Kepler, Marin Mersenne, Li-

25 Sigüenza y Gongora, *Triumpho Parthenico,* f. 16r-v; Id., *El Triunfo parténico*, 164. For discussions on patronage in the context of early modern Europe: Trevor-Roper, *Princes and Artists*; Westman, "The Astronomer's Role in the Sixteenth Century: A Preliminary Study"; Kettering, *Patrons, Brokers, and Clients*; Lux, *Patronage and Royal Science in Seventeenth-Century France*; Moran, *Patronage and Institutions*; Biagioli, *Galileo, Courtier*; Findlen, *Scientific Spectacle in Baroque Rome*; Baldwin, *Pious Ambition*; Krausman Ben-Amos, *The Culture of Giving*; Biagioli, *Galileo's Instruments of Credit*; Carolino, "Science, patronage, and academies in early seventeenth-century Portugal".

26 González González, *Mecenazgo y literatura*, 22.

27 Sigüenza y Gongora, *Triunfo Parténico*, lx-lxii; Id., *Triumpho Parthenico*, f. 16v.

28 *Ibid.*, f. 13r.

29 Rodríguez Salas, Fray Diego Rodríguez, 88.

30 For a discussion on this distinction, see Remmert, *Our mathematicians have learned*, 666.

bert Froidmond.[31] The works of these authors were accessible through the trans-Atlantic book trade between New Spain and European cities such as Seville, Antwerp and Genoa, as well as through the circulation of libraries across military and missionary networks.

The printed 1668 university statutes imply that the professorship in mathematics was renamed Chair of Astrology (*cátedra de astrología*). This document also indicates that the candidates for this position had to compete by reading parts of Sacrobosco's *Sphere* in Latin, although the actual lessons would have been held in Spanish.[32] The strong presence of Jesuit missionaries in New Spain suggests that Sacrobosco's work was taught through Christoph Clavius's commentaries, as occurred in Catholic colleges as well as in Protestant universities throughout Europe in the seventeenth century. In New Spain, Clavius's pedagogy was most likely inaugurated no later than the tenure of Rodríguez, the first mathematical chair, who cited the Jesuit mathematician in his cometary treatise of 1652.[33] The circulation of Clavius's last edition of *Sphere*, better known as his *Operum mathematicorum*, in this immediate context is also attested by an annotated copy that once pertained to the Convento Grande de San Francisco, the Franciscan convent which was associated with the Real Universidad de México.[34]

The status of mathematics in relation to astrology in the Mexican university has hitherto been little explored. As mentioned above, the 1668 statutes indicate that the Chair of Mathematics came to be renamed Chair of Astrology (*cátedra de astrología*). Yet in the 1680s, when Carlos de Sigüenza y Góngora published several propagandistic works, including the *Parthenic Triumph*, he appended to his name the title "tenured Chair of Mathematics" (*cathedrático propietario de mathematicas*). Understanding the reasons behind these nominal changes would require further research. The first modification in the chair's official title coincides with the end of Friar Diego Rodríguez's tenure and may indicate university efforts to regulate more closely the activities of the appointed instructor and his course syllabus. Disciplinary struggles should also be taken into consideration, as shown by some case studies in European contexts. In circles linked to Jesuit education, such as those in which Clavius's works were read, "mathematics" (including its associated disciplines) implied an epistemological distinction. Mathematics was concerned with physical phenomena and quantity, not causes; whereas "physics" or natural philosophy sought to

[31] Trabulse, *Fray Diego Rodríguez*. Rodríguez-Sala, Fray Diego Rodrigeuz: astrónomo-astrólogo-matemático. As of 2007, Rodriguez has been the focus of university theses that expand of the previous. See, for instance, Martinez Albarran, *Fray Diego Rodriguez*; Rodríguez Camarena, *Un análisis situacional de la obra de Fray Diego Rodriguez*; Paredes Hernández, *El contexto conceptual de la primera cátedra de matemáticas en México*; Serrano Bravo, *El tractatus matematices de fray Diego Rodríguez*.

[32] Palafox y Mendoza et. al., *Estatutos, y constituciones,* 21, 32r-32v, 47r.

[33] Rodríguez, *Discurso Etheorologico*, 13.

[34] BNM, *Operum mathematicorum* RFO 510 CLA.o. 1611.

reveal causes and essential natures. The hesitancy to teach "physics" and "mathematics" together led to a distinct classification of subject matters in the *Ratio Studiorum*, the educational statutes of the Jesuit colleges.[35] These arguments reached New Spain, where Jesuit colleges were closely tied to the teaching and politics of the Real Universidad de México. However, the extent to which Clavius' attitude against astrology affected changes in the official naming of the professorship, as well as the conception of mathematical sciences more generally, remains unclear.

The chair of mathematics was paid 100 pesos a year, which made it the lowest paid position alongside Anatomy and Method. However, it is likely that, since its inception, the position was associated with implicit non-teaching activities related to other economic, political and intellectual spheres within or outside the university, such as prognostication, important secretarial work and propagandistic theological disputation. The chair of mathematics could aspire to influential positions within university politics, such as the committee of treasury.[36] Friar Diego Rodríguez, for instance, was in charge of keeping the university's financial records and this occupation may have taken up the majority of this schedule. Carlos de Sigüenza y Góngora also engaged with university administration aside his teaching duties.[37]

Contextual evidence suggests that the chair of mathematics was created with an implicit agenda that represented both political and epistemic aspirations of New Spain elites: to provide rational proof of the apparition of the Virgin of Guadalupe. Indeed, the chairs of mathematics before Sigüenza had been concerned with this conundrum. Friar Diego Rodríguez wanted to decipher the relationship between celestial phenomena and their divine presages. With the passage of the comet of 1652, the Mercedarian friar penned a treatise entitled *Ethereological Discourse on the New Comet* in which he established an equivalence between the presence of the Virgin in Mexico, a lunar eclipse and the sign of grace.[38] He drew from the iconographic and exegetical tradition of the Book of Revelations (12: 1-6), which described a woman clothed with the Sun, standing on the Moon and crowned with twelve stars (*mulier amicta sole ut luna sub pedibus eius, et in capite eius corona stellarum duodecim*). Commentaries of this passage interpreted the woman clothed with the Sun (*amicta sole*) as the Virgin Mary, treading on the mundane and corruptible Moon that contrasted with her purity. In turn, the Sun was read as an allegory of Christ's justice. The mathematician understood the image of the woman's body eclipsing the divine light both as an astronomical phenomenon and a timely act of mercy, intercession and protection.[39]

35 Dear, *Discipline and Experience*, 34, 162-168.

36 Palafox y Mendoza et. al., *Estatutos, y constituciones*, 13r, 19v.

37 For a helpful overview of Sigüenza's educational activities as Chair of Mathematics, see: Gonzalez y Gonzalez, *Sigüenza y Góngora y la Universidad*, 204-232.

38 Rodríguez, *Discurso Etheorologico*, 4.

39 *Ibid*., f. Vv. On scriptural commentaries of Revelations 12:1-6 and their accommodation into painting and natural philosophy, see Reeves, *Painting the Heavens*, 139-225

This exegetical tradition uniting astral knowledge and Mariology held sway over the first wave of concerted efforts aimed to prove the actual apparition of the Virgin of Guadalupe, the Mexican incarnation of the Immaculate, in the outskirts of Mexico City. In 1648, four years prior to the Mercedarian's emblematic accommodation of astronomy and theology, Miguel Sánchez had also associated the Virgin of Guadalupe to the *mulier amicta sole*, in his *Imagen de la Virgen Maria Madre de Dios Guadalupe*.[40] In 1649, the priest and university scholar Luis Lazo de la Vega proceeded in a similar manner in a short book entitled *Huei Tlamahuiçoltica* (The Great Event), which mentioned a sixteenth-century Nahuatl apparition story attributed to the Nahua scholar Juan Valeriano.[41] In this poetic Nahua text beginning *Nican Mopohua* (here is narrated), allusions to the seasons, nightly sky and the location of sunrise and sunset, provided arguments to astrological and mathematical speculations.[42] The chair of mathematics was in open dialogue with these theological and astrological-astronomical arguments.

A successor of Friar Diego Rodriguez, the Jesuit Luis Becerra Tanco, was also chair of Mexican languages. Working on the chronological concordances between the Mexican and Gregorian calendars, he too was an active participant in the juridical inquiries concerning the miraculous apparition of the Virgin of Guadalupe in Mexico. Two years before his brief appointment, in 1672, he had published *Orden milagroso del Santuario de nuestra señora de Guadalupe*, reprinted as *Felicidad de Mexico* in 1675. In this case, calendrical practices, conceived as a key application of early modern mathematics, were used to establish temporal equivalences aimed to date more precisely the Virgin's apparition.[43]

These related productions and activities suggest that the person who was appointed to the chair of mathematics was expected to participate in some capacity in the Mexican defense of the Virgin of Guadalupe and the Immaculate Conception. Before occupying his professorship, Sigüenza himself had indeed delved into this polemics. In his earliest known work *Primavera Indiana*, he evoked the time and space of the Virgin's apparition in astrological terms.[44] This work was reprinted in 1680, the same year of the publication of his renowned yet non-extant *Philosophical Manifest* against the astrological interpretation of comets.[45] Although not in the same textual space, theology and mathematics were expressed in those two works created within the auspices of the university. In 1683 with

40 Sánchez, *Imagen de la Virgen Maria*.
41 Lasso de la Vega, *The Story of Guadalupe*.
42 Valeriano, *Nican Mopohau*, 11-13, 23, 26.
43 Becerra Tanco, *La felicidad de México*, f. 12r-v.
44 This work was first published in 1664 but is known only through a re-edition appended to his 1680 Glorias de Querétaro. Sigüenza y Gongora, *Glorias de Querétaro* [signature L^1-M^1].
45 There is no extant copy of the cometary pamphlet *Manifesto Philosophico contra los cometas*, published in 1680 (dedicated to the vicereine) but the text is included in Sigüenza y Gongora, *Libra Astronómica*, 8-20.

the publication of the *Parthenic Triumph*, the tenured Chair of Mathematics demonstrated once again his commitment to the Marian defense, this time overlapping more explicitly those two modes of thought, which in the *Academia Mexicana* were seen as interdependent.

Mathematics as a tool for theology

Juxtapositions of cosmographical and devotional language and beliefs were not unknown to the global Catholic world. A metaphorical map of Marian devotion comparable to the cosmographic-university atrium conveyed Sigüenza's *Parthenic Triumph* could be found in works such as the *Atlas Marianus*, by the Jesuit Wilhelm Gumpemberg, published between 1657-1672.[46] This illustrated inventory of sanctuaries, routes of pilgrimage and Marian shrines from around the world contained, as in Sigüenza's work, associations between the natural world and faith. As Olivier has shown, early modern Marian atlases contained, for instance, comparisons between the Virgin and contemporary cosmographic ideas related to magnetism: just as magnets attract iron rings by chain reaction, the ubiquitous and miraculous power of Mary irradiates from herself and from depictions of her. The devotees in contact with those emanations are thus affected and united in her realm.[47] Both Gumpemberg (who wrote in the Germanic Jesuit provinces) and Sigüenza (in New Spain) worked within and across cultures where exegesis contributed to mathematical arguments and vice-versa.

The licenses at the beginning of the *Parthenic Triumph* shed further light on the perception of the role of the mathematician within the *Academia Mexicana*. Notably, the book's censors, reputed theologians related to the Inquisition, stated that no other than the chair of mathematics was indicated to witness and record the celebration of Mary, since in their view celestial observation could not be separated from Marian devotion. The second approval by censor Francisco de Aguilar, doctor in law and canon law, lawyer of the High Court, vespers (*visperas*) chair of canon law and tenured chair of law, explicitly stated that mathematician was the ideal person for understanding the relation between the Virgin and the stars. First, he commended Sigüenza's work for his mastery of celestial matters. As a response to his dedicated skill and knowledge, he wrote, the heavens had revealed themselves, opening up their secrets to him:

[46] Gumppenberg, *Atlas Marianus*.

[47] "el imán transmite su poder al anillo de hierro de suerte que el anillo pueda transmitir a otro anillo y así sucesivamente, como una cadena. Es cierto de la fuerza milagroso que reside en la imagen de María viene de María misma y los verdaderos creyentes saben por una larga experiencia que este poder [XXII] se extiende también a las imágenes que han estado en contacto con la imagen original". Quoted in Christin, "La mundialización de María", 316.

> Owing to the excellency of his [Sigüenza's] speculation, the celestial bodies, in strong proportional friendship, allow the purity of their radiance to be recorded, along with the mystery and secrets of their lights. The sky itself explicates these secrets to him in its own tongue [...].[48]

Aguilar developed the image of the mathematician in contact with the sky by connecting this encomium to Saint Augustine's sermon *The Epiphany*, in which the Maggi, led be a star, arrive from the Orient to adore the newly born child. The star, preached Augustin, communicated with those biblical characters as if it were a voice reaching out from the skies: *stella tamquam lingua caelorum*. In the same way, the heavens, implied the censor, talked to the devout mathematician in their own language – one which he would be skilled to translate. Moreover, the commentator insisted that Sigüenza's crucial participation in the recording of the Marian festivities was even more pertinent given the Immaculata's scriptural associations with the Sun, Moon and stars, conveyed in the aforementioned passage in the Book of Revelation 12: 1-6. By way of the celestial emblems found in the Bible, Mary possessed every bright body in the sky. Therefore, the mathematician skilled in celestial observation was indicated to reason, summarize and conclude astrological matter in her name:

> And increasingly so when the most Holy Mary surrounds herself in astrological matter [...] for frequently she designates herself with the names of the Sun, Moon and stars, arrogating to herself all the luminous bodies, which are the instruments of time. The astrologer contemplates their dimension and influences.[49]

In Aguilar's appraisal, the Virgin, surrounded by celestial matter, was at the heart of divine and astronomical time and space. The deity thus both contained and generated the possibility of knowing these realms. The devout mathematician, who contemplated and used celestial bodies as his tools, was granted grace and knowledge. In the censor's view, science came through observation and experience but, more importantly, through revelation. This conception of science adhered closely to the Thomistic orientations of the post-Tridentine Catholic Church.[50] Sigüenza openly embraced this understanding of science in his

[48] "Pues por su aventajada especulación, los astros, con más proporcionada amistad, se dejan registrar lo puro de sus resplandores, lo misterioso y secreto de sus luces, y el mismo cielo con su lengua se los explica, en ponderación de san Agustin hablando de los reyes caldeos: *Nuntiavit stella illis quam lingua caelorum*". Sigüenza y Gongora, *Triumpho Parthenico*, f. VIr.

[49] "Y más cuando en Maria santisima se epiloga la materia de astrologia [...] pues tan frecuentemente se apellida con los nombre de Sol, luna y estrellas, arrogandose esta señora todo cuerpo Luminoso que son los instrumentos del tiempo, cuyas dimensiones e influjos son contemplacion del astrologo", *ibidem* .

[50] For confessional politics in early modern science, especially related to the Catholic world: Feldhay, *Galileo and the Church,* 73-198; Van der Browke, *How to be a Catholic Copernican in the Span-*

astronomical work *Libra Astronómica*, printed seven years after his *Parthenic Triumph*:

> We Catholics, who possess knowledge of the eternal truths and are much more privileged by God than the pagan poets, read the divine Scriptures yet not for that reason do we understand their most concealed mysteries, nor those things that depart from us all the more in the most distant skies, whose perfect knowledge [...] will only be given to those who are granted a revelation by the uncreated wisdom.[51]

Such conviction was the metaphysical standpoint for Sigüenza's work, whether astronomical or devotional. It was also the basis for the Catholic legitimation of the mathematician's role in knowledge making, which spoke more generally to the role of the chair of mathematics and to an idea of science that lived in *Academia Mexicana*. Any endeavor in natural knowledge in this community, I argue, was conceived within this understanding. Marian devotion was therefore an integral part of any epistemological exercise. In defense of the Immaculate Conception, Sigüenza reminded his readers that, at the moment of the Virgin's conception, she had been given every faculty and knowledge. Thus, she possessed the sciences and was the mediator between God and Man. It was through her presence that knowledge could legitimately, with grace, be granted.[52] In her divine generosity, Mary shared that wisdom with all those, especially the celestial observers, who were devoted to her.[53] The mathematician's defense of the Marian cult the *Academia Mexicana* was precisely what gave authority to his institution's profession of the sciences.[54]

ish Netherlands, 85-110; Remmert, *Our mathematicians have learned and verified this*, 665-690.

51 "[…] porque nosotros los catholicos poseedores del conocimiento de las verdades eternas, y privilegiados de Dios muchissimo mas sin comparacion, que los Poetas gentiles leemos las escrituras divinas, y no por esso comprehendemos los misterios reconditos, que ay en ellas, ni las cosas que se retiran de nosotros otro tanto quanto se alejan los cielos cuyo perfecto conocimiento […] solo lo tendra aquel que fuere servido de revelarselo la Sabiduria increada". Sigüenza y Gongora, *Libra Astronomica*, 25.

52 Sigüenza y Gongora, *Triumpho Parthenico*, f. 8v, f. 27.

53 *Ibid.*, f. 31v.

54 *Ibid.,* f. 8v.

Abbreviations

AGNM Archivo General de la Nación de México
BNM Biblioteca Nacional de México

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da Escritura. Describelo D. Carlos de Sigüenza, y Gongora, Mexicano, y en ella Cathedratico propietario de Mathematicas, Mexico, Juan de Ribera, 1683.

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– ESSAYS –

Jerónimo Muñoz y Juan Cedillo Díaz: el Sol como “corazón del mundo” en el debate en torno a Copérnico

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English title
Jerónimo Muñoz and Juan Cedillo Díaz: the Sun as the “heart of the world” in the debate on Copernicus

Abstract
The article examines the different evaluations of Copernicus and heliocentrism by the two most important Spanish astronomers between 1543 and 1633, Jerónimo Muñoz and Juan Cedillo, focusing on the motif of the Sun as the “heart of the world”. This motif, positively added by Cedillo in his handwritten translation of *De revolutionibus* (I, 10), had been employed by Muñoz to criticise Copernicus in his manuscript Latin translation of Theon’s *Commentary on Ptolemy’s Almagest* (Biblioteca Nazionale, Naples) for such an unacceptable denomination of the Sun. Although the motif might have come to Cedillo from other sources (ancient and medieval tradition; not ultimately Peurbach and Clavius), we argue that he may have received it from Muñoz himself during the latter’s lessons at the University of Salamanca. We show that Muñoz’s critique of heliocentrism and the Earth’s motion is related to his decision to eliminate the celestial spheres and his adherence to the Alpetragian model of a single planetary motion from East to West as well as to the attribution of a “spiral” motion to planets. In appendix, we offer the transcription of two important comments added by Muñoz to his translation of Theon’s *Commentary.*

Keywords
Heart of the world, heliocentrism, fluid heavens, planets’ double motion, spiral motion

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Jerónimo Muñoz (ca. 1520-1591) y Juan Cedillo Díaz (ca. 1565-1625) son seguramente los dos astrónomos españoles más importantes en el periodo comprendido entre la publicación de la obra de Copérnico (1543) y la condena de Galileo en 1633. Pertenecen a dos generaciones sucesivas, con Cedillo discípulo de Muñoz, cuyas lecciones sobre astronomía siguió durante sus estudios en la universidad de Salamanca entre 1580 y 1586. Es este el vínculo que nos permite relacionarlos a propósito del tema que abordamos aquí: la declaración de Cedillo en su traducción española del *De revolutionibus* copernicano, según la cual el Sol central e inmóvil es verdaderamente "el corazón del mundo",[1] declaración que se opone frontalmente al rechazo de ese punto por su maestro Muñoz, anticopernicano convencido.

El valenciano Jerónimo Muñoz se graduó en artes en la universidad de Valencia en 1537. A continuación completó su formación en diferentes países europeos: en París fue discípulo de Oronce Fine (1494-1555), lector "royal" de matemáticas desde 1531, y en Lovaina de Gemma Frisius (1508-1555), a quienes denominó respectivamente "praeceptor noster" e "institutor noster".[2] En París pudo conocer también al médico y astrónomo Antoine Mizauld (ca. 1512-1578), a quien menciona en alguna de sus obras.[3] Tras una temporada en Italia, donde enseñó hebreo en la universidad de Ancona, regresó a Valencia, en cuya universidad fue nombrado sucesivamente catedrático de hebreo (1563) y de matemáticas (1565). Allí publicó dos obras: unas *Institutiones Arithmeticae ad percipiendam Astrologiam et Mathematicas facultates necessariae* (1566) y el *Libro del nuevo cometa* (1573), a propósito de la nova de Casiopea, aparecida en noviembre del año anterior y que Muñoz interpretó como un cometa inmóvil situado en la región de las fijas por su total ausencia de paralaje.[4] Escrito a petición del rey Felipe II, el *Libro del nuevo cometa* se benefició de una traducción al francés por Guy Lefèvre de la Boderie (París, 1574) que sin duda contribuyó a su difusión por Europa y a granjearle la atención de Tycho Brahe y Thaddaeus Hagecius.[5] Sin embargo, el nulo agradecimiento

[1] Cedillo Díaz, *Ydea astronomica de la fabrica del mundo y movimiento de los cuerpos celestiales. Traducción de De revolutionibus i-iii, de Nicolás Copernico*.

[2] Véase Navarro Brotons, *Jerónimo Muñoz: Matemáticas, cosmología y humanismo en la época del Renacimiento*. De esta obra tomamos nuestras referencias a la vida y obra de Muñoz.

[3] Concretamente la *quaestio* manuscrita *Utrum sint plures orbes necne*. Véase la edición en Granada, "'Como peces por el agua': Jerónimo Muñoz y la eliminación de las esferas celestes. Edición y traducción del manuscrito *Questio de orbibus*", 257-291.

[4] Reproducción facsímil con traducción inglesa en Muñoz, *Libro del nuevo cometa (Valencia, Pedro de Huete, 1573), Littera ad Bartholomaeum Reisacherum (1574), Summa del pronóstico del cometa (Valencia, Juan Navarro, 1578)*.

[5] Sobre esta obra, además de Navarro Brotons, *Jerónimo Muñoz*, 128-139, 210-220, véase Granada, "Cálculos cronológicos, novedades celestes y expectativas escatológicas en la Europa del siglo XVI", 376-380 y más recientemente Recio, "A Spanish study of the 1572 nova: Jerónimo Muñoz and his Book on the New Comet", 3-12.

del rey y las críticas que recibió por su interpretación de la *nova* – probablemente las de Francisco Valles, médico de cámara de Felipe II – llevaron a Muñoz a declarar, en carta a Bartholomaeus Reisacher de abril de 1574, que no publicaría nada más en el futuro, pues "es de imprudentes, más aún, de pródigos querer editar en España algo de matemáticas, pues los gastos de impresión son inmensos y los libros no se venden".[6] Muñoz fue consecuente y no publicó con posterioridad ninguna obra, salvo un breve y poco riguroso opúsculo sobre el cometa de 1577.[7] Entre su obra manuscrita destacan: 1. *Astrologicarum et Geographicarum institutionum libri sex*;[8] 2. *Commentaria Plinii libri secundi De Naturali Historia*, un comentario al libro segundo de la *Historia Natural* de Plinio;[9] 3. *Traducción comentada del Comentario de Teón al Almagesto de Ptolomeo*, cuyo manuscrito autógrafo se encuentra en la Biblioteca Nacional de Nápoles.

El primero de ellos es una obra redactada ya seguramente en su periodo de profesor en Valencia, como base de sus lecciones. Consiste en una introducción a la astronomía (libros I-IV) – siguiendo libremente el modelo de la *Sphaera* de Sacrobosco en la actualización que había hecho su maestro Oronce Fine en su *De mundi sphaera sive Cosmographia* (1542) – y a la geografía (libros V-VI, que exponen los principios matemáticos de la descripción geográfica y de la cartografía). En esta obra Muñoz sigue las hipótesis tradicionales (geocentrismo e inmovilidad de la Tierra), como era práctica habitual en toda Europa en la primera enseñanza de la astronomía. Es lo que hizo también un copernicano convencido como Michael Maestlin en su *Epitome astronomiae* (1582, con bastantes ediciones en vida de Maestlin), si bien Muñoz fue siempre un geocentrista también convencido. Su autoridad fundamental en esta obra es Ptolomeo y el *Almagesto*, aunque hace algunas menciones de Copérnico y del *De revolutionibus* en puntos técnicos (paralaje y distancia de la Luna, latitudes de planetas, catálogo estelar). Defendiendo las hipótesis tradicionales en los capítulos 6 ("La Tierra está situada en medio del mundo"), 7 ("La Tierra es como un punto comparada con los cuerpos celestes") y 8 ("La Tierra [...] permanece inmóvil") del primer libro, Muñoz hace sin embargo un elogio de Copérnico como matemático: "Cuius [del pitagórico Filolao] opinionem nostro seculo Nicolaus Copernicus vir mathematum peritia antiquis mathematicis nullo modo inferior quodam modo renovavit, asserens Solem in mundi centro esse, Terram vero in quarto celo sub Saturni collocans".[10] Ello no impide que en esos tres capítulos Muñoz

6 Carta a Reisacher en *Libro del nuevo cometa*, 109 s.

7 Recogido *ibid*. en reproducción facsimil.

8 Texto latino transcrito y publicado con traducción española: Muñoz, *Introducción a la Astronomía y la Geografía*.

9 Transcrito y publicado también con traducción española: Muñoz, *Matemáticas, Cosmología y Humanismo en la España del siglo xvi. Los Comentarios al Segundo libro de la Historia Natural de Plinio*.

10 Muñoz, *Introducción a la Astronomía y la Geografía*, 253; traducción española, 91. Para una descripción de esta obra, véase Navarro Brotons, *Jerónimo Muñoz*, 46-70.

defienda la centralidad e inmovilidad de la Tierra repitiendo los argumentos habituales en la tradición de la *Sphaera* (libro I) y en el *Almagesto* (I, 5-7): la posición no central de la Tierra es incompatible con los fenómenos (de acuerdo con la distancia comúnmente aceptada de la esfera de las fijas); el movimiento "alrededor de su propio centro" en velocidad y dirección variables con respecto al movimiento del mundo es también incompatible con los fenómenos, sin que Muñoz considere en ningún momento – a diferencia de Ptolomeo en *Almagesto*, I, 7 – la propuesta de que el movimiento diario es propio de la Tierra (de occidente a oriente) y mera apariencia en planetas y esfera de las fijas.

El Comentario al segundo libro de la *Historia Natural* de Plinio es más parco en las menciones de Copérnico y Muñoz se limita prácticamente a repetir las declaraciones ya efectuadas en el manuscrito anterior sobre la centralidad e inmovilidad de la Tierra.[11]

Será el comentario a Teón de Alejandría el manuscrito que merecerá nuestra atención por encontrarse en él una crítica mucho más violenta y despectiva de Copérnico, así como también en relación con Cedillo y el tema del Sol como "corazón del mundo", pues desde 1578 hasta 1591, año de su muerte, Muñoz fue catedrático de astronomía en la universidad de Salamanca, donde Cedillo tuvo que seguir sus lecciones.

