OUTSTANDING INGENUITY AND GRAPHIC FREEDOM

THE COPERNICAN *ORGANON ASTRONOMICON* OF JEAN I DU TEMPS

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ABSTRACT

In the late sixteenth century, the French provincial lawyer Jean I du Temps of Blois (fl. 1570s–1590s) devoted countless hours to difficult forms of scholarship that wove together the cultures of letters and mathematics. Perhaps the most astounding product of his labour is a manuscript set of instruments for calculating the locations of the heavenly bodies: *Organon Astronomicon ex hypothesibus Copernici extructum (Astronomical instrument constructed from the hypotheses of Copernicus)*. Unusually, and as its title indicates, the work is based on the calculations that underpin Nicolaus Copernicus' proposition of a heliocentric world system, published in his *De revolutionibus* (1543). This, as we shall suggest, bears on the manuscript's distinctive aesthetic, whereby the data on which Copernicus' provocative hypotheses rest are rendered both delightful and useful. In making his *Organon*, du Temps deployed cunning visual tactics to engage the reader, guiding them towards an appreciation both of the heavens' mathematically ordered beauty and of his own *ingenium*.

KEYWORDS

Ingenuity; wit; diagrams; tables; visual culture; astronomy; Du Temps; Copernicus.

In the late sixteenth century, the French provincial lawyer Jean I du Temps of Blois (fl. 1570s–90s) devoted countless hours to difficult forms of scholarship that wove together the cultures of letters and mathematics.[1] Perhaps the most astounding product of his labour is a manuscript set of instruments for calculating the locations of the heavenly bodies: *Organon Astronomicon ex hypothesibus Copernici extructum* (*Astronomical instrument constructed from the hypotheses of Copernicus*; The British Library, Harley MS 3263).[2] Unusually, and as its title indicates, the work is based on the calculations that underpin Nicolaus Copernicus' proposition of a heliocentric world system, published in his *De revolutionibus* (1543). This, as we shall suggest, bears on the manuscript's distinctive aesthetic. An extraordinary repertoire of "epistemic images", the *Organon*'s finely wrought, hand-coloured figures were designed to convey astronomical information in novel and visually diverse ways. They constitute an inventive response to the challenge of graphically distilling what would otherwise be extensive tabulated calculations, set out as a series of diagrams and volvelles of varying design, quite different from comparable examples of this genre.[3] The manuscript, probably made in the third quarter of the sixteenth century (when du Temps was most active), belongs to the genre of *equatoria*: instruments for locating heavenly bodies at a given time in the past or future. It comprises 92 folios of diagrams, tables and occasional brief passages of explanatory text, including maps of both earth and sky, calculation devices and chronologies. Its diagrams range in shape, from organically snaking, coiling forms to densely ruled geometrical figures: triangles and semi-circles, delicately drawn in brown ink and picked out in lemon yellow [Figs. 1, 2, 3 and 4]. The precision and care with which the manuscript has been made suggests that it was a presentation copy (we do not know for whom) – wonderful to look at, but also designed to be used.[4] In addition to explanatory text, many of the diagrams feature strings, which could be manipu-

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See Alexander Marr, A Renaissance Library Rediscovered. The 'Repertorium librorum Mathematica' of Jean I du Temps, in: *The Library* 9, 2008, 428–470. Du Temps' dates are not certain, but Jean Bernier says he was born "around 1500", while Maurice Bouguereau's description of him in 1594 as "of recent memory" indicates he died around that time. Jean Bernier, *Histoire de Blois, contenant les antiquitez et singularitez du comte de Blois. Etc*, Paris 1682, 463; Marr, Renaissance Library, 431. The research for this output was supported by an ERC Consolidator Grant, 'Genius before Romanticism: Ingenuity in Early Modern Art and Science', funded by the European Research Council under the European Union's Seventh Framework Programme (fp7/2007–2013)/erc grant agreement no. 617391.

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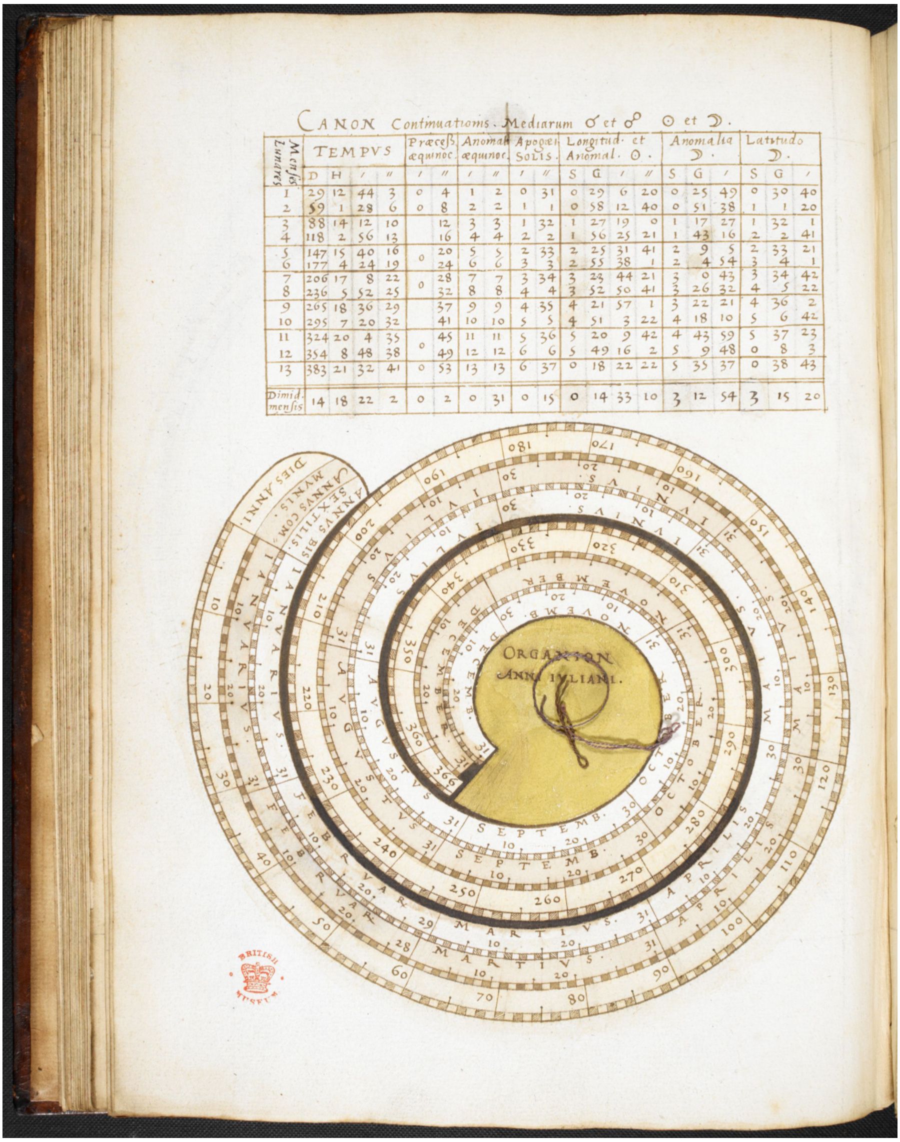
Available online at http://www.bl.uk/manuscripts/FullDisplay.aspx?ref=Harley_MS_3263.

3