El castellano Juan Cedillo Díaz (natural de la pequeña localidad de Camarena, en Toledo) estudió desde 1580 en la universidad de Salamanca, donde se graduó en Artes en 1583, matriculándose a continuación en Medicina (1583-1586). Durante esos años escuchó seguramente las lecciones de matemáticas y astronomía de Muñoz. En 1587, sin haber concluido los estudios de medicina, se inscribe en Teología y a partir de entonces se le pierde ya la pista en Salamanca.[12] A comienzos de los años 90 Cedillo está al servicio del sexto Marqués de Moya y se encarga de gestionar la encuadernación de algunos libros de su biblioteca, entre los que figura una copia del *De revolutionibus* copernicano en la edición de Basilea (1566), copia que presenta anotaciones a los libros primero y segundo que creemos proceden de la mano de Cedillo.[13] Su actividad profesional se desarrolla a continuación al servicio de la corona, desde 1596 como profesor de matemáticas en la Academia Real de Madrid, fundada en 1582 por Felipe II, y también como experto en matemática aplicada en diversos encargos. Cuando en 1611 Andrés García de Céspedes (ca. 1545-1611) se jubila, Cedillo asume su puesto de catedrático de Matemáticas en la Academia y de Cosmógrafo Mayor de Indias,

11 Véase la edición citada Muñoz, *Matemáticas, Cosmología y Humanismo*, 393: "Praecedentibus demonstrationibus obtinuimus eam [la Tierra] non posse esse extra mundi medium, quare errant Philolaus pythagoreus, Nicolaus Cusanus, Nicolaus Copernicus, qui eam ut sidus quoddam per celum convertunt".

12 Sobre los estudios de Cedillo véase Cedillo Diaz, *Ydea astronomica*, 62 ss.

13 *Ibid.*, 13, 66 s., 125-129. Este ejemplar, no recogido en Gingerich, *An Annotatated Census of Copernicus' "De revolutionibus" (Nuremberg 1543 and Basel 1566)*, se encuentra actualmente en la Biblioteca y Archivo Zabálburu de Madrid.

que ocupará hasta su muerte en 1625.[14] Como servidor de la corona ('criado del Rey'), la obra de Cedillo estaba sometida al secreto de Estado impuesto a materias sensibles como las relacionadas con la navegación oceánica, cartografía y similares;[15] además, su enseñanza en la Academia estaba unida a la obligación de traducir al castellano obras de matemáticas y astronomía asociadas a la enseñanza. No es, por tanto, extraño que la obra de Cedillo haya quedado manuscrita, conservada en tres legajos depositados en la Biblioteca Nacional de Madrid. Entre ella figura la obra que merece nuestra atención: *Ydea astronomica de la fabrica del mundo y movimiento de los cuerpos celestiales,* trabajo cuya fecha de redacción no consta y que seguramente se extiende a lo largo de bastantes años, probablemente entre 1611 y 1625.

Creída inicialmente una obra original, por su título y por las pretensiones de originalidad cosmológica expresadas en un prefacio a una primera redacción,[16] la *Ydea astronomica* es en realidad una traducción (algo libre) al castellano de los tres primeros libros del *De revolutionibus* de Copérnico, con omisión de la dedicatoria al Papa y de la *praefatiuncula* de Osiander al lector.[17] La realidad de la traducción quedaba además enmascarada por la atribución de la autoría que Cedillo hacía a sí mismo y por la frecuente mención de Copérnico como un autor distinto del que escribía. Lo importante, sin embargo, era que en esa traducción, que se realizaba antes y después de la condena del movimiento de la Tierra y la suspensión del *De revolutionibus*, en 1616, el heliocentrismo y el movimiento de la Tierra eran asumidos constantemente como hechos reales o verdades físicas.[18]

En esta obra, Cedillo traduce la loa con que Copérnico (en *De Revolutionibus* I, 10) justifica la posición central del Sol como centro del mundo (y el consiguiente desplazamiento de la Tierra a planeta en movimiento en torno al Sol central) en los siguientes términos:

> Y el Sol tiene el medio del universo como *coraçon* o lampara del mundo y luz que le alumbra y hermosea todo,[19] de donde como en un asiento real gobierna los demas astros, fer-

[14] Cedillo Diaz, *Ydea astronomica*, 80 s.

[15] Véase Portuondo, *Secret Science: Spanish Cosmography and the New World.*

[16] Cedillo Diaz, *Ydea astronomica*, 179-182.

[17] Que se trata de una traducción fue descubierto y mostrado en Esteban Piñeiro, Gómez Crespo, "La primera versión castellana de *De revolutionibus orbium coelestium*: Juan Cedillo Díaz (1620-1625)", 131-162.

[18] Véase la Introducción a Cedillo Diaz, *Ydea astronómica*, 121-157. Para un comentario anterior a estos aspectos de la *Ydea*, véase Copernic, *De Revolutionibus orbium coelestium / Des révolutions des orbes célestes*, vol. I, 655-663.

[19] Cedillo reduce a estas tres palabras la loa del Sol en *De revolutionibus*, 9v, lineas 4-9: "Quis enim in hoc pulcherrimo templo lampadem hanc in alio vel meliori loco poneret, quàm unde totum simul possit illuminare? Siquidem non inepte quidam lucernam mundi, alii

> tiliza y abunda la tierra, que con el anuo movimiento que tiene y el parentesco y vezindad de la luna nos da tan provechosissimos partos. Assi parece que está la fabrica del mundo y compostura.[20]

Lo significativo para nosotros ahora no es lo que Cedillo ha omitido en su traducción, sino lo que ha añadido: la designación del Sol como 'corazón del mundo'. En nota a esta adición decíamos en nuestra edición de la *Ydea*:

> Esta importante y significativa adición a Copérnico, que habla sólo del Sol como lámpara, aparece ya en la copia borrador (fol. 188^{v}) como un añadido sobre la línea. Se trata, por tanto, de una idea que ha venido a la mente de Cedillo como de improviso en el curso de la traducción (aunque acaso se le había ya presentado en su reflexión anterior) y que está en la línea de los autores copernicanos (por ejemplo, Kepler) de transferir al Sol junto con la centralidad y punto de partida del movimiento, el rango de corazón del mundo, que la tradición geocéntrica atribuye por el contrario a la esfera de las fijas o al primer móvil.[21]

En efecto, Kepler venía designando al Sol como corazón del mundo desde los comienzos de su desarrollo intelectual, ya desde los años de estudiante en Tubinga y de conversión al heliocentrismo bajo la guía de Michael Maestlin.[22] Esta designaciónaparecía ya en el *Mysterium cosmographicum* (1596),[23] se repetía en la *Astronomia nova* (1609)[24] y de forma aún más conspicua en la *Dissertatio cum nuncio sidereo* (1610)[25] y en el *Epitome*

mentem, alii rectorem vocant. Trimegistus visibilem Deum, Sophoclis Electra intuentem omnia"; traducción castellana, *Sobre las revoluciones (de los orbes celestes)*, 68 s.: "¿quién en este bellísimo templo pondrá esta lámpara en otro lugar mejor, desde el que pudiera iluminarlo todo? Y no sin razón unos le llaman lámpara del mundo, otros mente, otros rector. Trismegisto le llamó dios visible, Sófocles, en *Electra*, el que todo lo ve". Puede sorprender que Cedillo haya eliminado estas líneas, probablemente las más famosas de toda la obra de Copérnico. Lo cierto, sin embargo, es que Cedillo procede en consonancia con su actitud de prescindir de los elementos eruditos, históricos y patentemente humanistas de Copérnico.

20 Cedillo Diaz, *Ydea astronomica*, 210.

21 *Ibidem*, n. 176. Más adelante nos referiremos a la atribución al Sol del rango de 'corazón del mundo' en la tradición geocéntrica.

22 Véase Granada, "Johannes Kepler. The Sun as the Heart of the World", 133-140.

23 Kepler, *Gesammelte Werke*, vol. I, 70: "Hic iam longè rectius in Solem competunt illa nobilia epitheta, Cor mundi, Rex, Imperator stellarum, Deus visibilis, et reliqua".

24 Kepler, *Gesammelte Werke*, vol. III, 91, 97. See also Chapter 33, 238: "idem [el Sol] sit fons vitae mundi (quae vita in motu siderum spectatur)".

25 Kepler, *Dissertatio cum nuncio sidereo. Discussion avec le Messager céleste*, 125 ss., n. 241-244; traducción española en Galilei-Kepler, *El mensaje y el mensajero sideral*, 147.

astronomiae copernicanae (1620).[26] Aunque Cedillo no cita a Kepler, si no estamos equivocados, ni en la *Ydea* (donde es lógico que no lo haga) ni en ninguna otra obra suya, es posible que conociera esas tres obras, que circulaban por España en esos años y que, por ejemplo, son ampliamente discutidas en la obra de un colaborador y probablemente discípulo suyo: Juan Bautista Vélez, autor de una traducción y comentario manuscritos a los seis primeros libros del *Almagesto* (obra enorme de extensión, realizada en 1630-31 y conservada en la Biblioteca de El Escorial).[27]

Aunque, como veremos más adelante, la designación del Sol como 'corazón del mundo' pudo haber llegado a Cedillo por diferentes vías dentro de una representación geocéntrica, nos parece altamente probable que la deba también a su maestro Jerónimo Muñoz y concretamente a sus lecciones en Salamanca, pero con una sustancial modificación: la designación en Muñoz era crítica o, quizá mejor, *irónica*, de acuerdo con su convicción de que la Tierra estaba inmóvil en el centro del mundo, mientras que Cedillo la convierte (coincidiendo con Kepler, lo conozca o no) en positiva y en designación de la función cosmológica del Sol central e inmóvil.

Ciertamente, Muñoz – en su traducción y comentario latinos del Comentario de Teón de Alejandría al *Almagesto* de Ptolomeo (370 d. C.), conservado como hemos dicho en la Biblioteca Nazionale de Nápoles,[28] tras haber sido llevado a esa ciudad por el hijo de Muñoz con la finalidad de venderlo a buen precio para su publicación –comenta a Teón a propósito del capítulo séptimo del primer libro del *Almagesto* ("Que la Tierra no tiene ningún movimiento de un lugar a otro") y redacta una extensa glosa que trascribimos en el Apéndice 1. Allí, criticando a Copérnico y a su iniciativa de colocar al Sol en el centro del mundo, dice:

> Por estas razones, [Copérnico] osa establecer una nueva fantasía o sueño. Además, explicando su opinión, no priva al cielo completamente de movimiento, sino solo al Sol, al que coloca inmóvil en el centro del mundo como *corazón de todo el universo*, desde donde se difunda igualmente por todo el orbe una cierta fuerza nutricia y vivificadora.[29]

[26] Kepler, *Gesammelte Werke*, vol. VII, 261-264. Véase Granada, "Johannes Kepler", 135.

[27] Vélez colaboró con Muñoz en la observación del cometa de 1618. Sobre este autor y su traducción y comentario manuscrito al *Almagesto*, véase Gómez Crespo, *Un astrónomo desconocido: El debate copernicano en El Escorial.* Gómez Crespo es de la opinión de que la traducción y comentario se extendía a los siete libros restantes, que se han perdido. Para el conocimiento de la *Astronomia nova* y del *Epitome de Kepler*, véase, *ibid.*, Apéndices 3 y 4.

[28] MS VIII C 33. Se trata de una extensa traducción latina del original griego, de 300 páginas numeradas solo por el recto, de tamaño folio real, con extensas anotaciones en el margen.

[29] f. 35r: "His rationibus audet novam quandam phantasiam aut somnium stabilire. Ceterum suam explicans opinionem non adimit celo prorsus motum sed tantum Soli quem in mundi centro immobilem collocat tanquam *totius uniuersi cor* unde ex aequo per totum orbem vis quedam alma et vivifica impertiatur" (cursiva y traducción nuestras). Para una primera noti-

Navarro Brotons ha señalado este punto: "Con su teoría, prosigue Muñoz, Copérnico coloca al Sol en el centro, como si fuera el corazón del Universo",[30] pero no pasa a analizar este punto, ni lo pone en relación con Cedillo, concentrando su atención en otros puntos interesantes de esa glosa al capítulo 7, como son el diagrama cosmológico heliocéntrico que Muñoz construye, su negación de las esferas planetarias y sobre todo su adopción del modelo alpetragiano de un único movimiento planetario. De la lectura de este comentario de Navarro Brotons a esta importante glosa de Muñoz, nos hemos visto nosotros impelidos al pasaje de Cedillo, cuya edición habíamos publicado poco antes en colaboración con Félix Gómez.

Notemos, en primer lugar, que la designación del Sol como "corazón de todo el universo", no simplemente como "corazón del cielo" y "corazón del mundo" añade un énfasis nuevo: una función cósmica universal que el Sol ejerce al unísono ("ex aequo") desde su posición central e inmóvil. Es una designación positiva que sin embargo Muñoz rechaza a continuación porque la hipótesis heliocéntrica es una "locura".[31]

Muñoz escribió su Comentario a Teón en los años de su enseñanza en Salamanca. Una anotación al pie de esa única copia existente (autógrafa) reza: "Die 17 veteri calculo, 27 die vero novo, octobris mensis anni 1582, decima hora antemeridiana, absolvebat Salmanticae Hieronymus Munnos cathedraticus Astrologiae gymnasii Salmanticensis translationem commentariorum Theonis Alexandrini in magnam constructionem Cl. Ptolemaei".[32] No es muy probable que Cedillo hubiera podido acceder a esta obra ma-

cia del contenido de este comentario a Teón, véase Navarro Brotons, *Jerónimo Muñoz*, 115-128. En 1605 Giovan Battista della Porta publicó en Nápoles su traducción del libro primero del *Almagesto*, acompañada de la traducción del Comentario de Teón a dicho libro; véase la reciente edición: *Claudii Ptolemaei Magnae Constructionis liber primus cum Theonis Alexandrini commentariis*, en Della Porta, *Edizione Nazionale delle Opere*.

30 Navarro Brotons, *Jerónimo Muñoz*, 119. Una primera mención crítica de Copérnico aparece ya en f. 32v (a propósito de *Almagesto* I, 5: "Que la Tierra está en el centro del cielo"): "Deinde non tantum has rationes [a propósito de la sombra del gnomon] Ptolemei et Theonis efficaces esse non solum si Terra ponatur extra mundi centrum immobilis, sed si quis eam mobilem supponeret in quarto celo, Solem vero immobilem in centro mundi, ut Pythagorei et Nicolaus Copernicus, contra quos huiusmodi rationes etiam concluderent. Sed de hac hypothesi postea tractabimus [cap. I, 7]".

31 Del mismo modo, la afirmación de Plinio (véase *infra*, n. 40) de que el Sol es "alma del mundo y su mente" requiere, afirma Muñoz, que el Sol "permaneciendo inmóvil lo anim*e* y diri*ja* todo". Pero esta función *copernicana* del Sol es imposible porque "si el Sol no se moviera lo abrasaría todo".

32 f. 300r, citado por Navarro Brotons, *Jerónimo Muñoz*, 115 n. 8; hemos modificado ligeramente la transcripción. Nótese que la fecha de conclusión de su traducción y comentario coincide con la entrada en vigor del nuevo calendario gregoriano, precisamente en ese mismo octubre, pocos días antes. En uno de los folios preliminares a la traducción (que empieza en f. 21r) Muñoz declara "faciebam anº 1578. die 30 Septembris/ Valentiae" (f. 19r), lo cual

nuscrita, pero creemos que su existencia y la mención extremadamente polémica que en ella se hace de la cosmología copernicana y de la "osadía" de hacer del Sol el "corazón de todo el universo" permiten pensar que en sus lecciones en Salamanca Muñoz criticaba con aspereza la "fantasía" y el "sueño" heliocéntricos de Copérnico, ridiculizándolos ante su auditorio y mostrando la impropiedad de hacer del Sol el "corazón de todo el universo" sito en el centro geométrico del cosmos. Es muy posible que Cedillo, que comenzó sus estudios en Salamanca en 1580, hubiera escuchado esta crítica de Muñoz y hubiera guardado en su memoria esa designación de "totius universi cor".[33] Pero ¿de dónde la había tomado a su vez Muñoz?

Podríamos pensar en Aristóteles, que en *De caelo* II, 13 rechaza la cosmología pitagórica (en rigor de Filolao) de un fuego central como una confusión del centro geométrico con el centro natural del organismo cósmico, como si tuvieran que coincidir en un mismo punto. Igual que en los animales, dice Aristóteles, no coinciden, el centro geométrico del cosmos puede estar ocupado por un cuerpo innoble (la Tierra), mientras que el centro natural corresponde a la región que da principio al movimiento.[34] Aristóteles no pone nombre ni al centro natural de los animales ni al centro natural del cosmos, pero la tradición posterior (Simplicio y Tomás de Aquino en sus comentarios respectivos al *De caelo*, por ejemplo) los identificará: el corazón en los animales y la esfera de las fijas en el cosmos, que pasa a ser así el "corazón del mundo".[35] Aunque Muñoz conocía perfec-

permite pensar que la traducción y comentarios al libro primero (donde se hace la crítica de Copérnico) fueron realizados al comienzo de su enseñanza en Salamanca. – La traducción y comentario de Teón se une al interés que había despertado esta importante obra en la cultura científica del Renacimiento. Téngase presente la enorme obra de Regiomontano, *Defensio Theonis contra Georgium Trapezuntium*, ahora accesible online en la edición de Michael Shank (http://regio.dartmouth.edu). Pocos años después que Muñoz, Christoph Rothmann criticará también duramente la traducción del *Almagesto* de Trapezuntius (Venecia 1527) en su manuscrito *Observationum stellarum fixarum liber primus*, ahora editado en *Christoph Rothmanns Handbuch der Astronomie von 1589*. Para una crítica de Muñoz a Trapezuntius, véase el añadido al margen que transcribimos *infra*, Apéndice 2, f. 36r, n. 86.

33 Notemos que la terminación de la traducción del *Comentario* de Teón en 1582 coincide con los estudios de Artes de Cedillo en Salamanca y su seguimiento de las lecciones de Muñoz.

34 Aristóteles, *De caelo*, II, 13, 293a 15-293b15. Sobre este tema véase Granada, "Aristotle, Copernicus, Bruno: centrality, the principle of movement and the extension of the Universe", 91-114: 93 s.

35 Véase Simplicius, *On Aristotle On the Heavens 2. 10–14*: "it is necessary to seek something else as the most honourable <part> analogous to the heart, namely the centre; and this is not the central point but rather the fixed sphere because it is the starting point of the being of the cosmos and carries around the other spheres with it and contains the whole corporeal nature". Sobre el Aquinate, véase *In Aristotelis libros De caelo et mundo, De generatione et corruptione, Meteorologicorum expositio*. lib. II, lect. XX, # 485, p. 241: "Et haec duo manifestat: primo quidem ostendens quale sit medium universi quod proportionatur cordi animalis. Et

tamente el *De caelo* y remite a él y a su libro segundo en diferentes ocasiones, debemos mirar también en otra dirección para encontrar el desplazamiento del corazón del mundo de la esfera de las fijas al Sol .

En la Stoa, el segundo escoliarca, Cleantes (331 o 330-232 a.C.), acusó a Aristarco de Samos de impiedad por haber sostenido que el Sol estaba inmóvil en el centro del cosmos.[36] Sin embargo, identificó por otra parte al Sol con el *hegemonikon* o principio rector del cosmos.[37] Desde este momento hasta el final de la Antigüedad se desarrolla, en la tradición estoica y pitagórico-platónica, una tendencia a ensalzar el papel central del Sol en el mundo celeste, sin abandonar por supuesto el geocentrismo, pero enfatizando la "centralidad" del Sol en el cielo, entre los planetas inferiores y superiores y gobernando en gran medida el movimiento de los planetas: Mercurio y Venus son "clientes" del Sol, del que nunca se alejan más allá de una determinada distancia mientras que los planetas superiores, que experimentan todo tipo de distancias con respecto a él, imitan su movimiento con el componente epicíclico de su propio movimiento.[38] Hallamos un momento significativo de este desarrollo en Teón de Esmirna (siglos I-II d.C.), quien en su obra *Exposición de los conocimientos matemáticos útiles para la lectura de Platón* afirma, enlazando claramente con Aristóteles pero desplazando el centro natural al Sol:

> En los cuerpos animados, el centro del cuerpo o del animal es diferente del centro de la magnitud. Por ejemplo, para nosotros, que somos hombres y animales, el centro de la criatura animada está en el corazón, que siempre se halla en movimiento y siempre está caliente y por consiguiente es la fuente de todas las facultades del alma, fuente de deseo, de imaginación y de inteligencia, mientras que el centro de nuestra magnitud está en otro sitio, aproximadamente en el ombligo. De manera similar, si juzgamos lo más grande, lo más digno de honor y las cosas divinas de igual modo que en las cosas pequeñas, accidentales y mortales, el centro matemático del universo se encuentra donde está la Tierra, fría e inmóvil; pero el centro del cosmos, siendo como es un cosmos y un animal, está en el Sol, que es, por así decir, *el corazón del universo*.[39]

Encontramos expresiones similares sobre la centralidad solar y la dependencia de los

dicit quod est principium aliorum corporum, et maxime honorabile inter alia corpora: et haec est sphaera stellarum fixarum".

36 *Stoicorum veterum fragmenta*, vol. I, fr. 500.

37 *Ibid.*, fr. 499.

38 Dreyer, *A History of Astronomy from Thales to Kepler*, 167-170.

39 Citado en Dreyer, *ibid.*, 168; traducción y cursiva nuestras. Para un estudio reciente sobre esta obra véase Teone di Smirne, *Expositio rerum mathematicarum utilium ad legendum Platonem*.

restantes planetas en autores como Plinio,[40] Calcidio,[41] Macrobio.[42] El momento culminante de este proceso de ensalzamiento del Sol en el mundo celeste y de subordinación a él de los demás planetas está representado por el modelo heliocéntrico para los planetas inferiores propuesto por Marciano Capella (360-428) en el libro astronómico de las *Bodas de Filología y Mercurio*.[43]

Esta valoración del Sol llega al Renacimiento, donde la encontramos en autores platónicos como Marsilio Ficino, quien – teniendo también presente la conexión metafísica y teológica que el Sol posee, ya desde Platón, en la tradición platónica como "hijo visible del Bien" –[44] celebra la centralidad celeste del Sol como "corazón del cielo" en tanto que "rige y modera todos los cuerpos celestes", por lo que "los astrónomos hallan y miden los movimientos de todos los planetas a partir del movimiento, ya determinado, del Sol".[45] En la misma tradición astronómica geocéntrica, antes y después de Copérnico, se subrayará que los planetas participan del movimiento anual medio del Sol. Ya Georg Peurbach (1423-1461) lo indica en sus *Theoricae novae planetarum* (Nuremberg 1473): "es evidente que cada uno de los seis planetas tiene algo en común con el Sol en su movimiento y que

40 Plinio, *Historia Natural*, II, 12-13, donde el Sol es calificado de "rector de los propios astros y del cielo […] el alma o, más llanamente, la mente de todo el universo, el árbitro o divinidad primordial de la naturaleza". Sobre la dependencia del movimiento de los planetas con respecto al Sol véase *ibid.*, 72-80. — En su *Comentario a Plinio* Muñoz acepta que "temporum rector est Sol, quod annuae periodi sit atque quatuor temporum anni [...] auctor" (408); remitiéndose a Ptolomeo, lo hace también "reliquorum siderum rector, quare eorum motus opera solaris motionis deprehenduntur", *ibid.*, 410. Sin embargo, censura vehementemente a Plinio por haber atribuido al Sol el carácter de alma del mundo y su mente: "Si mens esset, non egeret locali motu, sed immotus cuncta foveret et gubernaret; atqui si Sol non moveatur omnia combureret", *ibid.*, 412-414. Su rechazo de que el Sol sea la "mente" del mundo (calificativo que le concede Copérnico en *De revolutionibus*, I, 10) coincide con la decidida denuncia que Muñoz lleva a cabo en el *Comentario a Plinio* de la divinización de los cuerpos celestes.

41 *Commentario al "Timeo" di Platone*, C, 308, donde remitiéndose a autores, quizá Teón de Esmirna, se dice: "Non ergo a medietate corporis, quae terra est, sed a regione vitalium, id est sole, animae vigorem infusum esse mundano corpori potius intelligendum pronuntiant, siquidem terra immobilis, sol vero semper in motu, quando etiam recens extinctorum animalium corda superstites etiam tunc motus agant. Ideoque solem cordis obtinere rationem et vitalia mundi totius in hoc igni posita esse dicunt".

42 *Commentaire au Songe de Scipion*, I, 20, 6-7: "'Mens mundi' ita [Sol] appellatur ut physici eum cor caeli vocaverunt, inde nimirum quod omnia quae stata ratione per caelum fieri videmus, [...] omnia haec solis cursus et ratio dispensat. Iure ergo cor caeli dicitur, per quem fiunt omnia quae divina ratione fieri vidimus. [...] hoc est ergo sol in aethere quod in animali cor".

43 Capella, *Le nozze di Filologia e Mercurio*, VIII, 854: "Venus vero ac Mercurius non ambiunt Terram".

44 Ficino, *De Sole*, 202.

45 *Ibid.*, 197, 189, 194. Para otro importante pasaje de Ficino, en este caso del *De amore* o Comentario a *El Banquete* de Platón, véase *infra*, n. 62.

el movimiento de este es como un espejo común y una regla de medida para los movimientos de ellos".[46]

Pero el cuadro general del cosmos seguía siendo geocéntrico en tanto que el Sol como "corazón del mundo" se movía en torno a la Tierra inmóvil en el centro geométrico del cosmos. La decisión absolutamente original y revolucionaria de Copérnico (en la que es seguido de forma explícita por Cedillo) fue superar todas estas centralidades celestes del Sol, corazón y en una cierta medida norma o medida del movimiento de los demás planetas, para postular decididamente la centralidad unívoca del Sol como en el pitagorismo criticado por Aristóteles en *De caelo* II, 13, esto es, hacer del Sol a la vez centro natural o "corazón del mundo" y centro geométrico, por lo que estaba necesariamente inmóvil, haciendo así posible lo que Muñoz afirma imposible en su *Comentario a Plinio:* "Si [el Sol] fuese la mente del mundo, no necesitaría de movimiento local, sino que permaneciendo inmóvil lo animaría y dirigiría todo".[47]

En la década de 1530, cuando Copérnico estaba terminando de elaborar el *De revolutionibus* a partir de la hipótesis heliocéntrica y el triple movimiento de la Tierra, Oronce Fine, cuya enseñanza seguiría Jerónimo Muñoz en París en los años finales de esa década, publica su *Protomathesis* (1532), cuya tercera parte (*Cosmographia, sive mundi Sphaera*) discurre, en el libro primero, "De generali ipsius Mundi compagine, sive structura". Allí, en el capítulo tercero ("De coelestium orbium numero, atque positione"), Fine concluye la exposición de la estructura del cosmos reiterando la posición media del Sol "corazón del mundo" y presentando su gobierno del movimiento planetario, pero siempre concediendo a la Tierra la centralidad geométrica carente de valor:

> Sin embargo el Sol, planeta entre los demás de admirable magnitud, como corazón del Mundo (el Mundo es ciertamente semejante a un animal), ha recibido en suerte el lugar intermedio no sin razón: para que pudiera impartir su virtud y su luz admirable a todos los as-

46 9v: "manifestum est singulos sex planetas in motibus eorum aliquid cum Sole communicare: motumque illius [el Sol] quasi quoddam commune speculum et mensurae regulam esse motibus illorum". Véase la reciente edición crítica de Malpangotto. *Theoricae novae planetarum Georgii Peurbachii dans l'histoire de l'astronomie*, 335. Para una crítica, en cambio, de Regiomontanus (1436-1476), el discípulo de Peurbach, a la analogía "Sol-corazón del mundo", asumida por Jorge Trapezuntius, véase ahora Shank, *Regiomontanus* versus *George of Trebizond on Planetary Order, Distances and Orbs (*Almagest *9.1)*, 305-380, en particular 340 s., 348-349. Por su parte, Regiomontano ofreció en el *Epitome astronomiae* (Venecia 1496, libro XII, caps. 1-2) la vía para transformar los modelos geocéntricos de los planetas superiores e inferiores en modelos heliocéntricos con el Sol en movimiento en torno de la Tierra, una propuesta que sirvió a Copérnico en su itinerario hacia el heliocentrismo. Véase Goldstein, "The Origin of Copernicus's Heliocentric System", 219-235: 221, 227; Goddu, "Reflections on the Origin of Copernicus's Cosmology", 37-53: 40-43.

47 Cf. *supra*, n. 40.

tros por igual, a los astros superiores y a estos inferiores que dependen de su movimiento.[48]

Antoine Mizauld, médico y astrólogo, que había escrito un poema encomiástico para la edición de 1542 de la *Cosmographia*, publicó en 1550 en Lyon un libro titulado *Aesculapii et Uraniae medicum simul et astronomicum ex colloquio coniugium, harmoniam microcosmi cum macrocosmo, sive humani corporis cum caelo paucis figurans, et perspicue demonstrans.* El diálogo séptimo se titulaba "De Solis cum corde humano aptatione" (pp. 62-70). Allí Esculapio (dios de la medicina) y Urania (musa de la astronomía) dialogan sobre el paralelismo entre el cuerpo humano y el mundo y por tanto entre el corazón y el Sol. Como Fine, Mizauld insiste también sobre la posición "media" o "central" del Sol en el cielo, dejando siempre clara la centralidad cósmica de la Tierra: "el corazón se ajustó al lugar intermedio en el cuerpo, igual que el Sol en el cielo [medium fere locum in corpore, perinde atque Sol in coelo, [cor] sibi coaptavit]" (p. 66), por lo que resulta que el corazón es "la parte más noble de todas las cosas del cuerpo, asociada en un matrimonio tácito, como un príncipe, con el príncipe sol, llamado por los antiguos corazón".[49]

Muñoz, sin embargo, no estima posible que el Sol copernicano – centro del cosmos y no simplemente 'medio' en el cielo, sobre el mundo sublunar – pueda ser "totius universi cor". En su larga anotación al comentario de Teón al capítulo I, 7 del *Almagesto*, en la que señala que Copérnico (calificado al comienzo de la nota como "mathematicus non vulga-

48 Fine, *Protomathesis*, 104r: "Sol autem inter alios mirae magnitudinis planeta, veluti cor Mundi (est enim Mundus animali similis) medium locum non iniuria sortitus est: ut suam virtutem et admirandum lumen posset omnibus aequa lance dispensare, superioribus quidem astris, et his inferioribus ab eius latione pendentibus"; la traducción es nuestra. La *Cosmographi*a se publicaría de forma independiente desde 1542 en sucesivas ediciones. El pasaje sobre el Sol-corazón del mundo se omite en la edición de 1542 (3r-v), que suprime también el cap. V ("De generali eorundem coelestium motuum expressione"), 105v, en el que Fine aplicaba la analogía animal/cosmos para conceder a la esfera de las fijas el rango de principio del movimiento cósmico, como el corazón en el animal, sin llegar no obstante a designar explícitamente a la esfera de las fijas como corazón. El ejemplar de esta edición propiedad de Muñoz y profusamente anotado por él (ejemplar conservado en la Biblioteca Nacional de Madrid; véase Navarro Brotons, *Jerónimo Muñoz*, 46, 48), también carece de ese pasaje y de toda anotación de Muñoz relativa a nuestro tema. — Sobre la cosmología de Fine, véase ahora Axworthy, "Oronce Fine and Sacrobosco: From the edition of the 'Tractatus de sphaera' (1516) to the 'Cosmographia' (1532)", 185-264; Ead., *Le Mathématicien renaissant et son savoir. Le statut des mathématiques selon Oronce Fine*. Axworthy aborda el tema de la esfera de las fijas como principio del movimiento (*Le Mathématicien renaissant*, 222 ss.), pero no el pasaje relativo al Sol como "cor mundi".

49 Mizauld, *Aesculapii et Uraniae coniugium*: "rerum omnium corporis pars nobilissima, et principi Soli, ab antiquis coeli cor appellato, tanquam princeps, tacito connubio sociata". Sobre el *Coniugium* véase Hirai, "The New Astral Medicine", 275-279 y Tessicini, "Antoine Mizauld e l'invenzione rinascimentale della cosmologia", 73-92: 78. El paralelismo corazón-Sol trazado por Mizauld suscita la pregunta sobre el posible conocimiento de su tratado por parte de Harvey.

ris")[50] coloca al Sol en el centro como "el corazón de todo el universo", Muñoz afirma que el astrónomo polaco:

> ha osado no tanto renovar la opinión de los pitagóricos, especialmente la de Filolao, como exponerla y realzarla, descuidando las demostraciones de Ptolomeo, por lo que invierte todas la cosas de arriba abajo y, apoyándose en razones probables o retóricas más que en demostraciones, quiere convencer de que es probable que el cielo esté inmóvil y la Tierra se mueva, puesto que el continente es de una condición más noble que el contenido y el movimiento es una afección de cosas imperfectas, por lo cual la inmovilidad se ha de otorgar al cielo continente y la movilidad a la Tierra. Se basa para ello en los dichos de algunos que dicen que la casi inmensa velocidad del cielo hace inmenso el cuerpo del cielo. De ello deduce que cuanto mayor es una cosa tanto menos apta es para el movimiento, pues si se diera un cuerpo infinito, no se movería en absoluto, puesto que el infinito no puede atravesarse. Por tanto, puesto que el cielo es inmenso o vastísimo, no podrá moverse, por lo que el movimiento corresponderá a la Tierra, no al cielo […]. Con estas razones osa establecer una nueva fantasía o sueño.[51]

En opinión de Muñoz, sin embargo, los principios de Copérnico son "locuras o delirios mal pergeñados" y su representación del orden de las esferas del mundo un sueño,[52] mientras que las objeciones que plantea contra los principios de Copérnico bastan, según dice, para mostrar la locura de este hombre: "Haec quae a nobis contra hanc non hypothesim sed insaniam proposita su<nt>, sufficiunt ad prodendum furorem hominis".[53] Es también posible que Muñoz no considere al Sol corazón del mundo geocéntrico y que, vinculándose a Aristóteles, piense que el verdadero corazón del mundo es la esfera de las fijas o

50 *Theonis Alexandrini Commentaria in magnam constructionem Cl. Ptolemaei*, f. 34v. Véase *infra*, Apéndice 1, 104.

51 *Ibid.*, f. 34v-35r; véase *infra*, 104-105. Muñoz expone la argumentación de Copérnico en *De revolutionibus* I, 8, en favor de la inmovilidad de la esfera de las fijas. Cf. Navarro Brotons, *Jerónimo Muñoz,* 119.

52 *Ibid.*, f. 35r: "explicemus adhuc Copernici furores aut delyria male confecta exploremusque qualem ideam ordinis partium mundi somniavit"; *infra*, 105.

53 *Ibid.*, f. 35v; *infra*, 108. En una extensa nota al comentario de Teón al capítulo IX, 1 del *Almagesto*, Muñoz vuelve a calificar de 'locura' (*insania*) la propuesta cosmológica de Copérnico: "Mercurius enim non potest recedere a Sole ultra 27 gradus, Venus vero ultra quadraginta septem, et Venus et Mercurius videntur potius imitari Solem circum ipsum ambulando, quam revolvi super centrum mundi, habentque Sol, Venus Mercurius eundem motum aequalem, ut non immerito alicui videri possit ipsos aeque a Terra distare cum Sole et propterea non esse ponendos orbes. *Quod autem ex hoc colligatur Sol esse in centro mundi insaniae simile potius est quam veritati*", f. 279r (cursiva nuestra).

el *primum mobile*, principio y punto de partida del movimento del cosmos,[54] tanto más cuanto que en la nota que hemos mencionado a su traducción del Comentario a Teón (cap. I, 7 del *Almagesto*) Muñoz muestra su adhesión a la propuesta de Alpetragio (cuyo nombre sin embargo no menciona) de un único movimiento celeste (el diario de oriente a occidente) que se transmite del primer móvil (novena esfera) a la esfera de las fijas y a los planetas, donde se da con un retraso creciente conforme aumenta la distancia a la fuente, retraso que produce la apariencia de un movimiento propio de los planetas en dirección contraria (de occidente a oriente):

> Puesto que los planetas cortan el cielo con una fuerza natural, como los peces el mar o las aves el aire más espeso, de ninguna manera pueden atribuírseles movimientos contrarios, de suerte que se muevan simultáneamente y a la vez hacia oriente con el movimiento propio y hacia occidente con el movimiento del universo, sino que se les debe atribuir un único movimiento, como creemos nosotros, que afirmamos que ellos solo se mueven de oriente a occidente, pero que los ojos se engañan (puesto que los [planetas] más lentos son dejados atrás por los más veloces) juzgando que se mueven de occidente a oriente, mientras que en realidad son dejados atrás por los otros y no se mueven con ese movimiento. Por todo eso pensamos que el más veloz de todos es Saturno y el más lento de todos la Luna, lo cual explicaremos más abundantemente en el siguiente capítulo.[55]

[54] Como parece también haberlo hecho el doctor Francisco López de Villalobos (1473-1549) en su *Libro intitulado Los problemas de Villalobos, que trata de cuerpos naturales y morales; y dos diálogos de medicina*, obra de considerable difusión que Muñoz pudo muy bien conocer y cuya primera edición tuvo lugar en Zamora en 1543, con reediciones en Zaragoza 1544, Sevilla 1550, y que citamos por la edición sevillana de 1574. Allí, en el diálogo titulado "Del calor natural", podemos leer: "Ningun movimiento de cuerpos corruptibles ay en toda la universidad de natura, que assi parezca al movimiento de los cuerpos celestiales [planetas], como es el movimiento del coraçon y de las venas pulsantes. Porque se mueven como el cielo sin cansancio ni pena, y *muevense los pulsos con el movimiento del primer mobile que es el coraçon*", 124v (cursiva nuestra). Nótese que, aplicando la analogía macro-/microcosmos (Villalobos ha afirmado antes, en 109r, "este mundo pequeño que es el hombre"), Villalobos califica al corazón del hombre-microcosmos de *primum mobile*, lo cual permite pensar que el corazón del macrocosmos es el *primum mobile*, esto es, la primera esfera del movimiento diario que impone su movimiento a "los cuerpos celestiales". Véase Rico, *El pequeño mundo del hombre. Varia fortuna de una idea en la cultura española*, 163.

[55] *Theonis Alexandrini Commentaria in magnam constructionem Cl. Ptolemaei*, f. 35v (véase *infra*, Apéndice 1, 109). Muñoz anticipa aquí su defensa del único movimiento planetario, que Ptolomeo había expuesto y criticado en el capítulo I, 8 del *Almagesto* (véase *Ptolemy's Almagest*, 46), crítica que Teón corrobora en su *Comentario*, si bien menciona las formulaciones anteriores de dicha concepción en Grecia, a las que Muñoz se remite también (véase *infra*, n. 56) sin mencionar a Alpetragio. No obstante, en su anotación al capítulo IX, 1 ("De ordine spherarum Solis et Lunae et 5 planetarum", 278v-280r), Muñoz introduce la mención de Alpetragio en

Como termina diciendo Muñoz en esta anotación, su adhesión a la propuesta cosmológico-astronómica de Alpetragio se repite, de forma más ampliada, en su anotación al comentario de Teón a *Almagesto,* I, 8 ("Quod duae differentiae primorum motuum sint in coelo"): ante la difícil concepción de un movimiento simultáneo de los planetas en direcciones contrarias (hacia occidente con el movimiento diario recibido del primer móvil y hacia oriente con su movimiento propio) Muñoz postula un único movimiento celeste (el diario de oriente a occidente) en el que el retraso mayor de los planetas inferiores sobre los superiores se explica por la naturaleza más densa del aire que deben atravesar:

> Entenderás que el movimiento de los planetas se hace de esta manera, si contemplas el cielo diligentemente, sin dejarte llevar por ninguna opinión vulgar. Las razones de Teón no pugnan contra esta hipotesis nuestra, pues nosotros concebimos la eclíptica y los polos de la eclíptica como imaginarios y en modo alguno reales, pues no resultan del movimiento de algún planeta, sino que a partir de los retrasos y retardamientos del Sol con respecto a las estrellas y también de la mutación ya dicha de las declinaciones alcanzamos a concebir la eclíptica, de cuya aceptación resulta después la comprensión de los polos de la eclíptica. A continuación percibí que esta hipótesis que yo había descubierto y que me parecía completamente verdadera era muy parecida a la opinión de los antiguos peripatéticos, según la cual se ha de entender que los planetas son tanto más veloces cuanto más altos son, puesto que tienen menos retrasos. Por eso, entre los planetas Saturno es el más veloz, la Luna la más lenta, pues parece del todo consonante con la naturaleza el que los astros, cuanto más cerca están del centro de la Tierra tanto más pesados y lentos son, ya que la naturaleza del cielo en que se encuentran es más espesa y más densa. Por tanto convendrá concederles un movimiento más lento, pues se ha de conceder a los planetas superiores una mayor velocidad, por encontrarse en un cielo más puro y más tenue y estar colocados más lejos de la sede de los cuerpos más pesados.[56]

conexión con el orden concedido por el autor andalusí a los planetas inferiores: "*Alpetragius autem qui motuum diversitatem et eorum apparentes velocitates incurtatione quadam accidere putabat*, sub Marte Venerem et sub Venere Solem et sub Sole Mercurium collocavit, *quia minus incurtat Venus a motu primo quam Sol* ex parte quidem epicyci, *Mercurius autem plus quam Sol ut ipse ait*", 279v-280r; cursiva nuestra. El *Comentario* de Teón había sido precisamente una de las fuentes de Alpetragio para sus dos principales innovaciones: el movimiento planetario en una sola dirección y la trayectoria "espiral" del mismo, que presentaremos a continuación; véase Al-Biṭrûjî, *De motibus celorum: Critical edition of the Latin Translation of Michael Scot*, 24 s., 40 s., 54. Para una presencia anterior del *Comentario* de Teón (en la *Defensio Theonis* de Regiomontanus contra Trapezuntius) y donde el orden de los planetas es discutido con referencia a Alpetragio, véase Shank, *Regiomontanus* versus *George of Trebizond,* 340 s., 353-356.

56 *Theonis Alexandrini Commentaria in magnam constructionem Cl. Ptolemaei*, 36v; véase Apéndice 2, 114-115. En las líneas anteriores Muñoz ha defendido la concepción de Alpetragio, que él remite (siguiendo a Marciano Capella) a los "antiguos peripatéticos" (f. 36v; *infra*, 115), sos-

Si Muñoz ha sido la fuente de Cedillo para su afirmación de que el Sol es el "corazón de todo el universo", no lo habrá sido seguramente por medio de la lectura del manuscrito sobre Teón, sino más bien por la vía de su enseñanza oral en Salamanca. Creemos altamente probable que en sus lecciones Muñoz expresara ante sus alumnos sus convicciones cosmológicas fundamentales: su rechazo decidido del movimiento de la Tierra y de las esferas sólidas portadoras de los planetas, así como su afirmación de un cielo fluído, consistente en un aire de densidad creciente hacia el interior, y del único movimiento planetario en líneas espirales.[57] Cedillo puede deber también a la enseñanza de Muñoz su adopción del cielo fluido de aire y su rechazo de las esferas celestes.[58] Los *Comentarios de Sphera,* obra manuscrita redactada en 1596-1598 por Diego Pérez de Mesa (1563 ca. 1632), otro discípulo de Muñoz en Salamanca entre 1577 y 1581, muestran la constante presencia y ampliación de las concepciones de Muñoz, en este caso incluyendo también el rechazo del doble movimiento planetario y el movimiento en espiral.[59] Dada la escasa obra impresa del maestro, los discípulos debieron conocer estos puntos por su magisterio oral en Salamanca.

En cualquier caso, Cedillo, copernicano convencido, podía resolver la aporía del doble movimiento de los planetas en direcciones contrarias (tema ampliamente desarrollado por Pérez de Mesa en sus *Comentarios de Sphera*) sin remitirse a la propuesta de Alpetragio, como había hecho su maestro y como hace también Pérez de Mesa con una extensa argumentación, y eliminando el movimiento diario como movimiento universal iniciado

teniendo que en el cielo fluido, donde no hay esferas portadoras de los planetas ni polos fijos del movimiento planetario por la eclíptica, el Sol y los demás planetas se mueven ("cortando el cielo en virtud de una fuerza natural, como los peces el mar y las aves el aire más denso", f. 35v; *infra*, 109) según líneas espirales (*spirae*): "Similiter hoc est intelligendum de motibus aliorum planetarum, quorum spirae diurnae differunt a spiris Solis nam habent latitudinem ab eccliptica. Et spirarum diurnarum eorum poli distant magis a polis mundi quam Solis spirarum", f. 36v; *infra*, 114. Sobre la propuesta de Alpetragio véase Duhem, *Le système du monde. Histoire des doctrines cosmologiques de Platon à Copernic*, vol. II, 146-156, y ahora Samsó, *On Both Sides of the Strait of Gibraltar*, 530-544. Sabido es que la concepción de Alpetragio encuentra en este momento y hasta entrado el siglo XVII seguidores entre filósofos naturales (Telesio, Campanella, Bacon) que veían inconcebible el movimiento planetario en direcciones opuestas. En España, esta concepción encontró un entusiasta defensor en la obra manuscrita *Comentarios de Sphera*, escrita entre 1596 y 1598 por el discípulo de Muñoz Diego Pérez de Mesa, sucesor de Muñoz en la cátedra de Salamanca. Pérez de Mesa renunció sin embargo a la cátedra de Salamanca para mantenerse en su cátedra en la universidad de Alcalá, de donde pasó a Sevilla.

57 Para la introducción por Teón del movimiento en espiral de los planetas en su comentario a Almagesto, I, 8, véase *Commentaire de Théon d'Alexandrie, sur le premier livre de la Composition mathématique de Ptolemée*, 98-100.

58 Véase Cedillo Diaz, *Ydea astronomica*, 180.

59 Pérez de Mesa, *Comentarios de Sphera*, MS 8882 en Biblioteca Nacional de España. Estudiamos esta obra en el marco de un trabajo en curso sobre la recepción de Copérnico en la España del siglo XVI.

en el "corazón del mundo" o *primum mobile*. En el heliocentrismo este movimiento es atribuido al planeta Tierra, con el resultado de que, en el mundo y entre los puntos fijos del Sol central y de la esfera de las fijas, no hay otro movimiento que el de los planetas de occidente a oriente, con periodos de revolución proporcionales a su distancia con respecto al verdadero "corazón", esto es, al Sol.[60]

No obstante, hemos de reconocer que, dada la gran difusión del motivo "Sol cor mundi", Cedillo podía haberlo encontrado también en otras fuentes, por ejemplo en Peurbach (cuyas *Theoricae novae* conocía muy bien) y en el Comentario de Cristóbal Clavio a la *Sphaera* de Sacrobosco, una obra conocida por él, como muestra la *Ydea*. En la edición de 1581, tenida presente en la *Ydea*, podemos leer: "El Sol es rey y casi corazón de todos los planetas, por lo que no sin razón está puesto en medio de todos ellos, igual que el rey está colocado en medio de su reino y el corazón en el centro del animal".[61]

En suma: es posible que el motivo del "Sol corazón del mundo" haya llegado a Cedillo por diferentes vías encontradas en la tradición astronómica y cosmológica (sin excluir a Kepler, que ciertamente no podía ser mentado en la *Ydea*), así como en la literatura,[62]

60 Véase Granada, "Aristotle, Copernicus, Bruno".

61 Clavius, *In Sphaeram Ioannis de Sacrobosco commentarius*, 68: "Sol est rex, et quasi cor omnium planetarum, quare non immerito in medio illorum constituetur, quemadmodum rex in medio regni, et cor in medio animalis collocatur". En esa misma página Clavius se hace eco del pasaje de Peurbach (*supra* n. 46) sobre la dependencia de los planetas con respecto al Sol: "motus Solis est regula, et mensura motuum aliorum planetarum, alia tamen atque alia ratione, Mars etenim, Iuppiter, et Saturnus ratione epicycli cum Sole in motu conveniunt: Luna vero, Mercurius, et Venus in deferentibus orbibus motui Solis conformantur, ut in Theoricis planetarum explicatur". Véase Westman, *The Copernican Question: Prognostication, Skepticism, and Celestial Order*, 209-213. — Sobre el conocimiento de esta edición del Comentario de Clavio por parte de Cedillo, véase Cedillo Diaz, *Ydea astronomica*, 145.

62 En su *Cronología y reportorio de la razón de los tiempos* Rodrigo Zamorano (1542-1620), Catedrático de Cosmografía y navegación en la Casa de Contratación, se hace eco de este lugar intermedio del Sol entre los planetas, si bien no registra su función de corazón: "Su lugar en el Cielo es el quarto, en medio de todos los planetas, como Rei sabio, que con su sentido mantiene su reino, y consideradamente, en medio del haze su asiento, para bien le governar, y que llegue su virtud a todas partes", 51r en la edición de Sevilla 1594. Aunque posterior a la muerte de Cedillo (1625), *La Dorotea* de Lope de Vega, impresa en 1632, se hace eco, de esta concepción tradicional, que debía tener amplia circulación: "Como el sol, corazón del mundo, con su movimiento circular forma la luz, y ella se difunde a las cosas inferiores, así mi corazón, con perpetuo movimiento, agitando la sangre, tales espíritus derrama a todo el sujeto, que salen como centellas a los ojos, como suspiros a la boca y amorosos concetos a la lengua", Lope de Vega, *La Dorotea*, III, 7, 284 s. El dramaturgo traducía sin embargo literalmente a Ficino, *Commentarium in Convivium Platonis, De amore*, VII, 4: "Atque etiam sicut cor mundi Sol suo circuitu lumen perque lumen virtutes suas ad inferiora demictit, sic corporis nostri cor motu suo quodam perpetuo proximum sibi sanguinem agitans, ex eo spiritus in totum corpus perque illos luminum scintillas per membra diffundit quidem singula, per oculos autem maxime".

para fijar en él la idea del Sol "corazón del mundo", voces o ecos escritos que pudieron unirse a la fuerza y el vigor del magisterio oral del maestro. Pero el motivo "Sol corazón del mundo" en clave copernicana solo podía provenir (excluyendo a Kepler) del magisterio oral de Muñoz. Si este no podía concebir que el Sol copernicano pudiera ser el "corazón de todo el universo" – lo sería si tal hipótesis no fuera una "locura" o un "sueño" – Cedillo lo afirma positiva y rotundamente: la atribución a la Tierra del movimiento diario y anual del Sol (en ambos casos de occidente a oriente), salva la dificultad del doble movimiento planetario sin caer en el *cul de sac* de Alpetragio.

Sea como sea, creemos que la posibilidad de una inspiración en Muñoz añade una razón más al interés de la publicación de esas notas relativas a Copérnico y al movimiento unidireccional de los planetas en la traducción latina comentada del Comentario de Teón de Alejandría al *Almagesto*, donde se constataba la osadía del "loco" astrónomo polaco de poner al Sol en el centro como el "corazón de todo el universo".

APÉNDICE

Jerónimo Muñoz, *Traducción y Comentario a Teón de Alejandría*[63]

Biblioteca Nazionale di Napoli, MS VIII C 33.

1. Excurso de Muñoz a Almagesto, I, 7: "Quod nullum motum progressivum habeat Terra", ff. 34v-35v.[64]

[**f. 34v**] [marg.: Interpres] Post Ptolemeum et Theonem acrimoniae ingenii viros incredibilis paulo ante nostra tempora extitit Nicolaus Copernicus mathematicus non vulgaris qui Pythagoreorum sententiam praesertim Philolai non tam renovare quam exponere et illustrare neglectis demonstrationibus Ptolemei est ausus, hic susque deque omnia invertit, et probabilibus rationibus aut rhetoricis potius quam demonstrationibus nixus celum quiescere Terramque moveri probabile esse vult persuadere, quod continens contento nobilioris sit conditionis, motusque sit affectio rerum imperfectarum, quare immobilitas coelo continenti mobilitasque Terrae est conferenda, occasionemque arripiens ex dictis quorundam dicentium celi velocitatem quasi immensam corpus celi immensum prodere. Hinc colligit quanto maior res est tanto ad motum minus idonea, nam si infinitum corpus daretur nullo modo moveretur, infinitum enim pertransiri non potest. Cum itaque celum sit immensum aut vastissimum moveri non poterit.[65] Quare motus Terrae erit non celi, nec est [**f. 35r**] quod obiiciantur phenomena quibus celum moveri demonstratur, ait enim deludi oculos, illud Vergilianum Aeneae dictum obiiciens, provehimur portu, terraeque urbesque recedunt.[66] Quoniam fluitante sub tranquilitate navigio cuncta quae extrinsecus sunt ad motus illius imaginem moveri cernuntur a navigantibus ac vicissim se quie<sce>re putant cum omnibus quae secum sunt. His rationibus audet novam quandam phanta-

[63] Agradecemos a Víctor Navarro Brotons el habernos facilitado una primera reproducción de las páginas del Comentario de Muñoz y a la Biblioteca Nacional de Nápoles su amabilidad y generosidad al procurarnos una copia digitalizada del entero manuscrito. Nuestro profundo agradecimiento va también a Concetta Luna, por su gran ayuda en la transcripción, que nos ha permitido corregir numerosos errores. El manuscrito es de difícil lectura, tanto por la poca claridad de la letra como por la frecuente difuminación de la tinta y la ocultación de palabras por causa de la encuadernación. Por todo ello es posible que todavía resten algunos errores, de los cuales somos los únicos responsables.

[64] Para el texto del Comentario de Teón véase *Commentaire de Théon d'Alexandrie*, 83-95.

[65] Cf. Copernicus, *De revolutionibus*. I, 8, 5v-6r.

[66] *Ibid*., 6r, donde Copérnico cita Virgilio, *Eneida*, III, 72.

siam aut somnium stabilire. Ceterum suam explicans opinionem non adimit celo prorsus motum sed tantum Soli quem in [in] mundi centro immobilem collocat tanquam totius uniuersi cor unde ex aequo per totum orbem vis quedam alma et vivifica impertiatur.[67] Reliquas uero om<n>es tam inerrantes quam errantes stellas (in quarum numero Terram etsi obscurum et tenebricosum astrum[68] collocat in quarto celo) moveri arbitratur, quae secum pugnant, nam si continenti immobilitas convenit contento vero mobilitas, cum Sol contineatur in centro mundi, proculdubio mobilis erit, atque celum terreum centrum proprium continens immobile erit, deinde cur potius Soli quam aliis astris debuit immobilitas conferri <?>[69] Nonne aliorum astrorum viribus regitur et vivif<ic>atur mundus et varia fiunt viventium genera in mundo, an alia omnia sunt imperfecta et eiusdem conditionis et temperamenti cum Terra? ut illa cum Terra aequentur participantia quidem ignobilitatis et imperfectionis quam prodit mobilitas.[70] Caeterum explicemus adhuc Copernici furores aut delyria male confecta exploremusque qualem ideam ordinis partium mundi somniavit. Vides centrum mundi Solem, et Terram centrum esse cuiusdam epicycli in quo [marg.: ca. 3, lib. 4 revolutionum][71] alius vehatur et in hoc movet Lunam ut phenomena de apparentibus Lunae inaequalibus magnitudinibus serventur. Nam posita hypothesi Ptolemaei de eccentricepicy<c>lis dicit si maxima distantia Lunae a Terra sit 64 semidiametrorum Terrae cum sextante, minima vero sit 33 semid. 33 m. fere duplo maiorem in minima distantia apparituram Lunam[72] et proinde fingit hos duos epicyclos ex ignorantia 9 proposit. Optices Euclid<is>.[73] Non enim proportionaliter distantiis rerum magnitudines apparentes augentur. [Marg.: Refutatio opinionis] Aut enim Terra revolvitur solum, aut convertitur. Si sola sit revolutio pars Terrae Solem aspiciens semper aspiceret illique semper esset dies, alteri vero parti minori scilicet semper esset nox. Si vero revolvatur et

67 *Ibid.*, I, 10, 9v.

68 En esta calificación de la Tierra, tendente a cuestionar la pertinencia del estatuto que le había otorgado Copérnico, Muñoz coincide sin embargo con el copernicano Thomas Digges, quien en su *A Perfit description* (1576) señalaba la inferioridad cosmológica y ontológica de la Tierra a pesar de su carácter de planeta. Véase Johnson, Larkey, "Thomas Digges, the Copernican System, and the Idea of the Infinity of the Universe in 1576", 81 la epístola al lector: "In the midst of this Globe of Mortalitie hangeth this darck starre or ball of earth and water".

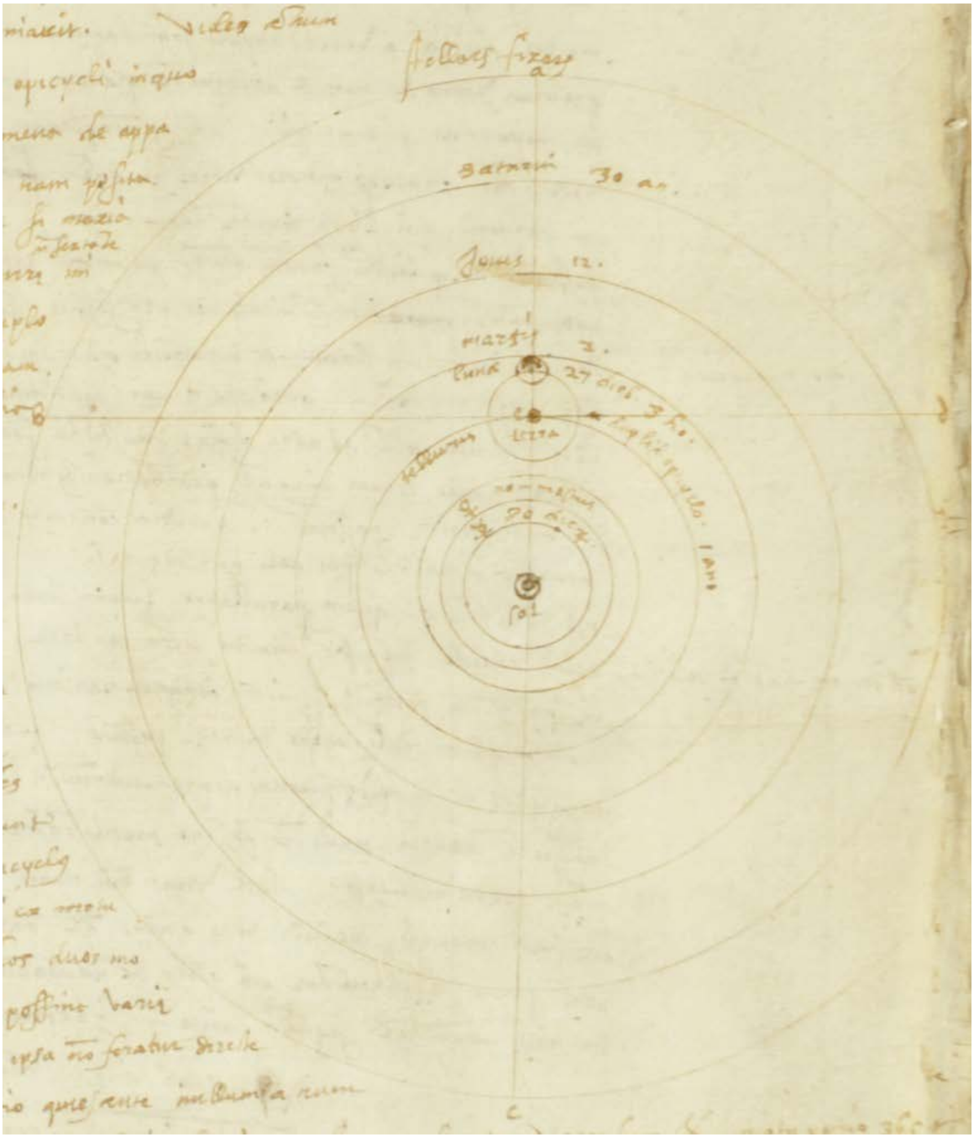
69 Añadimos el signo de interrogación, claramente presupuesto, para hacer más claro el razonamiento de Muñoz.

70 Muñoz interpreta la innovación de Copérnico como implicando la homogeneización de los planetas y la Tierra, contra la tradicional jerarquía, que él todavía acepta y que hace a la Tierra objeto de la influencia celeste y por tanto de la disciplina astrológica.

71 Copernicus, *De revolutionibus*, IV, 3, 100v.

72 *Ibid.*, IV, 2, 100r. Estos valores proceden de Ptolomeo; cf. *Almagesto*, V, 17, en *Ptolemy's Almagest*, 259.

73 *Euclidis Optica et Catoptrica e Graeco versa per Ioannem Penam,* 11 s. Cf. la traducción castellana: *La perspectiva y especularia de Euclides,* 10v.



convertatur necessario duos habebit motus, qui unico deferente explicari nequeunt. Deferentes enim solum planetas revolvunt epicycli vero convertunt quare preter deferentem tribuendus erat Terrae epicyclus ut dierum et noctium ratio quae in tali hypothesi ex motu conversionis explicanda erat servaretur.[74] Praeter hos duos motus alius secundum declina-

[74] Muñoz no acepta que la rotación de la Tierra pueda efectuarse con el solo giro sobre su eje y

tionem ab aequatore ei referendus erit, ut possint variae planetarum latitudines mota terra percipi, nam si ipsa non feratur directe sub eccliptice plano proculdubio Sole in mundi medio quiescente nullum astrum ecclipticam demonstrabit, quare movebitur motu primi mobilis spatio 24. horarum ab ortu ad occasum, et motu proprio 365 diebus et fere quadra<n>te ut facta Terra haerede motionum Solis possint phenomena servari. Positis tot in Terra motibus nullo modo percipi potest qui fient dies aequales noctibus, et qui dies maiores et qui minores, et quomodo crescant aut decrescant, mota enim Terra movendus est eodem motu horizon et totidem motibus quot movebitur Terra, totidem etiam horizon. Ex solo motu revolutionis non possunt dies artificiales concipi quia semper eadem Terrae facies aut Solem aspicit aut nullo modo videt. Reliquum est ut motu conversionis seu versationis dies artificiales fiant.[75] Quare hic motus versationis erit diurnus Terrae, singulis itaque diebus unam conversionem faciet quae propriae naturae ipsius non aut<em> primo mobili erit conferenda, nam primum mobile volvit omnes planetas non autem versat. Quoniam autem Sol centuplo septuagentuplo Terra maior est, necessario longe maior pars medietate corporis Terrae illuminabitur eritque Terre segmentum a Sole illustratum arcus Terrae diurnus, reliquus vero non illuminatus nocturnus, dies itaque perpetuo esse<nt> nocte longe maiores qua ratione segmentum illuminatum obscuro maius est et hoc ubique gentium fieret essetque in toto orbe perpetuo dies illa ratione nocte maior. Nam Sole stante et Terra aequaliter a Sole distante ut ex diagrammate constat,[76] semper manet eadem ratio arcus Terrae illuminati ad arcum Terrae non illuminatum. Quod si a spatio celi supra aut infra horizontem quantitates definias ita ut segmentum celi in quo Sol existit supra horizontem diem efficiat, reliquuum noctem, pari ratione dies essent ubique gentium omni tempore aequales et nocte longe maiores nam maior arcus semper est *bcd* quam *dab*, quare nulla ratione poterit ratio inaequalitatis dierum <servari> Sole stante in centro mundi ratione variarum partium zodiaci, neque ratione altitudinis poli iidem enim dies artificiales quanto altior est polus mundi tanto sunt maiores quam ubi polus humilior est, quia iuxta hanc hypothesim non potest altitudo cuiusque regionis stata et immobilis manere sed subinde [**f. 35v**] toto die mutarentur poli altitudines, quia quolibet die uterque polus videbitur ut manifeste patet ex circumlatione Terrae non collocatus, non

postula la necesidad de un epiciclo sobre el que la Tierra exponga al Sol sucesivamente sus dos hemisferios oriental y occidental.

75 El giro de la *conversio* o *versatio* efectuado por el epiciclo daría cuenta de la alternancia de día y noche y de la diferente duración del día.

76 Muñoz interpreta que el diagrama de Copérnico concede a la Tierra una distancia siempre idéntica al Sol en tanto que se mueve sobre una concéntrica. No toma en cuenta la téorica del Sol expuesta en *De revolutionibus*, III, especialmente cap. 15, donde Copérnico señala que la traslación por una excéntrica (por él adoptada) es equivalente a la combinación de epiciclo sobre concéntrica, siempre que la excentricidad sea igual al radio del epiciclo. Véase *Sobre las revoluciones*, 293 y Navarro Brotons, *Jerónimo Muñoz,* 123.

manente enim Terra neque rationes umbrarum constarent, nec differentia esset amphisciorum et heterosciorum et perisciorum, haec enim non possunt considerari nisi cuique regioni peculiaris altitudo poli perpetuo conveniat immutabilis.

Preterea patet ex diagrammate Sole a Terra aequaliter distante, Terra aequaliter moveretur, et inaequalitatis apparentis in motu diurno Solis, qui tunc Terrae conveniret, non posset reddi ratio, quae sumitur ex excentricitate aut ab epicyclo, nam Terra tunc hyeme velocius movenda, estate vero tardius foret alioqui nulla existente inaequalitate distantiae toto an<n>o Solis a Terra, ab aequinoctio verno ad solstitium et ab hoc ad aequinoctium autumnale, et ab hoc ad brumam, et ab hac ad aequinoctium vernum aequalis esset dierum numerus quod <fal>sum phenomena esse demonstrant. Iuxta hanc hypothesim nunquam celum in duo aequalia ab horizonte secaretur nec medietas celi semper appareret cuius contrarium superius est demonstratum.

Deinde Venus et Mercurius non possent unquam nisi de die videri nam arcus nocturnus definitur ab horizonte sic ut quum Sol existit sub horizonte fit nox quod si supra dies. Horizon uero iuxta hanc hypothesim semper moveretur et Venerem relinqueret in segmento in quo Sol existit, non autem in segmento in quo fit nox, nam semper inter Solem et Terram comprehendentur eorum corpora et horizon superior illis esset. Horizon enim accipitur ducta a vertice capitis semidiametro mundi linea secans semidiametrum mundi ad rectos ang<u>los Terram contingens. Preterea Venus et Mars et reliqui omnes planete semper a Sole aequaliter distarent semidiametris scilicet suorum circulorum quae res valde repugnat phenomenis. Ad haec omnes planete cum essent oppositi Terrae plusquam triplo minores quam cum essent Terrae proximi viderentur tantoque minores viderentur quanto Terra essent superiores cum haec phenomena non sint adeo differentia in omnibus sed in Mercurio qui seipso interdum longe maior. Haec quae a nobis contra hanc non hypothesim sed insaniam proposita sunt, sufficiunt ad prodendum furorem hominis, ut nititur expendere loca aeris et ignis, et accidentia Lunae et multa alia contraria rebus naturalibus quae in celo sunt non solvit sed involvit, nec respondet sed subterfugit.

[Marg.: Opinio interpretis]. Mea opinione celum statum et immobile est collocandum, Terra vero pariter immobilis, planetae vero et stellae moventur <non> autem corpus celeste. Ambiens enim aer continuus est expanditurque per totum celum donec sua tenuitate deficiens mundum terminet.[77] Nec celum ab aere differt substantia sed tenuitate seu raritate, quo enim superior est eo tenuior et rarior et transparentior. Ideo celum minus est perturbationibus obnoxium quod tenuius sit, verum suboriente aliqua siderum vi perturbatur, non ut aer inferior crassescit. Incendia cometarum id demonstrant, incenso enim celo ex

77 Véase la descripción de este pasaje final en Navarro Brotons, *Jerónimo Muñoz*, 124. Muñoz postula un cielo fluído de aire y elimina, como dice a continuación, las esferas sólidas e impenetrables de éter. Sobre este motivo, expresado ya en el *Libro del nuevo cometa*, publicado en 1573, y en el inédito comentario al libro segundo de la *Historia natural* de Plinio, véase también Granada, "'Como peces por el agua'": Jerónimo Muñoz y la eliminación de las esferas celestes".

collustrationibus seu concursibus radiorum planetarum incrassata prius celi parte in qua lumina planetarum coeunt, celum incenditur et fit cometa qui ut planetae variis motibus est obnoxius, quem parallaxes supra lunam fieri in celo demonstrant quo argumento nihil certius ad demonstrandum celum calido, frigido, humido sicco constare. [marg.: Quod cometae fiant in celo libro a me scripto demonstro.][78] Tanta celi raritas et tenuitas commenta orbium astrologicorum et philosophorum non patitur. Qui enim in tanta raritate tam absoluta orbium rotunditas perstare poterit, quum in aere hoc crasso non momento quidem tales orbes durare possent <?> Quare puto orbes confictos quod non posset aliter ab eis[79] reddi ratio diversorum motuum quos in singulis planetis deprehenderunt.[80] Quum planetis naturali vi celum secantibus, ut piscibus mare et avibus crassiorem aerem,[81] nullo modo possent motus contrarii conferri ut simul et semel moveantur ad ortum proprio motu, et ad occasum motu universi. Sed unus tantum debet tribui motus, ut nos existimamus asserentes eos solum ab ortu ad occasum moveri, deludi vero oculos, quod tardiores relinquuntur a velocioribus, iudicantes ipsos ab occasu ad ortum moveri quum relinquantur ab aliis et non moveantur tali motu, unde censemus omnium velocissimum Saturnum tardissimam omnium Lunam,[82] quod sequenti capite fusius explicabimus.[83]

2. Excurso de Muñoz a I, 8 ("Quod duae differentiae primarum motionum sint in celo"), ff. 35v-37r.[84]

[**f. 36r**] [Marg.: Interpres] Perspectae a me Theonis rationes quibus adversatur asserentibus tantum esse unicum motum nempe ab ortu ad occasum nec planetas moveri ab occasu ad ortum sed relinqui a tergo stellarum, nihil nostrae opinioni adversantur enervaeque sunt et nihil concludentes, contra eos vero qui unicum motum ab ortu in occasum solum in celo collocant recipiuntque preter octavam septem alias spheras distinctas quae super

78 Parece una referencia al *Libro del nuevo cometa*, en el que Muñoz demuestra que la nova de Casiopea, aparecida en noviembre de 1572 e interpretada como un cometa inmóvil, estaba situada en la esfera de las fijas, dada su total ausencia de paralaje.

79 Por los astrónomos (los astrólogos y filósofos mencionados antes).

80 Muñoz interpreta las esferas celestes como recursos astronómicos forjados para dar cuenta o "salvar" los movimientos de los planetas.

81 Igual que en otras obras, Muñoz asume aquí la proverbial expresión procedente de los padres de la Iglesia.

82 Muñoz asume el planteamiento de Alpetragio, que consideraba el presunto movimiento propio de los planetas una ilusión óptica causada por el retraso progresivo con el que los planetas cumplen su único movimiento, el diario.

83 *Almagesto*, I, 8: "Que en los cielos hay dos movimientos primarios diferentes". Véase a continuación el Apéndice 2.

84 Véase la descripción de este excurso de Muñoz en Navarro Brotons, *Jerónimo Muñoz*, 125-127. Para el texto del Comentario de Teón véase *Commentaire de Théon d'Alexandrie*, 96-108.

aliis polis quam aequatoris nempe zodiaci circumvertantur,[85] efficaces sunt rationes Theonis. Nam si planete et Sol et Luna ab ortu solum ad occasum moverentur diurno motu super polis zodiaci non autem super polis aequatoris, necessarium est ut quantum polus mundi a polo zodiaci distat, distet tantum eccliptica ab aequatore, et paralleli ecclipticae cum parallelis equatoris consimilibus aequales angulos efficiant, feraturque Sol semper aut per ecclipticam, ut illi contra quos disputabat Theon, aut per parallelos ecclipticae. Quocumque modo fieri dicatur, in utraque sphaera tam recta quam obliqua quando Sol erit in principio Arietis et Libre solum accidet, ut careat ortus amplitudine, id est habeat aequinoctialem exortum et aequinoctialem occasum. Extra haec duo puncta, si Sol habet exortum ab aequatore versus austrum, habebit eodem die occasum ab aequatore versus septentrionem atque ita fiet toto anno preterquam duobus anni diebus, quod falsum esse phenomena produnt. Nam si Sol habet amplitudinem ortus septentrionalem eodem die habebit amplitudinem occasus septentrionalem, si australem ortum, occasum etiam australem habebit. Si autem planete praeter motus cuique peculiares ab ortu ad occasum qui omnes sint tardiores motu stellarum (qui 24 horis partiliter fit), qui motus fieri dicantur super polis zodiaci, quod in illa retardatione quotidiana retardationis arcus non sit parallelus aequatori, sed per extremarum retardationum puncta, unum scilicet borealissimum alterum vero australissimum, circulus transiens polos habeat zodiaci, singulis planetis duobus motibus ab ortu ad occasum uno ratione universi, altero proprio motis, etsi in spheris ferantur et super polis zodiaci moveantur modo explicato non video quin circulis quasi aequatori parallelis lati habeant exortum unius diei similem (idest ad eandem mundi partem) occasui. Nam si dum proprio motu supposito ab occasu ad ortum super polis zodiaci facto, possunt moveri super polis mundi in contrariam simul partem describentes circulos quasi parallelos cum aequatore, cur non etiam ab ortu ad occasum super polis mundi et per zodiacum simul motu declinationis lati poterunt simul et semel duobus motibus non contrar<i>is quasi parallelos circulos cum aequatore describere <?>[86] Verbi gratia sit Sol

[85] Como se verá más adelante, Muñoz se refiere a los que postulan la existencia de esferas sólidas transportadoras de los planetas.

[86] Un añadido a estas líneas redactado al margen afirma de nuevo el único movimiento planetario de oriente a occidente mediante una crítica a Jorge Trapezuntius: "Trapezuntius in libello Cur astrologorum Judicia sepe falsa sint arguit contra ponentes verum motum in celo, scilicet ab ortu in occasum et eos relinqui ab stellis. Ait enim sensu deprehenditur falsa haec opinio, nam si Lunam precedere ad aliquam fixam observabis sequenti nocte aut propinquiorem ex eadem parte ipsi fixae quam antea videbis aut transgressam iam et propinquiorem ortui cernes, quod fieri motu relictionis minime potest. Contra vero si occasui precedente nocte Luna fuerit propinquior quam fixa, multo magis propinquior futura esset eidem occasui nocte sequenti, si ad occasum proprio motu properetur. Unde miror cur Leo Judeus hanc opinionem sequutus multa evomere in Ptolemeum et veritatem tam apertam non erubuit [*Cur Astrologorum iudicia ut plurimum sint falsa*, editado por Luca Gaurico en un volumen misceláneo que recogía en primer lugar y entre otras obras, el *De nativitatibus et interrogationibus* de Omar (Umar ibn al-Farrukhan

in initio Arietis qui si quiesceret, solum motum primae lationis haberet, moveatur itaque ab ortu versus occasum pariter cum prima latione 359 partibus, sed recedens ab aequatore versus aquilonem 24 m. primo die et reliquis diebus pro ratione augmentatae declinationis ad aquilonem accedat, unde rursum incipiant simili ratione qua creverunt decrescere declinationes, nonne Sol ab ortu ad occasum movebitur motu illo dum crescet longitudo declinatio vero perpetuo mutabitur et circulis quasi aequatori parallelis movebitur et servabuntur phenomena <?>.

Verum enimvero, mea quidem opinio delet potius illos motus contrarios quasi nulla ratione intelligi queant, spherarum multitudine prorsus sublata ut quae in tanta caeli rarita[ta]te et transparentia diutius durare nequeat. Quod autem nequeat percipi motuum illa contrarietas et diversorum polorum commentum ita ut motus aliquis super illos diurnus fiat diversus a motu universi hinc ostenditur spherae seu orbes celestes absolutissima sphericitate undique prediti concipiuntur ita ut superior orbis inferiorem undique solum tangat nec in tangentibus superficiebus, una cava superioris, altera convexa inferioris, aliquid offendendum concipitur quo motus ipsarum spherarum interpelletur. Praeterea cuique spherae peculiaris motus naturalis tribuitur, sive ille sit a sphere propria natura circa naturalem <locum> ut gravium est ad medium et levium a medio, aut ut aliis [**f. 36v**] peripateticis scilicet ab intelligentiis motricibus videtur spheris motus inesse. Quocunque modo sit, quum idem qua idem semper natum sit facere idem,[87] si peculiaris inesset motus cuique spherae, quum sit perfecte rotunda et in sese habeat motus principium, ipsa proprio motu solum agitabitur nec a superiore in contrariam partem trahetur cum nulla re alia connectatur cum superiore nisi quod ab ea prorsus continetur. Nam motis nobis motu recto, verum est omnia moveri a nobis. Si vero circulare aut sphericum sit corpus vacuum intra quod aliud sphericum concipiatur non est necessarium ut eodem motu circulari cum superiori corpore moveatur in superiori contentum, potest enim quiescere si quiescendi

al-Tabari, también conocido como Omar Tiberiades; fl. 762-812), Venecia, 1525; el opúsculo de Trapezuntius en 23r-25v]. Nos [Muñoz] defendentes veritatem respondemus argumentum Trapezuntii nullius esse momenti, quia concipit Lunam esse velociorem stellis, cum secundum hanc opinionem ponatur Luna omnium corporum celestium tardissima et ita relinquitur a stellis precurrentibus ei semper versus occasum, ipsa relicta ad ortum". El Leo Judeus con que termina el pasaje de Trapezuntius es Levi ben Gerson (1288-1344); véase *Collectanea Trapezuntiana: Texts, Documents, and Bibliographies of George of Trebizond*, 695-697, 678, 681 s. La atribución que hace Trapezuntius a Levi ben Gerson de haber defendido el único movimiento unidireccional de los planetas es errónea. Sobre la astronomía de Levi ben Gerson, véase Duhem, *Le système du monde*, vol. V, 201-213 y Goldstein, "The Physical Astronomy of Levi ben Gerson", 1-31. Sobre las ediciones de Omar Tiberiades véase Hasse, *Success and Suppression. Arabic Sciences and Philosophy in the Renaissance*, 396 s.

87 Cita de Aristóteles. Cf. Hamesse, *Les Auctoritates Aristotelis. Un florilège médiéval. Étude historique et édition critique*, 170, ref. 43: "Idem manens idem semper aptum natum est facere idem" = *De generatione et corruptione*, II, 10, 336a 27-28. Agradecemos a Concetta Luna la referencia.

habet naturam et motu similiter contrario agitari si talem habeat naturam nec necessarium erit ut duobus motibus contrariis agitetur, quod si superior sphera motu recto moveretur proculdubio traheret aliam spheram eodem motu, quod si superior sphera quia inferiores continet necessario omnes motu diurno 24 horarum circumferet, dicatur necesse esse minimam et infimam spheram, quia ab omnibus superioribus continetur preter eius motum peculiarem totidem motibus movendam quot sunt superiores ambientes, atque ita fiet de aliis spheris supra minimam, cuius contrarium phenomena ostendunt. Solum enim apparet motus 24 horarum et motus planetarum qui omnes salvantur necessarie multiplicatis spheris. Polorum zodiaci commentum ita evertitur. Si planetae super polis zodiaci moverentur, semper eandem latitudinem ab eccliptica servarent. Hoc enim est peculiare rei motae super aliquos polos, scilicet ut planum eius rei motae aequaliter undique distet a polis super talium polorum axem ad angulos rectos incidens. Quoniam autem planetarum latitudines subinde mutantur, nullum habebunt planum super quod moveantur, sed spirales efficient lineas non autem plana.[88] Quare non fiet proprie motus ille super polis zodiaci.

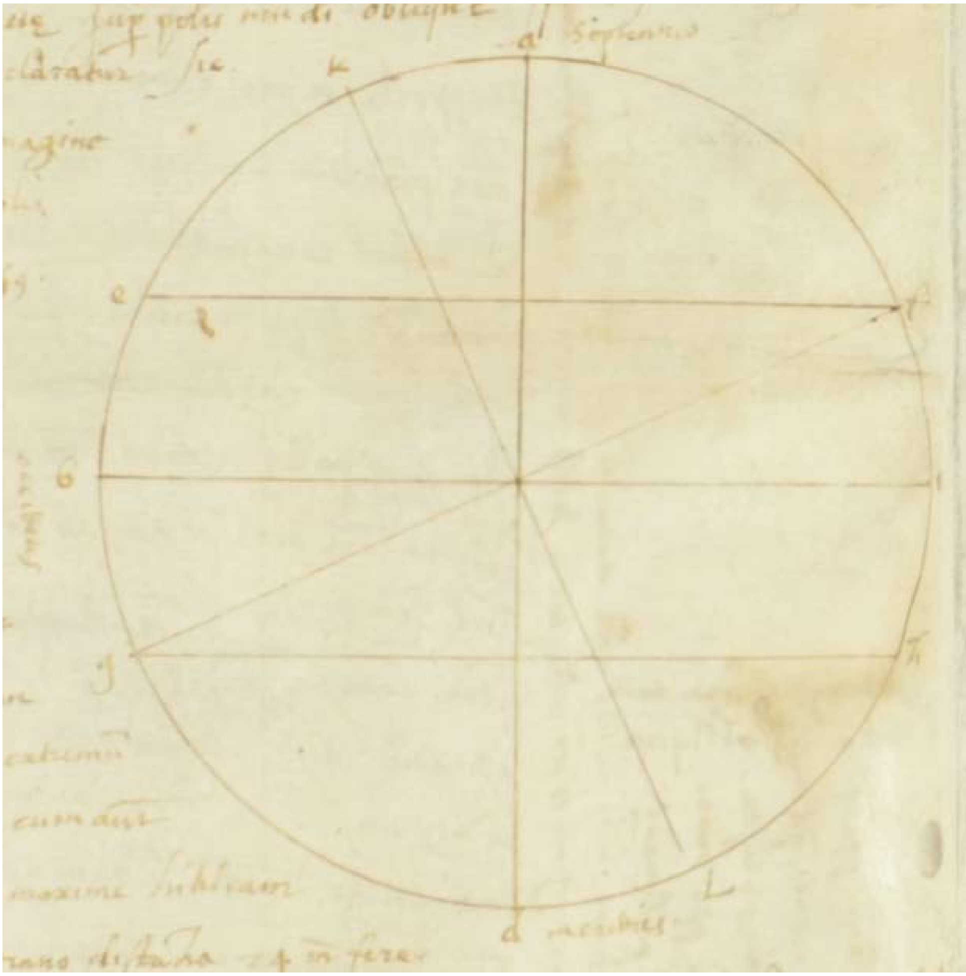
[88] Según la astronomía ptolemaica el Sol no vuelve en su movimiento diario exactamente al mismo punto del día anterior, sino que, como consecuencia del movimiento propio anual en dirección contraria, pierde un poco más de un grado; en la concepción alpetragiana de un único movimiento, el Sol se retrasa esa cantidad cada día, por lo que en 24 horas no regresa al mismo punto, sino que se queda algo retrasado hacia occidente. Además, según Muñoz, el Sol (los demás planetas también, con sus respectivos retrasos) no se mueve siempre por el mismo círculo, sino que sus polos (imaginarios) varían en latitudes que, a lo largo del año, oscilan progresivamente entre los equinoccios y los trópicos. Esa trayectoria recibe el nombre de *spira* para indicar la constante oscilación de sus polos en consonanacia con la variación de la declinación del Sol. El concepto de *spira* y el sentido de lo que Muñoz expone a continuación lo aclara el siguiente pasaje del *Comentario a Plinio*: "Planetarum vero lationes non sunt perfecte orbiculares sed spirales, nunquam enim circulum claudunt in mundi latera idest polos accedentes ob latitudines 6 planetarum et declinationes omnium propriis motibus, tantum ab ortu ad occasum motis super nullis polis; quippequi circulos non efficiant sed spiras, quarum spirarum poli sunt diversi. [...] De his rebus firmis demonstrationibus, non autem verbosis disputationibus, egimus loco citato, quales ignorant mathematicarum imperiti", 344 s. Véase también lo que dice Juan Pérez de Moya (ca. 1514-1597) en su obra *Tratado de cosas de Astronomía, y Cosmografía, y Philosophia Natural*, libro I, cap. 1, art. 21, 20: "Spira, es la buelta que el Sol da cada dia rodeando el mundo segun el movimiento rapto, que el primer mobil le haze hazer, las quales bueltas por razon del proprio movimiento del Sol son varias, unas subiendo desde la Equinoctial hasta el un Tropico, y bolviendolas a deshazer desde el Tropico a la Equinoctial. De suerte que partiendo el Sol de uno de los puntos de los Equinoctios, arrebatado despues con el movimiento del primer mobil en cada un dia descrive una linea, que en rigor no se dira circulo sino spira, pues no buelve ni acaba perfetamente en el punto mismo que començo, y do partio, todavia el uso comun ha usurpado que se llamasse Circulo, o Parallelo, aunque como avemos dicho no lo sea, porque son a manera de las bueltas que la cuerda que los muchachos arrodean al trompo da para hacelle andar. Destas bueltas, la mas ultima que el Sol haze a la parte del Norte es la del Tropico de Cancro, donde en llegando se buelve deshaziendolas hasta llegar a la Equinoctial, y

Sol etiam non facit ecclipticam quo modo docet Theon, nam cum declinationes maximae Solis mutentur, mutabitur etiam eccliptica quae fit ducto circulo per maximas declinationes Solis, quare non est iter Solis anniversarium sed ostenditur per motus Solis secundum declinationem, ducto circulo ab situ Solis borealissimo ad situm Solis australissimum in consequentia, qui circulus mutatur pro ratione motus Solis secundum declinationem unde fit ut eccliptica mutetur, cuius principium Aries non est octavae spherae constellatio ut nec alia signa eiusdem constellationis, sed eccliptica describitur solo conceptu, nempe ex aequinoctiis et solstitiis, nam quo momento dies est aequalis nocti et subinde crescit est initium Arietis et Sol in initio Arietis dicitur existere, quia tunc Sol existit in prima stella ex duabus cornuum Arietis, nempe antecedente, sed eam jam nostro seculo 27 fere gradibus ad occasum reliquit. Sic quando fit maximus dies tunc dicitur existere Sol in initio Cancri non octavae spherae sed imaginarie, quare aequinoctia et solstitia quae mutantur pro ratione mutatae maximae declinationis darent veram ideam eccliptice, non autem iter Solis, qui quidem proprio motu ab ortu ad occasum movetur absque ulla sphera ut etiam alii planetae super polis mundi oblique spiras facientes. Sed si singularum spira[ra]rum polos conceperis infinitos reperies polos. In Sole autem declaratur sic. Sit *abcd* circulus imaginarius meridiani, *a d*[89] poli mundi qui etiam sunt imaginarii, axis mundi imaginarius sit *ad,* aequinoctialis sit *bc,* punctum *f* sit situs Solis borealissimi. Quum Sol erit in *f* eo die movebitur per *c* redeundo versus *f* 359 fere gradibus descendetque nonnihil versus aequatorem fietque motus ab ortu ad occasum. Hoc die decrescet eius declinatio (posita maxima 23 grad. 28 min 14 sec.). Haec prima omnium spira polum habet fere 7 sec. a polo mundi boreali distantem versus occasum. Atque huius spire poli proximi sunt polis mundi, et pacta spira eius diei relinquitur 1 grad. a tergo stellarum quae absque spiris parallelos sensibiles faciunt. Sequenti die facit et spiram cuius extremum 55 sec. accedit plus ad aequatorem quam cum Sol erat in *f*, cuius spirae poli distant a polis mundi 27 sec. 30 tert.: extremum cuiusque diei spirae desinit prope lineam *fg* quae representat ecclipticam. Cum autem Sol spirificus[90] pervenerit ad punctum *c* aequatoris, eo die facit spiram maxime hiulcam seu patentem eritque ab uno puncto inchoante spiram ad aliud in meridiano distantia 24 min. fere, quibus ab una declinatione ad aliam transibit, et huius spirae poli a polis mundi 12 min. fere absunt; maxima hic erit distantia polorum motus Solis a polis mundi. Ad hunc itaque modum describet spiras Sol ab ortu ad occasum donec moveatur a Cancro ad Capricornum. Si omnium spirarum simul quas Sol toto anno facit polos con-

de la Equinoctial bolviendo a hazer otras hazia la parte Meridional, la postrera de las quales es la del Circulo del Tropico de Capricornio, y luego buelve a deshazerlas poco, a poco hasta bolver a la Equinoctial". En esta obra de Pérez de Moya no hemos encontrado mención del motivo Sol-corazón del mundo.

89 En el ms. *ab*.

90 Se trata probablemente de un término acuñado por Muñoz para significar el movimiento en espiras (*spirae*) del Sol entre los dos trópicos.



sideres, reperies ipsum fere super polis mundi moveri, eccliptica vero considerabitur circulo circum *f* borealissimum punctum et *g* australissimum ducto qui versum diametrum *fg* concipitur. Huius circuli imaginarii axis est *kl* et poli *k* et *l*. Ceterum haec puncta non sunt poli motionum Solis, quia eius motus diurni sunt quasi paralleli cum equatore et proinde movetur ab ortu ad occasum super polis super quibus spiras facit. Similiter hoc est intelligendum de motibus aliorum planetarum, quorum spirae diurnae differunt a spiris Solis nam habent latitudinem ab eccliptica. Et spirarum diurnarum eorum poli distant magis a polis mundi quam Solis spirarum. Ad hunc modum intelliges motus planetarum fieri si celum diligenter absque affectu aliquo opinionis communis contemplatus fueris. Adversus hanc nostram hypothesim non militant rationes Theonis, nos enim ecclipticam et polos ecclipticae imaginarios et nequaquam veros concipimus, non enim fiunt ab alicuius planetae motu, sed ex retardationibus et subrelictionibus Solis a stellis atque etiam ex predicta declinationum mutatione in conceptionem eccliptice pervenimus, qua concepta polorum ecclipticae fit deinde comprehensio. Hanc hypothesim mihi maxime veram visam atque a me excogitatam antiquorum peripateticorum opinioni deinde percepi vere esse valde similem, ex qua colligendum planetas quo altiores eo velociores quia minores habent retardationes. Ideo inter planetas Saturnum velocissimum, Lunam pigerrimam quod naturae videtur maxime consentaneum ut quo pro<p>inquiores sint stellae centro Terrae eo sint graviores et tardiores, nam natura celi in quo versantur crassior est et densior et proinde tardiorem motum illis conferre oportebit, superioribus planetis ut in puriore et tenuiore celo existentibus longius a gravissimorum sede locatis conferenda est maior velocitas.[91]

Martianus Capella lib. 8 cap. de planetarum orbibus[92] ait, peripateticorum dogma contendit non adversum mundum haec sidera [**f. 37r**] promoveri, sed celeritate mundi quam sequi non potuerunt, praeteriri, quod quidem etiam ut verum sit meis non poterit rationibus obviari, sive enim Saturnus nimia cum mundo celeritate concertans vix exiguis cursibus superatur a Luna quidem quod tardius incedat intra trigesimum diem a mundi parte eadem preteritur, sive contra mundum nitentibus, ideo celerior quia breviore ambitu orbem circuit Luna, tardiusque Saturnus propter latitudinem orbis effusi. Utcum<que> velis meis regulis non obsistit.

Sive igitur teneas hanc hypothesim sive ptolemaicam, eadem erit supputandorum motuum ratio. Aristoteles libro 2 de celo ca. 8[93] huic nostrae sententiae levibus rationibus adversatur quod stellae sint rotundae, dicens eas non posse per sese moueri quia carent instrumentis ad motum quasi stellae essent terrena animalia et pedibus ad motum egerent, cum motus circularis non fit instrumentis, sed a natura. Adhuc dicit eas non revolvi[94] quod cum non probet, sed asserat, ideo reicitur. Sed de his satis.

[91] Frente a Alpetragio, que retenía las esferas y atribuía la velocidad decreciente a una disminución de la fuerza motriz impartida por el primer motor localizado en la novena esfera (cf. Samsó. *On both sides*, 538-540), Muñoz elimina las esferas y atribuye la disminución de la velocidad a la creciente densidad del aire por el que los planetas se mueven "como aves por el aire".

[92] Véase Capella, *De nuptiis Philologiae et Mercurii*, VIII, 853: "denique etiam Peripateticorum dogma contendit non adversum mundum haec sidera [los planetas] promoveri, sed celeritate mundi, quam sequi non poterunt, praeteriri". Sobre los antecedentes griegos de esta concepción véase Duhem. *Le système du monde*, vol. II, 156-171. Sobre su presencia en la alta Edad Media y la atribución a Aristóteles y su escuela, veáse *ibid.*, vol. III, 82 ss.

[93] *De caelo*, II, 8, 290a 25-290b 11.

[94] *Ibidem*. Los astros están inmóviles y son arrastrados en sus "revolutiones" por las esferas que los contienen.

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Between *matematici* and *architetti d'acque*: Vincenzo Viviani, Galileo's legacy, and hydraulic engineering

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Abstract
For a long time, Vincenzo Viviani has been regarded by historians in the light of his devotion to Galileo. However, while saying that Galileo had a great influence on Viviani might seem to be an understatement, it should not be forgotten that after Galileo's death Viviani carved out a career of his own, and that he devoted almost all his life to a specific field – engineering – which often forced him to relax his allegedly strict Galilean beliefs. In particular, his apprenticeship under the guidance of Baccio del Bianco and the years he spent as an assistant engineer for the *Capitani di parte Guelfa* (before being appointed as *Primo Ingegnere*) allowed him to become a member of the narrow circle of versatile craftsmen who place themselves halfway between the *matematici* and the *architetti d'acque*. This circumstance contributed to shape both Viviani's peculiar approach to hydraulic engineering and his role in the process of institutionalisation of Galilean science.

Keywords
Vincenzo Viviani, hydraulic engineering, Galilean science, Florence, Tuscany

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Introduction

The aim of this paper is to show that a deeper look at Viviani's experience as engineer can offer new insights into his role in the cultural and institutional changes that were taking place in the second half of the seventeenth century in the wake of Galilean science. I shall do this first by looking at the early period that Viviani spent in the service of Baccio del Bianco, and then by arguing how the need to negotiate between different cultures, expertises, practices, and cultural legacies led him to adopt a highly original and modern approach to hydraulic engineering. My claim is that we need to look at Viviani from a broader perspective – a perspective that, while including the obvious Galilean influence, will acknowledge other influences as well – in order to make sense of his role in the culture of the time.

Galileo's last disciple

Even though it lasted more than sixty years, the long time spent by Viviani as hydraulic engineer in the service first of Grand Duke Ferdinand II and then of Cosimo III is arguably the most overlooked part of his scientific activity. This is due, to a certain extent, to Viviani himself, as he not only considered engineering as something "contrary to the genius" of his studies,[1] but also reputed himself physically unfit for the job.[2] He never managed to publish or even complete a mathematical treatise on hydraulics of the kind published by other disciples of Galileo like Benedetto Castelli, Evangelista Torricelli, or Famiano Michelini;[3] and he never boasted about his role as *Primo Ingegnere*. On the contrary, over the course of his entire life he took pain to present himself as "Galileo's last disciple", a custodian of Galileo's legacy who did not miss any occasion to campaign for the rehabilitation and celebration of his master. As engineer, he served loyally and diligently, but was never happy in his office and hoped in vain to be, sooner or later, left free to follow his own inclinations. He considered himself a mathematician, and to pure mathematics he would have likely attended had the circumstances of life not plotted against his wishes.

Viviani's career in engineering started in 1644, when he was 22, shortly after Galileo's death, when he was appointed as *capomastro* for the *Capitani di parte Guelfa* on recommendation from Galileo's friend Andrea Arrighetti. That same year he was promoted to *Aiuto dell'Ingegnere* at the service of the *Primo Ingegnere*, Baccio del Bianco. After Baccio's departure for Madrid, Viviani was named *Ingegnere sostituto* (1653), and then confirmed in the position as *Primo Ingegnere* (1658) after Baccio's death in 1656. Finally, when Famiano Michelini died in 1665, Viviani was called to replace him as *Idrometra* and *Matemati-*

1 Vincenzo Viviani to Baccio del Bianco, January 13, 1656. BNCF, Gal. 157, f. 18v.
2 Vincenzo Viviani to Alamanno Salviati, April 5, 1697. BNCF, Gal. 155, f. 8r.
3 On this regard, see Maffioli, *Out of Galileo: The Science of Waters, 1628-1718*, part II.

co Granducale.[4] With the latter appointment he was formally relieved from his duties as *Primo Ingegnere*, but since no substitute was ever nominated in his place, he was forced to maintain that position as well.[5] In 1697, in a pledge for intercession addressed to Alamanno Salviati, Viviani expressed his wish to be freed from a time-swallowing office that, because of the bone-crushing journeys and tiresome dealings with bureaucracy it required, had prevented him from attending to mathematical and geometrical studies the way he wanted and, as *Matematico Granducale*, was also supposed to.[6] Moreover, during all those years, his tenure as *Lettore di Matematiche* at the *Accademia del Disegno*, his involvement in the *Accademia del Cimento*, his role as editor of both Galileo's and Torricelli's collected works, and his commitment to King Louis XIV of France to carry on with the *Divinazioni* had burdened him with further tasks, worries, and responsibility, so that by age 75 he had published relatively little. It is no surprise, then, that historians, following a lead that Viviani himself was nothing but happy to give them, for a long time looked at him merely as "Galileo's last disciple", a mathematician whose scientific achievements did not match his talents.[7] This view, however, is increasingly being challenged by recent research.[8] As studies on correspondence, work notes and personal papers flourish, it is more and more apparent that Viviani's career in engineering, given its continuity over time, the full commitment it required on Viviani's part, and the relatively large amount of sources at our disposal, represents a fertile field of study.

Highly praised until at least the first half of the XIXth Century, Viviani's work in engineering was thereafter virtually ignored by historians of science. A significant exception is Raffaello Caverni, who transcribed parts of Viviani's manuscripts on hydrodynamics and studied them thoroughly. In his monumental *Storia del Metodo Sperimentale in Italia,* Caverni noticed that, when it comes to hydraulics, Viviani's devotion to Galileo seems to waver, and that his theoretical treatise *Sogno Idrometrico*, if finished and published, "would have made the publication of Grandi's *Trattato del Moto delle Acque* pointless."[9] Studies on Viviani's engineering resurfaced in the late 1970s with a paper by Paolo Galluzzi published in the *Annali dell'Istituto e Museo di Storia della Scienza*. In this study, Galluzzi analyzes Viv-

4 On Viviani's life, see the entry in *Dizionario biografico degli Italiani* by Simon Dumas Primbault; and Righini Bonelli, "L'ultimo discepolo: Vincenzo Viviani", 656-688.

5 The *motu proprio* from the Grand Duke of 1666 established that Viviani was to be freed from his duties as *Primo Ingegnere*, but would be available as consultant on important matters.

6 Viviani to Salviati, BNCF, Gal. 155, ff.5r-5v.

7 Righini Bonelli, "L'ultimo discepolo: Vincenzo Viviani", 687.

8 Cf. for example, Bonechi, "Dediche tortuose: la geometria morale di Vincenzo Viviani e gli imbarazzi dell'eredità galileiana", 75-181; Dumas Primbault, "Le compass dans l'oeil: la mécanique géometrique de Viviani au chevet de la coupole de Brunelleschi", 5-52; Dumas Primbault, *Un galiléen d'encre et de papier. Une archéologie des brouillons de Vincenzo Viviani (1622-1703)* [forthcoming].

9 Caverni, *Storia del metodo sperimentale in Italia*, 184.

iani's attempt to mathematically demonstrate that encircling the dome of Santa Maria del Fiore with chains was an adequate solution to its stability problems. The proof is far from being convincing from a mathematical viewpoint, and Galluzzi shows that Viviani engaged in it mostly because those who opposed the proposal to encircle the dome with chains had argued that such a solution contradicted Galileo's principles of static. As Galluzzi points out, by that time Viviani had already given his approval to the chain solution and, apart from the risk that this may not work, it was the veiled accusation of 'betraying' Galileo that bothered him. To show that the approved solution was perfectly consistent with Galileo's science, Viviani resorted to an obscure theorem by Torricelli. By way of conclusion, Galluzzi notices that while Viviani was working on the proof, he was also drafting the letter to Salviati in which he asked to be released from his duties as engineer: his personal dissatisfaction with engineering, thus, seems to be somehow linked to his devotion to Galileo.[10]

In the following years, an ever-growing body of literature on the developments of hydraulics after Galileo, on the environmental policy of the Medici, and on Viviani's work as *Ingegnere* has consigned us a radically new image of Galileo's last disciple. Today, Viviani's approach to hydraulic engineering is recognized as surprisingly modern, innovative, and effective;[11] his half a century's service in the position of *Primo Ingegnere* is regarded as a key element in the institutionalization process of Galilean science and in the reformation of the technical bureaucracy of the Tuscan State;[12] and many of his theoretical researches on hydraulics have been reconsidered in the light of the concerns on some aspects of Castelli's theories expressed by contemporaries like Domenico Guglielmini.[13] In all these, however, the issue signaled by Caverni and Galluzzi – that is, a possible controversial Galilean legacy, when it comes to engineering – remains mostly on the background. The complex accommodation between 'practical' and 'mathematical' wisdom as it was experienced by Viviani received relatively little attention, and has been often reduced to the mere observation that Galilean mathematical science progressively replaced the old practical and empirical expertise. On the other hand, delving deeper into the issue by investigating Viviani's career as engineer, his engagement with the culture of his time, and his key role in the general restructuring of epistemological hierarchies led by the post-Galilean generation both at the intellectual and institutional level reveals a far more complex situation that

10 Galluzzi, "Le colonne "fesse" degli Uffizi e gli screpoli della Cupola. Il contributo di Vincenzo Viviani al dibattito sulla stabilità della Cupola del Brunelleschi (1694-1697)", 90-102.

11 Barsanti, "La scuola idraulica galileiana", 83-130; Maglioni, "Vincenzo Viviani e l'Arno. Scienza Galileiana e problemi di un fiume e del suo bacino nel XVII secolo", 151-170; Di Fido, Gandolfi, *Idraulici italiani*, 88-92.

12 Vivoli, Toccafondi, "Cartografia e istituzioni nella Toscana del Seicento: gli ingegneri al servizio dello Scrittoio delle Possessioni e dei Capitani di Parte", 167-202.

13 Maffioli, *Out of Galileo: The Science of Waters, 1628-1718*, 193-195; Gottardi, Bugini, Camprini, Manferrari, "Aspetti della tradizione scientifico-tecnica idraulica bolognese", 69-70.

cannot be reduced to the assumption that Galileo's science influenced the practice of the *architetti d'acque*, but must take into account the possibility that the process worked in the other direction, too – that is, that the *architetti d'acque*'s approach to hydraulic engineering had its share in the shaping of the institutionalization process of Galilean science.

Viviani was the first mathematician of the Galilean school to hold the highest technical position in the Tuscan State. He trained generations of engineers and technicians, and, as both *Primo Ingegnere* and *Matematico Granducale*, he experienced firsthand the need of negotiating knowledge, discourses, skills, and practices in a fast-changing intellectual and political environment, and so his career as engineer is a privileged standpoint for looking at how, during the second half of the XVIIth century, Galilean science became Tuscany's main truth-producing paradigm at institutional level.

An engineer in the making: Viviani's apprenticeship with Baccio del Bianco

For Viviani, entering the service of Baccio del Bianco was like entering a new world. Unlike Castelli and Torricelli, who were recruited as senior consultants right from the start, Viviani began his career in hydraulic engineering at the bottom of the ladder and went up through the ranks of the *Magistratura dei Capitani di parte Guelfa*. Established in 1267 in the aftermath of the battle of Benevento (1266) and the restoration of Guelph rule in Florence, the *Magistratura* was originally charged with prosecuting Ghibellines. Over time, however, it had evolved into an authority with a broad range of responsibilities in Public Works matters, and after the *Ordinazioni* of 1532 that abolished the *Signoria* and turned the Florentine State into a monarchy it assumed an increasingly technical role. The *Magistratura* was governed by a council of ten citizens (the *Capitani*), three of whom were randomly chosen among high-rank Florentines and seven were directly nominated by the Grand Duke. The *Capitani* served on temporary appointment, but two of the councilors nominated by the Grand Duke were hired on permanent basis to act as *Ufficiali dei fiumi*.[14]

Important as it was, in the XVII century the *Magistratura* was just one of the administrative bodies, within the confusing institutional structure of the Grand Duchy, that had some kind of jurisdiction over river management. Its functions and power often overlapped and conflicted with those of the so-called *Magistratura dei Nove*, the institution created by Cosimo I in 1560 to control local governments. Moreover, there was the peculiar organization of the Tuscan State, which consisted of a *Stato vecchio* (the Duchy of Florence) joined in personal union to a *Stato nuovo* (the Republic of Siena), with Pistoia and Pisa, included

14 On the *Magistratura*, see Vivoli, Toccafondi, "Cartografia e istituzioni nella Toscana del Seicento: gli ingegneri al servizio dello Scrittoio delle Possessioni e dei Capitani di Parte", 167-202. More generally, on the institutions of the Medicean state, cf. Neri, "Relazione sulle magistrature della città di Firenze (1745-1763)", 569-689.

in the Duchy of Florence, enjoying some autonomy over territorial government and tax collecting. So, when it came to river management in the *Stato vecchio*, the main authorities involved were the *Magistratura dei Capitani di Parte Guelfa*, the *Magistratura dei Nove*, the *Pratica di Pistoia*, and the *Ufficio dei Fossi* of Pisa, not to mention the Grand Duke himself, who loomed over all of them and was always ready to intervene issuing a *Motu proprio* or appointing a *Sovrintendente* on suggestion from personal advisers like the *Matematico Granducale*.

The funding system further complicated the situation, as it ignited and exacerbated disputes. River maintenance was not part of the *spese universali* of the Grand Duchy, that is, it was not a regular service routinely funded by the State, but consisted mainly of emergency interventions ordered by the State and paid for by local landowners according to a complex system of fee distribution (*imposizioni*). As this usually sparkled disputes, it was often necessary, in the case of major projects, to mediate between conflicting interests by bringing together local communities, land-owners, and State agencies in the so-called *Congregazioni*. The issue, however, stood: the disarticulation between the State's centralistic approach to river management on the one side and the river maintenance funding system on the other remained a source of endless litigations and, perhaps more importantly, forced local communities into debt. By 1770 (when the *Magistratura dei Capitani di parte Guelfa* and the *Magistratura dei Nove* were united in the *Camera delle Comunità*) there was a huge debt of 201.792 ecus on the part of the *imposizioni* of Val d'Arno di Sopra alone.[15] Consequently, authorities like the *Magistratura dei Capitani di parte Guelfa* operated on a very tight budget and were unable to implement long-term global policies.[16]

When Viviani joined the *Magistratura* in 1644, the *Capitani* were responsible for engineering projects in their entirety: they had to survey the interested areas and draw maps, approve plans, contract out the works, calculate the *imposizioni*, settle controversies between the stakeholders, and inspect the construction works. To carry out these tasks, they employed a technical staff of *Ingegneri dei Fossi e dei Fiumi*, usually hired on a temporary basis and assigned to individual projects or specific areas. The *Primo Ingegnere*, instead, was hired on permanent basis and served at the same time as consultant of the Grand Duke and the *Ufficiali dei fiumi*, as *Ingegnere dei Fossi e dei Fiumi*, and as project inspector of the ongoing works. The *Primo Ingegnere*, being always on the move either for routine inspections or emergency interventions, had his personal staff of *Aiuti* and *capimastri* to help him out with the work. On the administrative side, the *Magistratura* relied on a bureaucratic staff of *Ministri*, *Segretari* and employees (*scrivani*), managed by the *Provveditore*,

15 Cit. in Sordi, *L'amministrazione illuminata. Riforma delle comunità e progetti di costituzione nella Toscana leopoldina*, 102.

16 On these topics, see Fasano Guarini, *Lo Stato Mediceo di Cosimo I*; Mannori, *L'amministrazione del Territorio nella Toscana Granducale. Teoria e prassi di governo fra antico regime e riforme*; Sordi, *L'amministrazione illuminata...*, 21-75.

who was appointed by the Grand Duke and served as his man of trust within the institution.[17] Viviani was hired as *capomastro* in 1644 on recommendation from Galileo's friend Andrea Arrighetti, who was subsequently nominated *Provveditore* in 1648. With Viviani's appointment, a new route was opened for the institutionalization of Galilean science, and from then on this process of institutionalization ran both ways: from the top down (with the occupation of didactic and managing positions), and from the bottom up (with the appointment of medium-level technical personnel).

We can only imagine how the 22-year-old Viviani must have felt on his first day as *capomastro* at the service of the *Primo Ingegnere*, Baccio del Bianco, since this was a job heavily charged with operative duties. It is true that Viviani was a skilled mathematician with a clear understanding of hydraulics and engineering at a theoretical level and also knew about the basics of *disegno*, having attended Baccio's school, but being on the field was a totally different business. He was to work side by side with artists and architects who had been in the trade all their life and had an eminently practical education. Members of this closely tied group of multi-skilled craftsmen revolved around the *Accademia del disegno* and the private academies that supplemented its teaching, and filled all the technical positions of the *Magistratura dei Capitani di parte Guelfa*.[18] They were often born into well-connected families, had started their career early, and had perfected their education abroad, travelling with armies or working in the service of court architects. Baccio himself was born in 1604, the son of Cosimo del Bianco, a mercer of the *Arte di Calimala*, the Merchant Guild of Florence.[19] The *Calimala* controlled foreign textile trade and thus was one of the most important Florentine guilds. Their prominent members had important connections to the court and Florentine elites. Cosimo del Bianco was especially tied to influential *Calimala* members Baccio and Domenico Comi, who were also notable members of the *Confraternita dell'Arcangelo Raffaele*, a confraternity that was renowned for their musical and theatrical productions. This put young Baccio del Bianco in contact with the artists/architects that were variously involved in the Florentine theatrical production apparatus. Afterwards he studied with artists Giovanni Bilivert and Vincenzo Boccacci (both pupils of Cigoli), met with artist and architect Giulio Parigi, and ended up, on Bilivert's recommendation, in the service of engineer Giovanni Pieroni. Under Pieroni's guidance, Baccio engaged in mathematics and geometry, about which he would later joke in his autobiography:

17 See Vivoli, Toccafondi, "Cartografia e istituzioni nella Toscana del Seicento: gli ingegneri al servizio dello Scrittoio delle Possessioni e dei Capitani di Parte", 167-202.

18 Cf. Guarducci, Azzari (eds.), "Mappe e potere: pubbliche istituzioni e cartografia nella Toscana moderna e contemporanea, secoli XVI-XIX", 29-33.

19 On Baccio dal Bianco's life, see Thielman, *Baccio del Bianco at the Court of Spain: Early Modern Scenic Design in Context*.

> vistommi innanzi con le pratiche, mi ritirò alle teoriche, dichiarandomi Euclide; che se sudava, se sbavigliavo, Dio lo dica; contrario tanto alla mia natura quello studio, che, con tutto sentissi li 6 libri ben tre volte, sempre quando potevo (non conoscendo potermi servire a nulla), con pratiche mi esercitavo.[20]

In 1620, following the outbreak of the Thirty Years War, Emperor Ferdinand II asked his sister, Grand Duchess Maria Maddalena, to send him a specialist in military fortifications, so Maria Maddalena had Pieroni depart, together with Baccio, who was then 16, for the Holy Roman Empire. After a brief period spent surveying and restoring fortifications in Austria, Bohemia, and Moravia, Pieroni entered the service of Albrecht von Wallenstein and settled in Prague with his family. As Pieroni was often on the road, Baccio was left in charge of Pieroni's household and soon grew bored and unhappy. So he decided to go back to Florence and by 1625 was already in town, seeking a career on his own. His connections, as well as his experience in military engineering, helped him find free-lance works and eventually allowed him to land the position of *Primo Ingegnere* of the *Magistratura dei Capitani di Parte Guelfa* in substitution of Alessandro Bartolotti. As *Primo Ingegnere*, Baccio worked in close contact with architects and artists who, for the largest part, had had life experiences and education similar to his own. People like Ferdinando Tacca and Alfonso Parigi, who worked for the *Magistratura* as *Ingegneri* on several occasions, had all started their career in family workshops (they were sons of Pietro Tacca and Giulio Parigi, respectively) and by the age of 20 had accumulated significant experience on the field. They also shared a common view of *disegno*, and an approach to hydraulic engineering deeply rooted in the practice of the *architetti d'acque*. When Viviani became *Aiuto dell'Ingegnere* in 1644, together with the other *capomastro* Pier Francesco Silvani they joined the *Aiuto* already in service, Giovan Pietro della Bella. Silvani was three years older than Viviani and, as the son and apprentice of famed architect Gherardo Silvani, by the time he became *Aiuto* he had years of training; the same goes for Della Bella, who was the brother of artist Stefano and had been a student of sculptor Pietro Tacca.[21]

So, when Viviani started journeying around the Grand Duchy with Baccio, he needed to acquire a set of skills proper to the *architetti d'acque* that it is unlikely he could have acquired during his peaceful stay with Galileo at *il gioiello*.[22] These were practical skills that needed to be trained and practiced independently from mathematical and philosophical speculations, as they mostly depended on common sense, experience, and received wis-

20 *Racconto della Vita di Baccio del Bianco scritta da se medesimo al suo carissimo amico sopra ogni altro Signor Biagio Marmi*, 396.

21 On these artists, see the entries in Baldinucci, *Notizie de' professori del disegno da Cimabue in qua*.

22 See, in this regard, Jensen, *Engineering and technology, 1650-1750*; Fiocca, Lambertini, Maffioli (eds.), *Arte e scienza delle acque nel Rinascimento*; Romby, *Architetti e ingegneri militari nel Granducato di Toscana: formazione, professione, carriera*.

dom. He had to learn how to draw and take field notes on the go, how to take topographical measures in tricky situations, how to deal with peasants, land-owners, and authorities, and how to find solutions to the big and small complications that could happen along the road. He also had to familiarize with engineering technical vocabulary and slang. His surviving notebook sheets from the 1640s are populated with notes, suggestions, and remainders, perhaps coming from Baccio himself. There are lists of technical terms like *posticciare, ringorgare, imporre, dapporre, argine, scannafosso, scoli di campi*, but also common words and phrases, sometimes with explanations:

> Stiancia è una erba che ha le foglie lunghe strette
> Melma sono quei suoli grandi di terra ricoperti di erbe che galleggiano nelle Chiane sopra le quali si pareggiano pascendovi vacche et altri animali
> Diramarsi di un fiume, cioè dividersi in più rami
> Batter la campagna, cioè far viaggi[23]

On other occasions, Viviani records measurement conversions:

> Le pertiche [di Pescia] sono di b[raccia] 4 di Firenze
>
> 4 pertiche quadre fanno una Scala
> 30 Scale un Quartiere
> 4 Quartieri una Coltra
>
> 2 Staia di seme alla fiorentina seminano una coltra
> 120 pertiche quadre sono una Coltra
> 20 pertiche quadre sono uno Staio fiorentino[24]

There are also instructions on how to measure height at night, notes about which kind of gunpowder is more explosive, lists of places and names, and weekly to-do lists. Most of these notes were very likely taken on the go, as they are hurriedly jotted down with a pencil and in some cases overwritten later in ink with minor revisions. In general, they suggest the image of a diligent, humble young man, willing to learn as much as he can. This image is consistent both with the one Viviani presented publicly,[25] and with the views he expressed in the barely started *Dialogo sulla conoscenza*, where he states that "if you ask what being erudite means, here is the answer: knowing the difference between things, be-

23 BNCF, Gal. 215, f. 13r
24 BNCF, Gal. 238, f. 1r.
25 Viviani to Salviati, cit. note 2, f. 5r-6v.

ing able to demonstrate it and to give a name to each of them. […] The basis of erudition is learning the nomenclature of the things pertaining to art and nature. – Is this difficult? – Yes, it is, if you do it unwillingly, and with a prejudiced mind."[26] The use of extremely precise terminology, moreover, has been recognized as one the characteristic features of Viviani's engineering work.[27]

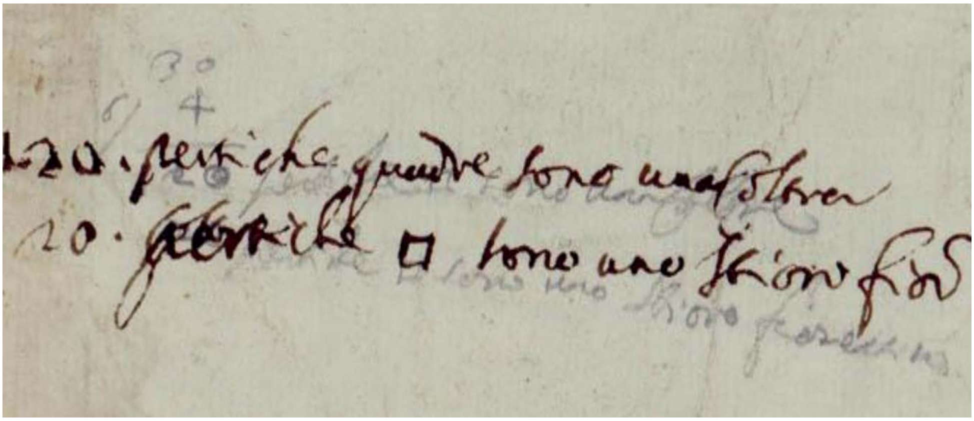

Fig. 1 – Notes jotted down with a pencil and later overwritten in ink, BNCF, Gal. 238, f.1r.

The single most important skill that Viviani needed to master proficiently as *Aiuto dell'Ingegnere* was drawing. It was not until recently that the importance of *disegno* as a crucial field of intersection between science, arts, and craftmanship has been thoroughly investigated, and in the case of Viviani his proficiency in *disegno* appears to be a promising field of study.[28] For the purposes of this paper, however, it suffices to highlight that Viviani needed to master drawing in order to become part of a community that made almost exclusive use of the graphic medium and considered it a fundamental tool for the investigation of the natural world. Members of this community filled technical positions not only of the *Magistratura dei Capitani di parte Guelfa* but of the Grand Duchy in general.

Again, what we find in the notebooks is quite interesting, as it shows us what Viviani deemed important to know about *disegno* both on the practical and theoretical side. He reminds himself, for example, to always use "red pencil or black ink" when sketching, to practice in drawing *vedute* and *paesi*, and to learn how to use colors and shadowing. On a more theoretical level, he notes that there are disciplines he needs to study more: Civil and military architecture, Practical perspective, Mechanics of Moving Machines, Gnomonics,

26 BNCF, Gal. 156, f. 37r.

27 Di Fido, Gandolfi, *Idraulici italiani*, 89.

28 On *disegno*, see Bambach, *Drawing and Painting in the Italian Renaissance Workshop: Theory and Practice, 1300-1600*. On Viviani: Dumas Primbault, *Un galiléen d'encre et de papier*, Ch. 2.

and Repairing water damage (*Ripari d'acque*). To this end, he plans to write compendia of Practical geometry, Mechanics, and Fortifications, and to learn how to build scale models of machines.[29] This training program is fully consistent with Baccio's working practice and, more generally, with the conceptions and ideas of the new generation of artists and technicians revolving around the *Accademia del disegno* and the private academies, like Baccio's own school, that supplemented the practical training programs offered by the *Accademia* with theoretical ones influenced by Galilean science.[30] It is telling, in this regard, that Viviani mentions works by Galileo (the *Bilancetta*), Cigoli, Pieroni, and Baccio as reference-books.[31]

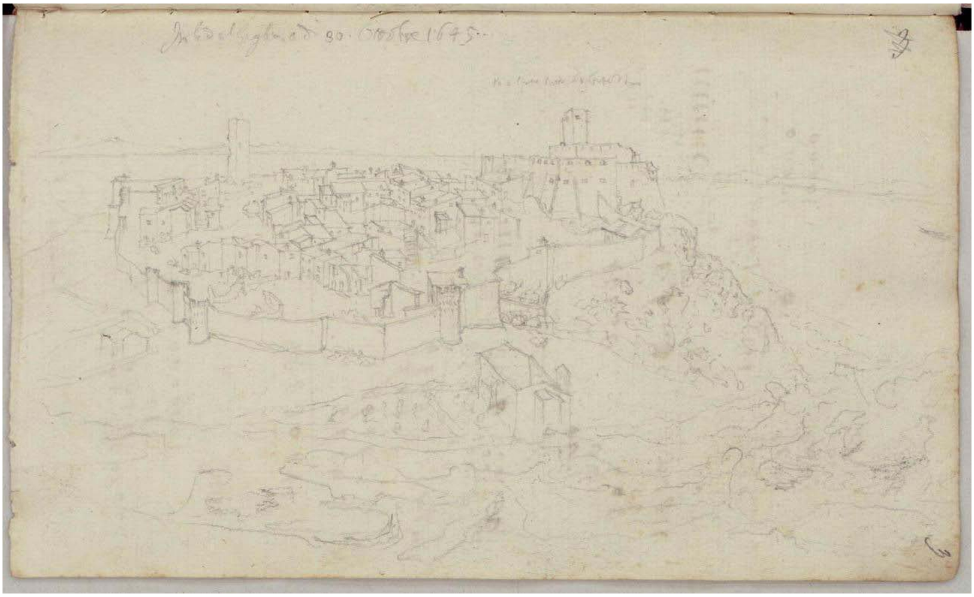

Fig. 2 – A *veduta* of Isola del Giglio, pencil on paper, October 30, 1645, BNCF, Gal. 239, f. 3r.

Mastering *disegno* would not only provide Viviani with a basic skill, but would also shape his whole attitude towards mathematics and engineering, making him a full member of a community that, while influenced by Galilean science, was nevertheless informed by ideas coming from Leonardo da Vinci, Leon Battista Alberti, Vasari, and maintained a clear distinction between the *teoriche* and the *pratiche*.[32] With his appointment as *capomastro*, Viviani was entering a world that would force him to negotiate not only between

29 BNCF, Gal. 215, ff. 17r-17v. Viviani also drafted compendia on mechanics and fortifications.
30 Magureanu, "Baccio del Bianco and the cultural politics of the Medici court", 22-24.
31 Dumas Primbault, *Un galiléen d'encre et de papier*, Ch. 2.
32 BNCF, Gal. 215, f. 17v.

epistemological perspectives and practices but also, on a more profound level, between personal desires and public duties.

This is all the more evident if we look at the initial tasks Viviani was expected to perform. As *Aiuto dell'Ingegnere*, during the 1640s he was always busy sketching drawings and maps, taking measures of the surveyed sites, doing calculations, and instructing laborers. All these tasks should be performed on the spot, and so efficiency was often more appreciated than mathematical rigor. He was also in charge of keeping track of the meetings with land-owners and representatives of the local communities, something that was of no concern to the *matematici* and would define Viviani's peculiar approach to hydraulics as compared to that of Galileo's other disciples. While both Castelli and Torricelli were routinely summoned to provide advice on engineering issues and were even sent on occasional on-site surveys, neither of them had to deal with the actual realization of engineering works on a daily basis: once a project was approved, its realization was left to technicians. Viviani, on the contrary, soon found out that this was perhaps the most awkward, demanding, and time-consuming part of the profession. Conflicting interests could undermine, or even reverse, the expected effects of an engineering project, especially if the engineers themselves were prone to surrender to external influences or were unwilling to personally oversee its implementation and execution. As Viviani would explain to Salviati in 1697, an engineer must be "a righteous, impartial, selfless, and truthful man," and above all "must personally follow the execution of the projects until they are completely finished."[33]

Rethinking engineering: Viviani and the Ombrone

By 1650, Viviani was skilled enough to work independently on sub-projects, manage map-making, and write *relazioni* and *pareri.* One the first major works he was actively involved in was the accommodation of the Ombrone Pistoiese river, a project that would end up occupying most of his professional career and contributed decisively to shape his views about hydraulic engineering. In 1644 the river had flooded its banks causing extensive damage to the lands, some of which were property of Ferdinand II. Emergency measures taken by Baccio del Bianco proved ineffective, as more floods occurred in subsequent years, and so in 1647 Ferdinand II decided that a long-term global intervention program was needed.

The matter was by no means simple. The Ombrone originates from the Tuscan-Emilian Appennine and is fed by tributaries that significantly increase its flow downhill into the Arno near Carmignano. Even though the Ombrone was neither as politically sensitive as the watershed between the Arno and Tiber in Valdichiana, which marked the boundary

33 Viviani to Salviati (cit. note 2), f. 8v.

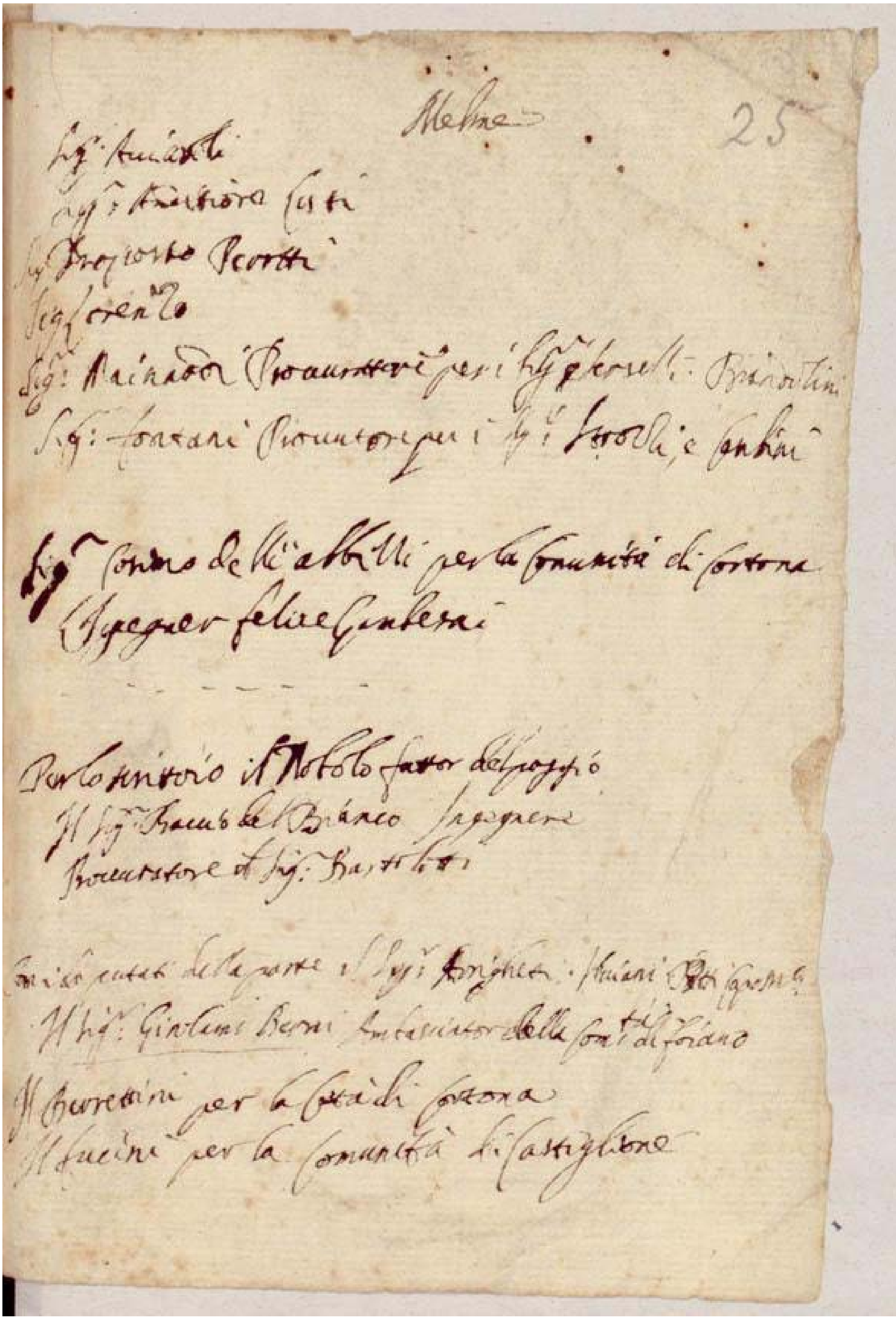

Fig. 3 – Record of a meeting with landowners, BNCF, Gal. 215, f. 24r.

between the Grand Duchy of Tuscany and the Papal States, nor as economically significant as the diversion of the river Reno, which gave rise to endless controversies between Bologna and Ferrara,[34] it presented nonetheless a number of challenges on both sides, since it traversed State-, town- and private-owned lands in the territories of Pistoia, Firenze, and Prato, and farming along its banks was intensive. So, when the engineers started working around 1650, they envisioned works that were to impact significantly the economic life of the local communities. They planned to remove weirs, demolish mills, increase bank resistance by tree planting on farmland, and so on, sparkling protests and controversies since the involved parties were required to pay for the works. Moreover, there was the issue of jurisdiction, which was addressed for the first time in 1649 with the creation of a council of three *Giudici delegati* (the secretary of the *Pratica di Pistoia*, a member of the *Magistratura dei Capitani di Parte Guelfa*, and the *Provveditore*), who worked together with the *Ufficiali dei fiumi*.

Viviani's notes from 1650 report about the situation of the Ombrone with drawings, measures, calculations, suggestions, and details about boundaries and quotas. They show how "Galileo's last disciple" had become fully acquainted with the engineer's work routine and methods,[35] and how by then he had already started to realize that the main problem of the Tuscan fluvial system was a generalized riverbed rise mostly due to poor environmental management.

This view is further developed in a *relazione* addressed to the Grand Duke Cosimo III in 1679. By then, the controversies between State officials and landowners, as well as those between the authorities involved in the Ombrone management, had reached a peak, forcing the Grand Duke to issue a *motu proprio* that granted State auditors Ferrante Capponi and Giuseppe Orceoli the authority to settle controversies and disputes. In the *relazione*, Viviani claims that the main reasons behind the unsolved issues of the Ombrone are due to both art and nature. The 'artificial' issues are "negligence, poor maintenance of the banks, transgression of the law […], and greed as well;" the 'natural' one, instead, is a generalized riverbed rise that originates in tributaries, trickles down on the Ombrone and, eventually, impact the Arno itself. While there are technical solutions for the 'natural' issues of the Ombrone, they can be effective, Viviani argues, only after having properly addressed the artificial ones. Thus, Viviani suggests, the Grand Duke should promulgate strict and clear ordinances and have them enforced tightly. It would be of no use, Viviani claims, to invest money in restoration works if the owners and tenants can destroy them for their own inter-

34 On the watershed between Arno and Tiber in Valdichiana, a matter that at some point involved Viviani as well, see Corsini, *Ragionamento istorico sopra la Valdichiana, in cui si descrive l'antico, e presente suo stato*, 45-61. On the Reno: Maffioli, "La controversia tra Ferrara e Bologna sulle acque del Reno: l'ingresso dei matematici, 1578-1625", 239-267; Lugaresi, *Idrodinamica e idraulica. Le Raccolte sul moto delle acque. La questione del Reno*.

35 BNCF, Gal. 238, ff. 14r-26v.

est without fearing prosecution, or if they are allowed to ignore laws preventing clearcutting and weir-building.[36]

Lack of proper legislation had always been one the main factor impacting the river management policy of the Medici, preventing them from adopting a global approach even after the entire Arno basin fell into their dominion.[37] This often would often result in conflicts of competences between engineers, state officials, and mathematicians. Viviani had just been appointed *Aiuto dell'Ingegnere* when a most-publicized and bitter dispute erupted between Famiano Michelini and Evangelista Torricelli about the reclamation of Valdichiana,[38] and was to experience himself how this kind of arguments could led to institutional and operative *impasse* in 1651, when he was instructed, together with his fellow *Aiuti* Annibale Cecchi and Pier Francesco Silvani, to provide a *parere* about the best way to reinforce the Arno banks near Rovezzano, where the river had flooded in 1647. Relying on the opinions of Baccio and Torricelli, Viviani and his partners proposed to build riverbank protection structures and dig a drainage ditch. The project was rejected by the *Ingegnere dei Fossi* responsible for the area, Stefano Marucelli, who chose a less-expensive plan drafted by Alfonso Parigi and Francesco Nave instead. However, at this point the *Ufficiali dei fiumi*, Baccio Manetti and Domenico Dazzi, weighed in, rejecting both projects and putting everything on hold. It was not until years later, when Viviani became *Sovrintendente* for the area, that he would be able to realize at least part of his original plan.[39]

The case of the Ombrone is illuminating, in this regard, as it made clear, to Viviani, the difference between being a *matematico* and being an *ingegnere*. In 1666, Viviani had been officially dismissed from his office as *Primo Ingegnere* but he was still expected to serve as "consultant on important matters" – an euphemism used in the Grand Duke's *motu proprio* to signify that Viviani was to work as usual but would be spared some journey. In 1678, then, he was sent to inspect the area between Prato and Pistoia, damaged again by a flood of the Ombrone. After the visit, Viviani wrote the *relazione* of 1679, which was approved by Cosimo III in 1681. The provisions Viviani proposed, however, were not fully implemented, first because landowners acted in court against Viviani's project and then, when the legal matter was settled by direct authority of Cosimo III, because the *Ingegnere* charged with the material execution of the works – Giuliano Ciaccheri, a disciple of Viviani – was sent elsewhere to take care of more urgent matters. To replace Ciaccheri,

36 BNCF, Gal. 235, ff. 169r-182v.

37 See Ferretti, Turrini, *Navigare in Arno. Acque, uomini e marmi tra Firenze e il mare* The *Bandi* (laws) issued between 1485 and 1737 are collected in Cascio Pratilli, Zangheri (eds.), *La legislazione medicea sull'ambiente*.

38 See *Raccolta d'autori italiani che trattano del moto dell'acque*, IV, 65-164. On the *Raccolta*, see Lugaresi, "Le raccolte italiane sul moto delle acque", 201-304.

39 See Targioni Tozzetti, *Notizie degli aggrandimenti delle scienze fisiche accaduti in Toscana nel corso di anni XL del secolo XVII*, vol. III, 284-298.

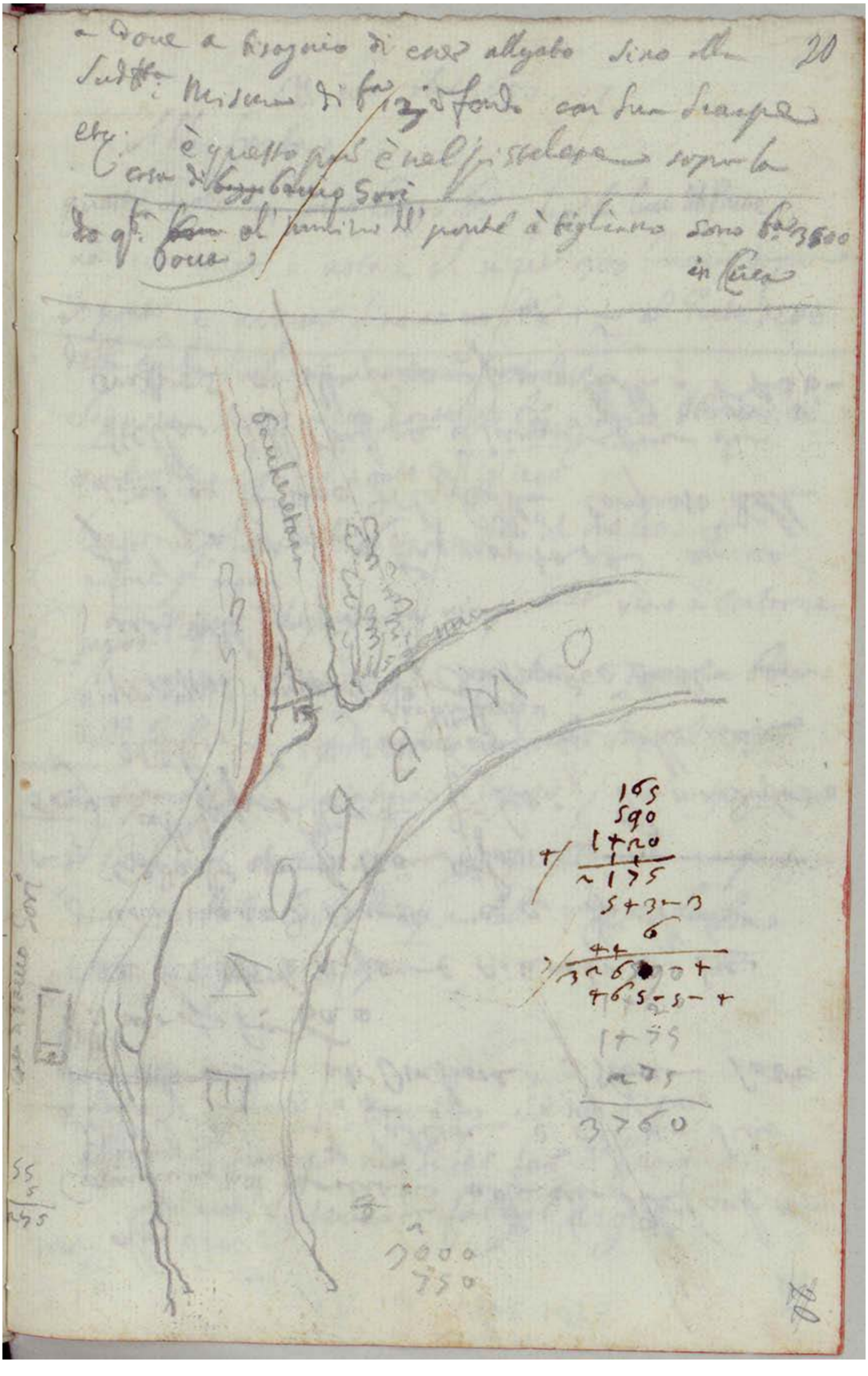

Fig. 4 – Studies on the Ombrone, 1650, Pencil and ink on paper, BNCF, Gal. 238, f. 20r.

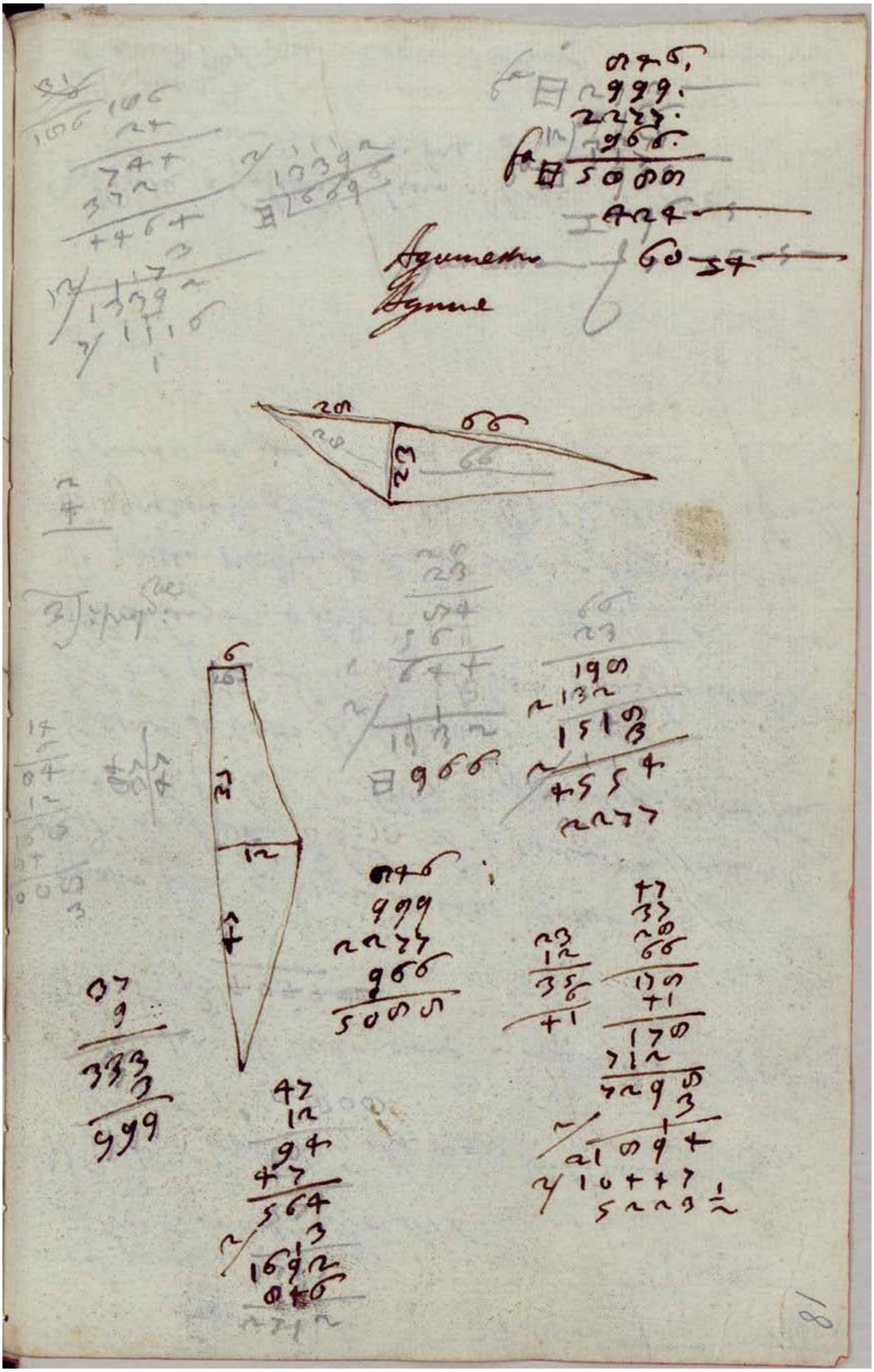

Fig. 5 – Studies on the Ombrone, 1650, Pencil and ink on paper, BNCF, Gal. 238, f. 18v.

the *Capitani* appointed Viviani's former colleague Pier Francesco Silvani, who, after several studies and with full approval from the *Sovrintendente*, decided to modify the original plan. The works planned by Silvani were finished in 1686: the main constructions were a new *Ponte di riboccatura* and a smaller bridge on the Elzana stream personally designed by Viviani, in homage to Galileo, as a single cycloidal-arched bridge.

In 1702 representatives of the town of Scarperia and other local communities filed a lawsuit against those in charge of the project – Viviani included – on the claim that the new *Ponte di riboccatura* was barely useful and that the expenses they had sustained were higher than they should have been according to the *imposizioni*, so they asked for a full reimbursement. The memoir that Viviani presented in his defense that same year 1702 can be read as a concise summary of what, according to him, was wrong with the profession. First of all, Viviani remarked, he was officially only a consultant, and thus could not be held accountable for works that are responsibility of the *Primo Ingegnere*. Secondly, in 1678 he had made clear what the cost of the works would be, and his project had been fully approved by the Grand Duke. Moreover, the plan that was actually realized was not his, but Silvani's, and the costs of the new works had been repeatedly approved by the *sovrintendente* Barberini. Finally, the local communities were contesting the work and judgment of two professionals like Ciaccheri and Silvani without providing evidences or calling expert opinions in support.[40] To Viviani, it was absurd and frustrating that, after more than fifty years, the Ombrone matter was far from being resolved, even if technical issues had been identified and addressed. He was acutely aware that engineering needed to be grounded on new institutional and legislative basis–an awareness made all the more acute by the fact that he didn't want to be an engineer. In this perspective, his insistence on tight regulations, economic planning, prevention, and good maintenance can be regarded as an attempt to free engineering from external, time-consuming duties that, in the end, prevented engineers from doing their job, that is, "putting their propositions into executions."[41]

Negotiating Galileo's legacy: Viviani and the Bisenzio

When Baccio del Bianco left for Madrid in 1653, Andrea Arrighetti, from his influential position as *Provveditore*, managed to create for Viviani the office of *Sostituto dell'Ingegnere* – an office that never existed before and would never exist anymore after Viviani – so that, at Baccio's death in 1656, the confirmation of Galileo's last disciple in the position of *Primo Ingegnere* was just a matter of bureaucracy.[42] This appointment, masterfully orchestrated by Arrighetti, marks a turning point in the institutionalization of Galilean science, all the

40 The whole affair is reported by Viviani in his defensive memoir. BNCF, Gal. 235, ff. 208v-213r.
41 BNCF, Gal. 235, f. 208v.
42 Andrea Arrighetti to Ferdinand II, BNCF, Gal. 155, f. 27r.

more so because, in 1666, Viviani was also nominated *Matematico* of the Grand Duke, and so for the rest of his life he held at the same time the highest technical office in the *Magistratura* and one of the most important consultancy position at the court. Viviani crucially restructured the technical staff of the Grand Duchy, gradually putting an end to the era of the practically-trained adventuristic artist-architect, who was replaced, in the office of state engineer, by professional figures with a solid background in mathematics who operated according to standardized working routines.[43] On the other side, Viviani also contributed to reshape the role of the *Matematico Granducale*, at least for the consultancy part related to engineering. Even when written from the *Matematico*'s position, Viviani's *pareri* are always detailed to the extreme and informed with economic, geographical, geological, sociological, and historical concerns. Engineering issues are never addressed from a purely theoretical perspective – in fact, the theoretical perspective is almost nonexistent. Viviani never wrote *pareri* similar to those written by Galileo on the Bisenzio in 1630 and Castelli on the Venice lagoon in 1641[44] – that is, 'mathematical' reports written without having carefully surveyed the area to take into account its geomorphological, historical, and socioeconomic features: he wrote as *Matematico* pretty much in the same way as he wrote as *Primo Ingegnere*.[45]

All these, I think, should make us problematize the common assuption that, with Viviani, the *matematici* replaced the *architetti d'acque* as state officials in charge of engineering. From this perspective, the main question is: in which sense, by the time he became *Primo Ingegnere*, Viviani was a *matematico* of the Galilean school? The question is more complex than it may appear at first sight. If we look at Viviani's published writings on hydraulics, we notice that they are almost completely devoid of mathematics – a striking circumstance, even if we take into account that they were intended as non-technical writings. The *Discorso al Serenissimo Cosimo III Granduca di Toscana intorno al modo di difendersi da' riempimenti e dalle corrosioni de' fiumi applicato ad Arno in vicinanza della città di Firenze*, published in 1688, in fact contains just two references to mathematics, with one being an explanation of why the bridge on the Elzana stream is designed as a homage to Galileo. Viviani argues his main point – the riverbed rise of the Arno – by means of on-field observations, historical evidences, and conclusions derived from the *architetti d'acque* expertise. There is no reference to the Galilean science of motion or to Castelli's mathematical treatment of hydraulics: without knowing beforehand that the treatise is written by Galileo's last disciple, a reader might as well wonder if the author knows anything at all about Gali-

43 See Vivoli, Toccafondi, "Cartografia e istituzioni nella Toscana del Seicento: gli ingegneri al servizio dello Scrittoio delle Possessioni e dei Capitani di Parte".

44 On Castelli's report, see Omodeo, Trevisani, Babu, "Benedetto Castelli's *Considerations on the Lagoon of Venice*: Mathematical Expertise and Hydrogeomorphological Transformations in Seventeenth-Century Venice", 420-446.

45 Viviani always signed his *pareri* and *relazioni* as *Matematico* from 1666 onwards.

leo's new science of motion and Castelli's hydraulics.[46]

Moreover, if we look closely at Viviani's approach to hydraulic engineering we can see how Galileo's last disciple is also the one who more often departed from the master's advice of being cautious about straightening rivers.[47] The practice of *raddrizzamenti* – diverting waters in a new bed running in a straight line – was not really popular among the followers of the Galilean school of hydraulics. Forcing a river outside its 'natural' bed, Galileo argued on mathematical grounds, was a costly operation of dubious efficacy. Castelli, for his part, remarked that it was risky, too, and could be disastrous if undertaken without a precise quantitative cognition of the river flow. The *raddrizzamenti*, however, were commonly practiced by the *architetti d'acque*, who did not share the *matematici*'s 'philosophical' concerns about the 'unnaturality' of the operation, and grounded their opinion on the common-sense observation that the absence of bends prevents the accumulation of sediment and, thus, floods.[48] Moreover, the *raddrizzamenti* could make a river navigable. During his career as engineer, Viviani realized several *raddrizzamenti*, both on the Ombrone and on the Bisenzio, the very river that, according to Galileo, did not need to be straightened. What is interesting, though, is that Viviani favored the practice because it allowed to gain cultivable lands – in other words, for him the *raddrizzamenti* were part a general environmental management policy that featured the human element as a crucial part of it.

On the other side, if we look at Viviani's unpublished theoretical writings on hydraulics, while we can have little doubts about his trust in Galileo, Torricelli, and Castelli, we can also see how Viviani was working on an alternative approaches to problem of water measurement.[49]

A convenient starting point for addressing the question is looking back at the controversy over the Bisenzio of 1630-1631, which involved Galileo and, significantly, also Andrea Arrighetti, Viviani's future patron at the Medici court and within the *Magistratura*. As is well-known, the controversy arose after a disastrous flood of the Bisenzio, when residents of the area east of the river addressed a petition to the Grand Duke asking for the intervention of a state engineer. Ferdinand II instructed the *Ufficiali dei Fiumi*, and they in turn entrusted the *Primo Ingegnere*, Alessandro Bartolotti, with the matter. After surveying the area, Bartolotti presented an ambitious and controversial plan: fixing the

46 Cf. Viviani, *Discorso al Serenissimo Cosimo III Granduca di Toscana intorno al modo di difendersi da' riempimenti e dalle corrosioni de' fiumi applicato ad Arno in vicinanza della città di Firenze*. See also Dumas Primbault, *Un galiléen d'encre et de papier*, Ch. 4.

47 See Barsanti, Rombai, "La politica delle acque in Toscana: un profilo storico", and Barsanti, "La scuola galileiana, sec. XVII", 1-42 and 43-68.

48 See Menduni, "Alcune considerazioni sulla evoluzione storica recente dell'Arno fiorentino e la relativa narrazione", 31-33.

49 Maffioli, *Out of Galileo: The Science of Waters, 1628-1718*, 193-195; Gottardi, Bugini, Camprini, Manferrari, "Aspetti della tradizione scientifico-tecnica idraulica bolognese", 69-70.

Fig. 6 – Viviani's *raddrizzamento* of the Ombrone (detail), 1700-1710, ink and watercolors on paper, Archivio di Stato di Pistoia, Deputazione sopra l'Imposizione del Fiume Ombrone, Cartoni e mappe.

Bisenzio issue once and for all by diverting the lower half of the river in a new bed that would run straight into the Arno. The plan was fiercely opposed by landowners west of the river, since while the problem was on the east bank of the Bisenzio, the new bed was to be realized in the west area of the plain, in their lands, and therefore according to the *imposizioni* it was them who were to pay the extraordinary sum of 15000 scuds estimated by Bartolotti for the realization of the work. So, they appointed an engineer, Stefano Fantoni, to argue against Bartolotti's plan. As both parties featured prominent Florentine families, the matter soon became a public affair, and then the Grand Duke decided to have his *Matematico*, Galileo Galilei, provide a *parere.* Galileo strongly opposed Bartolotti's plan, and recommended to just clean out the sediment from the bends as often as possible. As Richard S. Westfall has argued, the Bisenzio controversy is notable because it shows the ambiguous relations between "science and technology during the early stages of scientific revolution"[50]: while Bartolotti's common-sense approach and analysis makes sense, his solution was like "smashing a peanut with a sledgehammer".[51] On the other hand, Galileo's solution, though undoubtedly better "from the standpoint of modern hydraulic engineering," is derived from a misleading, abstract geometrical reasoning that "does not impress when set beside Bartolotti's conviction, born of experience, that something does happen in streams as they are forced around bends."[52]

50 Westfall, "Floods along the Bisenzio: Science and Technology in the Age of Galileo", 905.
51 *Ibid.*, 890.
52 *Ibid.*, 893.

What is interesting for the purposes of this paper, however, are not the details of the arguments brought about in the controversy, but instead the circumstance, pointed out by Cesare Maffioli, that the long theoretical discussion of the science of motion featured in Galileo's report about the Bisenzio seems to be a reply to Andrea Arrighetti rather than to Bartolotti.[53] Toward the end of 1630, after the controversy over the Bisenzio had become public, it also became a matter of discussion between the two cousins Andrea e Niccolò Arrighetti.[54] They were both friends of Galileo, knew about his new science of motion and totally agreed with it, yet on the Bisenzio they were on opposite sides: while Niccolò opposed Bartolotti's plan, Andrea favored it. They exchanged letters, and in the end, since they could not find an agreement, got in touch with Galileo.

The interesting thing in Andrea Arrighetti's position is that, as Cesare Maffioli notes, he managed to craft Bartolotti's point of view in 'galilean' fashion. More importantly, Arrighetti insisted on the fact that, as mathematically sound as they were, Galileo's and Niccolò's arguments were too far removed from reality:[55]

> Torno a dire a V.S. che non metto in dubbio nel dimostrato da S.re Galileo [...] ma non voglio già concederli per questo che lo facci né l'aqqua né altro mobile se non nella maniera che suppone il S.re Galileo, cioè rimossi tutti gl'impedimenti. Però se non insegnia la maniera del rimuovere gl'infiniti impedimenti che possano impedire e trattenere lo scorrere di detti mobili o fiumi per detti canali, non mi sento strignier in maniera che sia per mutarmi d'opinione. [...] Però torno a dire a V.S. che mi pare che equivochi fortemente nel supporre che nello scorrere detti fiumi e mobili per detti canali sieno rimossi tutti gl'impedimenti, perché in praticha è impossibile il fare tale cosa [...].[56]

Arrighetti's view is important not only because it acknowledges the crucial role of resistance in this particular matter, but also because, from a more general perspective, hints at his conviction that the new science of motion, in order to be successfully applied to material endeavors, must take into account all the "accidents" of a situation. This is suggested also by Arrighetti's correspondence with Castelli of the mid 1630s about the construction of a channel to take waters from Monteriggi to Palazzo Pitti: while Arrighetti sought mathematical advice from Castelli, he took upon himself the task of figuring out the *accidenti* e *impedimenti* that should be taken into account in order to successfully implement the project.[57] From this perspective, for Arrighetti, the on-field, common-sense expertise of the old-fashioned *architetti d'acque* could be critically reviewed, but not totally obliterated.

53 Maffioli, "Galileo, Guiducci and the engineer Bartolotti on the Bisenzio river", 194.
54 On Andrea Arrighetti, see the entry by Mario Gliozzi in *Dizionario Biografico degli Italiani.*
55 Maffioli, "Galileo, Guiducci and the engineer Bartolotti on the Bisenzio river", 190-193.
56 Andrea Arrighetti to Niccolò Arrighetti, December 16, 1630, OG, vol. XIV, pp. 185-186.
57 Cf. BNCF, Gal. 126, ff. 4r-14v.

Arrighetti played a fundamental role in the institutionalization process of Galilean science. He not only campaigned for Viviani's appointment as *capomastro*, but, as Viviani himself reports, also sponsored that of Torricelli as *Matematico Granducale*.[58] In the case of Viviani, the appointment appears instrumental in the creation of a technical staff of engineers who, while firmly rooted in Galilean science, were also familiar with the traditional expertise of the *architetti d'acque*. As seen from the bottom end, the institutionalization process of Galilean science appears as a matter of including the practical wisdom of traditional engineering into the new science of motion spread by the *matematici* through teaching, theoretical writings, and consultancy work. Consequently, it is my opinion that, by the time Viviani became *Primo Ingegnere*, he was no longer a *matematico* in the same sense as Castelli and Torricelli were, but his views on engineering had been profoundly shaped by his apprenticeship with Baccio and were by then aligned with Arrighetti's idea of the role of the *Ingegnere*. When he took the highest technical office, Viviani had already realized that the *Ingegnere* is a specific professional figure whose peculiar expertise is the result of a subtle negotiation between those of the *matematici* and those of the *architetti d'acque*, in the sense envisioned by Arrighetti.[59]

That this may be the case is suggested, first of all, by Viviani's recruitment policy. Viviani turned his own career path into a curriculum, and between 1654 and 1666 *de facto* transformed the technical office of the *Magistratura* in a practical school of engineering. By the late 1670s, the technical staff of the *Magistratura* consisted mostly of young professionals who, after having studied mathematics (with 'Galilean' teachers – sometime Viviani himself or his substitutes at the *Accademia del Disegno*), went on the field as *capomastri* and *Aiuti* to complete their education by dealing with the *accidenti* and *impedimenti*.[60] When they started working as *Ingegneri*, they adopted Viviani's approach, and on some occasion took it to the next level: in 1691, Giuliano Ciaccheri (one of Viviani's favorite disciples and close collaborators) presented an ambitious plan for the *raddrizzamento* of the Vingone river that Viviani himself rejected as too extreme.

Another element that points us towards the same conclusion is Viviani's understanding of the distinction between 'pure' and 'applied' mathematics – a distinction that over time would become, on a personal level, an unbearable separation. More than an ontological difference between a 'platonic' and a 'material' mathematics, for Viviani the distinction is functional, and resembles the modern distinction between research and operative work. The *matematici* engage in *speculazioni*, that is, they work with abstract principles in a fictitious, ideal world where it is assumed that the *infiniti impedimenti* and

58 OG, vol. XIX, 626.

59 The circumstance that Viviani agreed with Arrighetti, rather than with Galileo, was already noticed by Caverni. Cf. Caverni, *Storia del metodo sperimentale in Italia*, 184.

60 See Vivoli, Toccafondi, "Cartografia e istituzioni nella Toscana del Seicento: gli ingegneri al servizio dello Scrittoio delle Possessioni e dei Capitani di Parte".

accidenti can be successfully removed.[61] In this regard, Viviani's unfinished theoretical manuscript on hydrometry, the *Sogno idrometrico*, is illuminating. The rhetorical framing of the treatise is somewhat bizarre and out-of-fashion, even for Viviani's times: the treatise is an *adempimento* (solution) of the problems borne out of a dream that Viviani had during his five-months stay in Rome, on leave from his official duties and free to pursue *speculazioni*. The dream is reported in a letter of June 15, 1690, addressed to Gian Gastone de' Medici, that was likely to serve also as a dedicatory letter or preface to the treatise. In the dream, young Viviani is guided by Galileo through an allegorical fantasy place. At some point, the two reach a heptagonal building. They go inside, and see that at each angle there is a statue:

> La prima alla mia sinistra, dicevami il Galileo, che n'era pratico [...] esprimeva l'Amor della Verità. L'altra incontrole a destra, il Buon Genio. La terza in seguito della prima la Arimmetica, la quarta oppostale l'Astronomia. La quinta accanto alla Arimmetica era la Musica, la sesta dall'altra parte la Meccanica e l'ultima in sesta fece arrossir quel buon Vecchio [*Galileo*], e me rallegrare, perché in luogo d'un Archimede ch'egli vi aveva veduto prima, vi era sostituito il suo proprio simulacro.[62]

Once explained the meaning of the statues, Galileo takes Viviani to the center of the building:

> Fattomi così prima riconoscere il giro interno del Tempio condussemi il Galileo verso il mezzo di quello spatiosissimo ettagono, dove era in cerchio formato un gran chiuso di una bizzarra balaustrata composta d'innumerabili figure solide geometriche d'alabastro orientale, alcune delle quali io riconobbi, ma le più mi giunsero nuovissime. Dentro di questa vedevasi in eminenza una alta vasca concentrica ma in forma triangolare equilatera, tutta anch'essa d'un pezzo e di quella pietra che noi chiamiamo Amianto, atta a resistere a ogni gran fuoco. Nel centro sopra ad un gran piedistallo cubico di diamante tersissimo, stava eretta una statua maravigliosa, la qual possanza, a giudizio mio, al par delle ginocchia di que' circostanti Colossi. Questa rappresentava la Geometria in aspetto di una fanciulla di sovrumana bellezza cavata con mirabil magistero da una sola lucidissima Agata. Ma quello ch'io non potei mai comprendere si fu che al moto che noi facevamo dalle parti di quella balaustrata, non so con qual arte, ella ridente teneva fissa la faccia sua verso di Noi. Co' pollice et indice d'ambe le mani (le quali con avvenenza e grazia mirabile sporgeva dal petto in fuori) sosteneva al di sotto un perfetto globo di vera e d'ottima Calamita, dal di cui polo inferiore pendeva aderente ad una punta un gran Tetraedro di e pulitissimo acciaio. Le cingeva la testa una superba corona tempestata di gioie a me incognite, e nella falza o

61 See Dumas Primbault, *Un galiléen d'encre et de papier*, Ch. 7.
62 BNCF, Gal. 224, ff. 8r-8v.

> fascia della sua splendididissima vi si leggeva a caratteri accesissimi: *Undique singulis semper eadem.* [..] La Vasca poi, a quanto riferivami il Galileo, era piena in giro d'oro fuso finissimo, indeficiente, e convien veramente che così fosse, perché da' tre angoli della Vasca, vedevasi quello traboccar in gran copia, e profondarsi, senza sapersi dove, né da qual vena o sorgente e' pervenisse.[63]

Then, on the three sides of the basin, Viviani reads, in the form of *enigmi*, the hydrometric problems addressed in the *adempimento*.[64] Encouraged by Galileo, who explain that Viviani has at his disposal everything he needs to solve the *enigmi* (namely, Galileo's *teoremi della scientia del moto*), Galileo's last disciple, on his waking up, immediately sets to work.

The problems addressed in the *Sogno idrometrico* actually derived from water measurement experiences carried out by Viviani while in Rome, but what is interesting in the *Sogno* is the choice, which Viviani himself recognizes as out-of-fashion,[65] to use such elaborate metaphors and allegories to introduce his work. Viviani penned this dantesque fantasy in his spare time. Upon his return from Rome, he had been instructed by the *Congregazione* in charge of the Bisenzio, of which he was a member as *Matematico*, to embark on a survey of the river, as the situation had further deteriorated. So, starting from June 1691, the 69-year old Viviani was on the field again, with pencil and notebooks in his hands, like when he was a 20-year old *Aiuto*.[66] In the plain near the Arno, sediment had accumulated in the bends; moving towards Prato, riverbanks were in ruin; and in Prato there was an ongoing, decades-long litigation between landowners about the works to be done on the channels. In the end, an ambitious and expensive plan featuring major *raddrizzamenti* was approved.[67] It is interesting to observe how Ciaccheri and the *Giudici* of the *Congregazione* explained the matter of *raddrizzamenti* in the *Relazione* they sent to Viviani for approval. It seems as if they were careful to not be too harsh on Galileo's last disciple:

> Portatisi alla Visita del Fiume Bisentio i Giudici di S.A. con l'assistenza degl'Ingegneri Ciaccheri, e Ramponi, e Ministro Palloni e altri, principiando dal suo sbocco nel Fiume Arno, et in andarlo scorrendo si è riconosciuto, che il medesimo si trova in stato molto ristretto e pieno di tortuosità con avere ancora le sue ripe piene di varie sorte di Posticce, consistenti in legname, grosso e minuto, quale gli cagionano ritardamento della Corrente, e acquisto di Ripa con rodere la parte avversa, e simili sconcerti. Per provvedere a questo disordine si

63 BNCF, Gal. 224, ff. 8v-9r.

64 Actually, in the dream Viviani manage to see only two *enigmi*, as he is awakened by his servant before seeing the third one.

65 BNCF, Gal. 224, f. 11r. "I moderni analitici si contentano di meno assai".

66 See BNCF, Gal. 232, ff. 4r, 33r.

67 On the works on the Bisenzio, see Lambrini, Lazzareschi, *Campi Bisenzio: documenti per la storia del territorio*, 209-263.

è fermato destinarli la sua larghezza parte parte, come la medesima si è notata su la Pianta, che cavata ora modernamente s'aveva con noi, e rimarcarla quivi con due linee, che si sono andata tirando per il Corso permanente del Fiume, con facilitar la sua dirittura, in passarla per quei gomiti, che evidentemente si riconoscono acquisti, questa terminazione poi si è ancora accennata su la propria Ripa di Fiume con alcuni paletti piantati nelle rivolte, et Angoli dell'istesse tortuosità [...].

Poco giovano gli addirizzamenti in riguardo di loro solito grave dispendio, ma perché qui se ne vedono due, quelli si potriano intraprendere con forse avvantaggio del Publico, con trovarsi chi se ne vuole incaricare con solo conseguire il Letto vecchio di Fiume, e far tutto a sua propria spesa, a questo noi tutti ci concorreremmo vedendo molto bene che il Letto vecchio in riguardo della gran tortuosità è incaricato di continue spese [...] che queste poi non cessano di sempre più obbligare a altre [...][68]

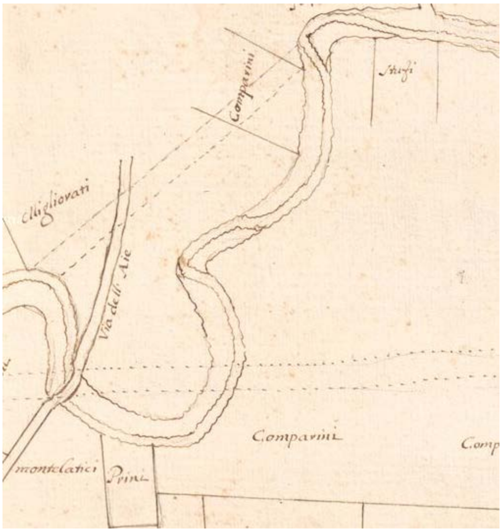

Fig. 7 – *Raddrizzamenti* on the Bisenzio (detail), 1650-1700, ink on paper, Archivio di Stato di Firenze, Piante dei Capitani di Parte Guelfa, Cartoni, Cartone XIII.

If we consider the Sogno idrometrico in this context, it is hard, for us, not to recognize the sharp contrast between the joyful walk with Galileo in fantasyland and the bone-crushing *batter la campagna* around Florence and Prato; between the otherworldliness of the enigmi posed by Geometry and the vicious disputations of landowners; between the safe haven of Galileo's theorems and the hellfire of the *accidenti* and *impedimenti*; between the

[68] BNCF, Gal. 232, ff. 52r, 56r-56v.

clear, well-defined rules of mathematics and the confusing, ever-changing laws of the State; between the freedom to engage in luxuriant allegories and the need to write sober, unimaginative *relazioni*. What we see in the Sogno is an old man trying to reconnect with his past, with a Galilean legacy that looked every day more distant; an old man who contributed remarkably to the definition of a fundamental profession – the engineer – that he did not want to do, as it seemed to require questioning at every step the legacy of his great master.

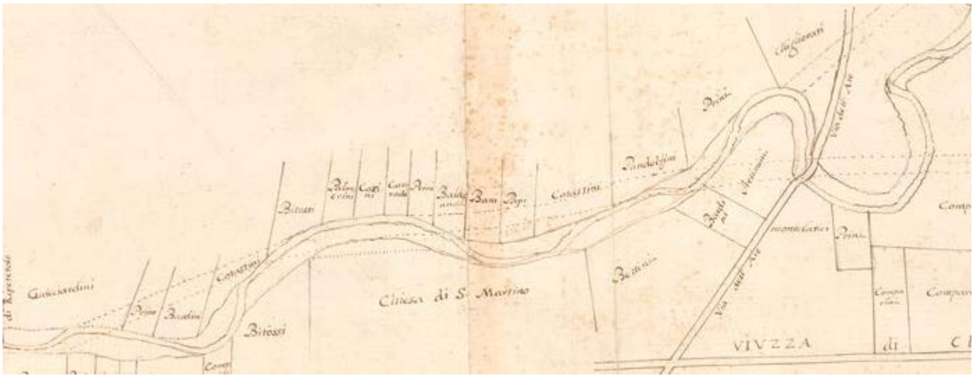

Fig. 8 – *Raddrizzamenti* on the Bisenzio (detail), 1650-1700, ink on paper, Archivio di Stato di Firenze, Piante dei Capitani di Parte Guelfa, Cartoni, Cartone XIII.

Conclusion

Today, Viviani's approach to hydraulic engineering is recognized as surprisingly innovative, modern, and effective. The *Discorso* published in 1688, where Viviani framed the problem of the Arno management within the more general context of environmental management, is seen as somewhat an anticipation of a modern tendency that would emerge only in the XIX century, and the *relazioni* are praised as examples of exactness, excellent economic planning, and careful consideration of pros and cons in engineering. Viviani's flexibility in choosing the technical solutions that best suited a particular problems is considered incredibly modern, and he is regarded as an engineer ahead of his times for the global policy he proposed. These distinctive features of Viviani's approach are often linked to his devotion to Galileo and Galilean science. It is assumed that Viviani's work in engineering is so peculiar precisely because even in engineering he was a loyal, almost sycophantic follower of Galileo. In this view, 'Galilean' influence, when is not immediately apparent – like in the *Discorso* – is implied as an attitude, a set of moral values, or a worldview that permeates everything Viviani did, almost like a religious belief.[69] While the influence of

69 Maglioni, "Vincenzo Viviani e l'Arno. Scienza Galileiana e problemi di un fiume e del suo bacino nel XVII secolo", 169-170.

Galileo on Viviani could hardly be overestimated, delving deeper into Viviani's engineering service may help to look at the matter the other way around – that is, by investigating how his training and experience as engineer and *architetto d'acque* influenced and acted on the 'galilean orthodoxy' he always professed.[70] This is useful, I think, not only to shed light on Viviani's life and work, but also to better understand, in general, the institutionalization process of Galilean science.

Acknowledgments

I am deeply indebted to Simon Dumas Primbault who let me read in advance and make use of his forthcoming monograph on Viviani, and provided me with advice and references to material relevant for this paper.

[70] As Westfall states, "It is far from clear that the new science of motion had lessons to teach on this level of established empirical practice." Westfall, "Floods along the Bisenzio: Science and Technology in the Age of Galileo", 893.

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– ESSAY REVIEWS –

A physiological challenge to qualitative philosophies: the weighty matter of insensible substance

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Book review of Barry Jonathan, Bigotti Fabrizio, eds. *Santorio Santori and the Emergence of Quantified Medicine, 1614-1790. Corpuscularianism, Technology and Experimentation*. Palgrave Studies in Medieval and Early Modern Medicine. Cham: Palgrave Macmillan-Springer, 2022.

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The title of the book at hand might suggest a study of the work of a secondary early modern medical author and the more famous figures who read and quoted from him. But it makes a case for something much more ambitious, hinted at in the sub-title: restoring Santorio to the first rank of importance as an early advocate of the corpuscularian and experimental philosophy. Santorio was among the first to demonstrate how it was possible to draw rigorous conclusions about subtle but consistent physical changes in bodies by the use of instruments that could record and track events imperceptible to the human senses alone, which in turn gave clear evidence of matter as prior to qualities. Santorio is often taken to have borrowed much of his natural philosophy from Galileo, but the reverse would be closer to the truth. The contributions to this volume add up to a powerful case for recognizing the novelty and significance of Santorio's work and of the esteem in which his work was held by later advocates of experimental medicine. And yet, because Santorio often presented his views in the form of aphorisms, questions remain about what he really meant to say: did he mean his readers to discern a radical innovator or a reformer working to improve Galenic orthodoxy? The form, content, and context of his work all invite further exploration.

As many readers of this journal will know, Santorio has been mostly overlooked in accounts of medicine and science during the past few decades. An acquaintance of Galileo, when considered at all he was commonly seen as following the example of the more famous figure. Within the history of medicine his publications did not fit easily into narratives of developments in anatomy and physiology, or the history of diseases, chemistry, surgery, or pharmacy. His name was mainly associated with the constant weighing of himself and everything that went into or came out of his body in order to show that some sort of insensible perspiration also needed to be accounted for: an amusing anecdote about an age that did not have the chemical and biological methods to properly explore metabolism. A couple of decades ago Santorio caught the attention of a scholar of eighteenth-century medical culture, Lucia Dacome, although until recently scholars of his own period continued to keep their distance. Then roughly half a decade ago, when studying controversies among Galenic philosophies of the late Renaissance, Fabrizio Bigotti obtained a research fellowship at the University of Exeter to work with Jonathan Barry and saw in Santorio's work an example of the medically-orientated natural philosophy of the day, grasping the significance of his quantitative investigations in support of a form of corpuscularianism. Bigotti's important study of 2019, *Physiology of the Soul*,[1] included some of his findings on Santorio. He and Barry spell them out more thoroughly here, and a number of other scholars follow their lead by taking up the various ways in which Santorio made a difference to those who came in his wake.

The two editors' main claims are set out clearly in a jointly-authored first chapter and Bigotti's independent contribution on Santorio's corpuscularian and experimental natural philosophy. (These two chapters are available in an open access form on the publisher's website.) The introduction begins by dealing with problems with the prevailing view that Santorio should be read in light of Galileo's mechanics, giving the medical professor an independent precedence based on the evidence of his life, times, and works. They lay out what is known about Santorio's biography, show that he and Galileo moved in overlapping circles of acquaintance but kept their distance from one another; make a case for recognizing him for inventing instruments for experimental investigation, clinical use, and surgical intervention; and conclude that Santorio promoted a "fully fletched programme of quantification" for understanding the life of the body, substituting quantifiable physiological processes for qualities and faculties. They also make the convincing case that Galileo's famous interpretations of the pendulum were inspired by Santorio's use of the *pulsilogium* to measure beats of the pulse, and that he also first invented the thermometer despite Galileo's claim to priority. Such examples allow them to distinguish Galileo's self-promoting behavior from Santorio's, who "was instead a patrician, reserved and not inclined to direct polemics: each criticism he levels either at Galen or at Aristotle is always pondered with great care and against a precise target. The overthrow of medicine as a whole was of no appeal to him although – as the Obizzi controversy reveals – it was clear to those who understood the essence of Santorio's methods that these had the capacity to revolutionise it" (33). Santorio argued that his methods were unknown to the ancients and yet that he was not trying to establish a com-

1 Bigotti, *Physiology of the Soul*.

pletely new medicine, since the consequences of his studies would not necessarily apply to all medical methods. After the authors go on to describe the instruments he invented for quantifying various phenomena, the rest of the volume digs more deeply into Santorio's philosophy and those of others who grappled with the implications of his work.

Bigotti's own contribution carefully takes the reader through Santorio's arguments so as to show how his "fully fleshed programme of quantification and measurement" engaged with some of the most powerful views of the day, transforming the occult qualities of Galenic medicine into manifest qualities that flow from elemental substances. He places Santorio among the "Aristotelian corpuscularians" – Christoph Lüthy's term – such as Italian physician-philosophers of the early sixteenth century like Girolamo Fracastoro and Julius Caesar Scaliger. Santorio's own theoretical contribution to this lineage, Bigotti argues, anticipated "aspects and trends that are pivotal to the understanding of early modern mechanical philosophy in its attempt to mathematize nature by developing new theoretical and technological tools" (66). A Venetian patrician, Santorio's earliest interests in the new approach were stimulated by his teacher, Jacopo Zabarella, and by Paolo Sarpi, who advocated the reduction of qualities to "position, figure, and number". (Sarpi not only pushed for the building of the famous anatomy theater in Padua but conducted many experiments of his own in medicine, optics, alchemy, distillation, and mechanics.) By 1612 Santorio had even developed Sarpi-like views about clockwork mechanism as an explanation for contagion, and by the mid-1620s he had drafted a now-lost work with fine engravings of medical instruments that also discussed the nature of the void. One of the chief implications of such views was the ability to rid medical theory of "occult" qualities, including those of "the whole substance", which Santorio considered unintelligible. Quantity preceded quality. Physical substances possessed weight, for instance, allowing measurement of otherwise indiscernible presence and absence, as in the proof of insensible perspiration. He could dispense with faculties, humors, and other immaterial active properties that were taken for granted in medical and natural philosophy. While Bigotti argues that Santorio presented his work as bringing Aristotelian and Galenic assumptions up to date, later readers seized on it as a foundational move in the establishment of the "new and experimental philosophy".

Twelve further studies follow. Four of them look deeply into the natural philosophy of Santorio by exploring responses to his work among his immediate contemporaries. Fabiola Zurlini describes the attack on Santorio by Ippolito Obizzi, a physician and astrologer from Ferrara, who understood Santorio's *Medicina statica* (1614) to be offering a radical attack on the very foundations of Galenic medicine and went into print immediately to refute him; an account of the objections of Leonardo Di Capua in 1681 to Santorio as an exemplar of *mathematica medica* further supports the point. William Newman examines the objections of Daniel Sennert to Santorio's attempt to make occult qualities physically manifest, even though Sennert himself had openly adopted Democritean atomism in

1619. Newman sees the difference as one of mathematical or mechanical corpusculari-anism versus "chymical atomism", the latter being a philosophical lineage that Newman himself has excavated with great clarity, and in which he places Sennert's approach (rather than Santorio's) as prefiguring "the modern chemical atom". Elisabeth Moreau also takes up Sennert, along with Isaac Beeckman, to explore how neo-atomism was explored in medical discussions of temperament in the early seventeenth century. She finds that in contrast to the views of the first two, Santorio never mentioned atoms or atomist philosophers and instead offered an account "of material shape, position, and number [that] was inspired from the matter theory of the Venetian theologian Paolo Sarpi" (155). Fabrizio Baldassarri goes on to examine the possible effects of Santorio's views on theories of the passions presented by Henricus Regius – a "former disciple of Santorio" – and René Descartes, who also had a "disciple" in Regius. He sees in the *Medicina statica* a quantitative approach to the analysis of the passions. In their two later works on the passions Regius and Descartes also treat mind-body as a composite. But Baldassarri's careful examination sees how Regius "advanced a theory of soul pertinent to Paduan Averroism and consistent with his medical pragmatism" (166) whereas Descartes substituted his own metaphysical foundation; both were therefore "complementary" approaches to Santorio's proposition rather than simple derivations of it.

The last group of eight contributions examines how Santorio's work continued to prompt productive responses from scholars in later years. Andreas Blank takes up Leibniz's understanding of Santorio as offering a view of the mind-body composite as emergent from a "kernel of substance" that retains its identity despite the effluvia of insensible perspiration, hence holding out the possibility of immortality. In this proposition Blank sees Leibniz to have simply deeply misunderstood Santorio's view of how new causal powers emerge from material composites. Vivian Nutton and Silvana D'Alessio co-author an account of the aphorisms Santorio wrote after the Venetian plague of 1630-31 and their effect on the work of Neapolitan Geronimo Gatta two decades later. Salvatore Ricciardo points to the inspiration Robert Boyle took from Santorio even as he circumscribed the application of mathematics for interpreting physical experiments. Fabio Zampieri uncovers the debt owed by the iatrochemist Giovanni Alfonso Borelli to Santorio, particularly in his understanding of fevers. Luca Tonetti does the same for Giorgio Baglivi's *Canones*, seeing how in his grappling with Santorio's work Baglivi was able to coherently join Hippocratic clinical empiricism with deductive theory in his "fibrous" concepts of bodily substance and *statica mentis*. Ruben Verwaal explores the writings of the early eighteenth-century Johannes de Gorter to show how Santorio's theory of insensible perspiration could provide a foundation for the new physiology and pathology of the nervous system that was gaining acceptance. Luciana Costa Lima Thomaz takes up the admiration of Linnaeus and his mentor Boerhaave for Santorio's dietetics, a part of Linnaeus's own medical concerns that is often overlooked. Lima Thomaz also shows that Linnaeus imitated Santorio's aphoristic method as well. In the final contribution Francesca Antonelli explores the model of Santorio's use of experimental physical instruments in the development of the chemical methods of Lavoisier and his assistant, Armand Séguin, although at the same time they criticized his ignorance of the chemistry of gases, the pneumatic chemistry of their own efforts that established a fresh understanding of metabolism.

As an excavation of the views of a sadly neglected figure of early modern medicine and natural philosophy, and of the example he set for others, this collection of essays will be indispensable. The history of ideas remains fundamental to histories of early modern knowledge. One of the important interpretative moves of the recent generation of historians has been the addition of attention to the practices employed by one or more persons in establishing their claims, and in their introduction Barry and Bigotti emphasize the innovative instruments and methods employed by Santorio. But given that his working notes have disappeared (unlike those of contemporaries like Galileo or Kepler), the editors have to fall back onto his published findings and argumentative positions rather than exploring the experimental practices in which he clearly invested considerable care. Little is known about his medical practice, either, although given the substantial wealth Santorio acquired during his lifetime he clearly had a reputation for clinical ability among a sizeable group in Venice. The rest of the contributors, who approach Santorio and his legacy from the persons and places they know best, understandably focus on the views he presented in his publications that were praised or contested by other authors. Overall, a powerful case is made for setting Santorio among the first rank of the Moderns once again.

In fact, Santorio himself self-identified as a Modern, or at least as one of the Venetian "youngsters", the anti-papal and anti-Spanish *giovani.* That sets him among patricians with an agenda, opening up other avenues for interpreting his work, too. Nick Wilding's study of Galileo's good friend from among the *giovani*, Sagredo – a member of the government and a dealer in magnetic ores among other things – points the way toward comprehending his time and place.[2] Many of the biographical details carefully checked by Bigotti and presented in the first chapter describe a heady moment. In 1561 Santorio was born into a family descended on his mother's side from nobility and on his father's side from Friuli lawyers and notaries high ranking enough to exhibit a coat of arms. They moved to Capodistria (just south of Trieste in today's Slovenia) when Antonio was appointed to the important administrative post of head bombardier and "keeper in chief" of munitions for the republic. He was clearly skilled as well as knowledgeable since the position required him to teach mathematically-intensive military engineering and to test various kinds of substances for their material quality. The Santori family were also close to the powerful Morosini patricians, in whose lodgings Santorio received his early education. He became

2 Wilding, *Galileo's Idol.*

a regular member of a sub-set of the *Ridotto Morosini*, a gathering of the Venetian elite where politics, religion, and natural philosophy were among the topics under discussion. Through the Morosini he also became close to Nicolò Contarini, a powerfully innovative statesman and philosopher who at the end of his life ruled the Republic as Doge. (An older member of the clan, Giacomo Contarini, had become known as a collector of mathematical instruments.) He also moved in the humanist circle around Gian Vincenzo Pinelli, who introduced him to Paolo Sarpi. At Padua, where Santorio graduated in philosophy and medicine, among his teachers were Girolamo Mercuriale, best known for his *De arte gymnastica*, and Jacopo Zabarella, known as a humanist philosopher who pushed Aristotelianism in an empirical direction. Santorio was probably conducting his famous weighing experiments on himself from the mid-1580s. In the later 1580s the authorities recommended him on behalf of the university to serve as a physician to a Polish prince (exactly who is disputed), but he returned to the city around 1594. His first publication, *Methodi vitandorum errorum* (1603), offered an approach to certainty in clinical cases on the basis of individuals being composed of universal properties that can be discerned through the use of instruments such as his *pulsilogium*. Due to Sarpi's good offices Santorio gained the appointment as physician to the Convent of Servites in the early 1600s, too.

Santorio's connection with Sarpi is worth pausing over, since Sarpi's views are well known and important.[3] As Barry and Bigotti note, Sarpi's clockwork-like view that bodies can be explained by "position, figure, and number" was a foundation for Santorio's experimental method. This was not far from Augustine's approval of a passage in the Book of Wisdom that says "God has ordered all things *in mensura, et numero, et pondere*" (Wisdom 11.21). For figures like Sarpi, it was therefore pointless to disentangle a natural philosophy from his political and religious positions. Sarpi was absolutely clear about defending the rule of law as superior to loyalty to persons, and his opinions of the papacy were in keeping with such principles, as his only publication, the *Istoria del Concilio Tridentino* (1619), would clearly state. Some, including the utopian philosopher Tommaso Campanella, considered Sarpi to be an atheist.[4] Modern historians have sometimes agreed, favorably.[5] A more moderate line treats him as a believer "whose religio-political ideals were essentially in line with those of St. Paul, St. Augustine and sixteenth-century reformers (both Protestant and Catholic). For Sarpi, there was no difference between serving the senate of Venice and serving God".[6] Moreover, his views about an omnipotent God compared to the ignorant pride of humans who think they can know the ineffable clearly had natural

3 Because I have not studied Fra' Paolo Sarpi, the current paragraph is not meant to be current or conclusive but simply indicative of how the breadth of Sarpi's interests points to the range and depth of the patrician milieu of the time.

4 Ernst, *Tommaso Campanella*, 26.

5 Wootton, *Paolo Sarpi*.

6 Kainulainen, *Paolo Sarpi*, 1-2.

philosophical implications. Sarpi had become a Copernican as early as 1592 and by 1595 produced a theory of the tides compatible with what Galileo later set out under his own name.[7] In that period he also helped to organize the building of the permanent anatomy theater in Padua. In 1601 the papal nuncio accused Sarpi of having denied the immortality of the soul and controverted the authority of Aristotle. More generally, his naturalism held that existence emerges from substance, and "qualities are nothing but quantities", so that "essence and universality are works of the mind" that humans are prone to elaborate imaginatively, requiring the constraints offered by mathematics to demonstrate the truth.[8]

Building a robust consensus about naturally lawful phenomena held out the possibility of a Republic in which all could participate lawfully in civil society without regard to personal conscience. It was a programme that suited urban magistrates and would also suit the needs of empires and states. Chandra Mukerji has termed that kind of naturalized state activity as "impersonal rule".[9] But while the polity framed in terms of natural law might imply a natural theology in which Creation did not respond to personal prayer, the polity in turn promised bodily well-being for its members, soon identifying measures of collective improvement of populations in the language of political arithmetic and physiocracy.[10] For persons, "mind" was also naturalized in studies of the embodied passions, as indicated in Baldassarri's essay on the echoes of Santorio's mind-body composite in the works of Regius and Descartes.[11] Did Santorio see his analysis of living composites as providing a proven path for the members of La Serenissima to remain healthy and live long, thereby supplementing the naturalized politics of Sarpi and at least some of the *giovani*?

Santorio not only came of age in the same intellectual circles as Sarpi, he also supported Sarpi's leadership of Venice's successful defiance of the papal interdict of 1606-7. Following the attempted assassination of his friend by papal agents a few months after the lifting of the interdict he rushed to Sarpi's aid from his nearby residence. He also became known as a friend of the English ambassador Sir Henry Wotton (who was aiding the anti-Jesuit party) while Fulgenzio Manfredi, an informant for the Roman Curia, reported that Santorio read prohibited books and had acquaintances among heretics. In 1611, with the likes of Sarpi, Morosini, and Contarini on his side Santorio nevertheless gained the chair in theoretical medicine at Padua, from where he published new work, including the *Medicina statica*. He served as the first President of the *Collegio Veneto* (1616-18, and again in 1622-24), meant to create a path for the awarding of doctoral degrees without the

7 Naylor, "Paolo Sarpi ...", *British Journal of the History of Science*, 47 (2014): 661-675.

8 This summary of Sarpi's position comes from the paeon to him found in the classic work of Bouwsma (which makes no mention of Santorio), *Venice and the Defense of Republican Liberty*, 520.

9 Mukerji, *Impossible Engineering*.

10 McCormick, *William Petty*; Vardi, *Physiocracy*.

11 For instance, see Giacomoni, "The Light of the Emotions", and Vila, *Suffering Scholars*.

need for candidates to publicly profess their Catholicism (and to get around the unregulated palatine degrees). The papal nuncio, Berlingero Gessi, fingered Santorio as a danger. Following Sarpi's death in 1623 Santorio was accused of negligence in lecturing, and although he was promptly exonerated he was refused a rise in his salary, causing him to resign his professorship in 1624. Or perhaps he decided to step aside from lurking dangers? In Rome, in the same period, the person who had seen Sarpi's *History of the Council of Trent* through the press in London, Cardinal Marc Antonio de Dominis, was imprisoned. He had returned to Catholicism and taken up his offices again but had confessed that he believed a reunion of the Christian churches to be possible. While awaiting trial by the Inquisition he died, but as a punishment his remains were dragged through the streets to the Campo dei Fiori and publicly burned, along with his books. Even in Venice itself, the nuncio had demanded that Sarpi's body be exhumed and tried for heresy.

Barry and Bigotti are cautious, simply noting that Santorio had become "a hindrance to new conservative politics as the Senate started taking a more conciliatory approach towards the Pope and Spain" (23). Nevertheless, Venice would ally with France against Spanish interests in the War of Mantuan Succession of the late 1620s, and Santorio's old friend Contarini was elected Doge in 1630, serving until his death in 1631. Santorio continued to issue newer editions of the *Medicina statica* and produced his last works in 1629, described by Barry and Bigotti as "textbooks" for medical students (one on the first part of the aphorisms of Hippocrates and one on new remedies). During a terrible epidemic of 1630 – reputed to have taken the lives of one-third of the city's population – Santorio refused to accept that the epidemic was truly the plague, perhaps for reasons related to the political needs of his old friend, now the Doge.

Stepping back, Santorio's life and work were as interconnected with Venetian conversations as were Sarpi's. He came from not only a privileged but also a practical background, and in his youth his education offered the latest Humanist critical studies while his personal circles put him in touch with the latest currents of interest, not least in medicine. At the same time, his world circulated many opinions, theories, dogmas, and ideologies that were hotly and sometimes violently contested, creating dangers. One can see many of the same kinds of reading, conversation, and threat in the work of an exactly contemporaneous patrician elsewhere, Francis Bacon, or in the less privileged and three-year younger Galileo. The obvious strength of Santorio's work – which made it of continued interest to people in other places and times – was therefore in the robustness of the physical evidence from which he drew his discrete and conclusive findings. In showing that insensible corpuscles could detected by exacting and tireless weighing, for instance, he gave some of the first experimental evidence for corpuscularianism a couple of decades before Jan Baptist van Helmont published his willow-and-water demonstration, which was itself a few years before Otto von Guericke or the Boyle-Hooke air-pump, or the Torricellian barometer. At the same time, however, his most important work was published in the form of aphorisms, a Hippocratic form that is excellent for presenting clear and distinct information and instruction but not best for drawing out implications from the evidence. Perhaps he chose the form for his *Medicina statica* (1614) to avoid the necessity of contradicting incompatible views, thereby side-stepping controversy? But perhaps that also made it hard for others to see the natural philosophical principles to which he adhered, in the longer run condemning him to the "second rank". Should we see that as a consequence of patrician nonchalance or necessary discretion due to the growing power of the neo-Aristotelians of the day who objected so strongly to the new philosophy?

One final implication about Santorio's work should be noted, since it comes through so clearly in his volume: he was wrestling with one of the hardest problems in medicine, how to explain qualities. As readers will know, Aristotle and his followers, including Galen, derived the elements from the qualities. According to the master, the four qualities are "primary opposites"[12] known conclusively by Reason, which combine with substance in doublets to compose the four elements. (Cold and wet yield water, for instance.) In turn, an alteration of a body composed of any of the four elements is caused by "an affective quality in virtue of which a thing is said to be affected or to be incapable of being affected".[13] As Aristotle wrote in the *Meteorologia,* this even allowed for alterations in the elements themselves: "We maintain that fire, air, water and earth are transformable one into another, and that each is potentially latent in the others, as is true of all other things that have a single common substratum underlying them into which they can in the last resort be resolved".[14] Qualities are primary. Assessments of the qualitative properties of mixed temperaments in individual bodies, foods, and remedies was therefore the foundation of medical practice, whether preventative or remedial.[15] But by Santorio's generation it was possible to think that qualities could be reduced to quantities discernable according to place, shape, and weight. This would soon be called the Mechanical Philosophy. But it was clearly already alive in some places, the commercial empire of Venice chief among them. [16]This volume provides an indispensable guide to Santorio as one of the chief interpreters of that moment.

In short, the thoughtful and well-informed studies brought together here by Barry and Bigotti add up to yet another powerful case for associating the new philosophy with the profound concerns raised by medical practice and theory. Santorio's works therefore point to fundamental questions about the sources of change in early modern European knowledge-making.

12 Lloyd, *Early Greek Science*, 107.
13 Apostle, ed., *Aristotle's Physics*, 94: Bk E, 226a.
14 Sambursky, *The Physical World of the Greeks*, 90-91: *Meteor*. 339a.
15 De Vos, *Compound Remedies*.
16 Celati, *The World of Girolamo Donzellini*. Regrettably, I discovered this important recent book only after writing the review, and wish to draw it to the attention of readers interested in the politics of medical knowledge in Venice not long before Santorio.

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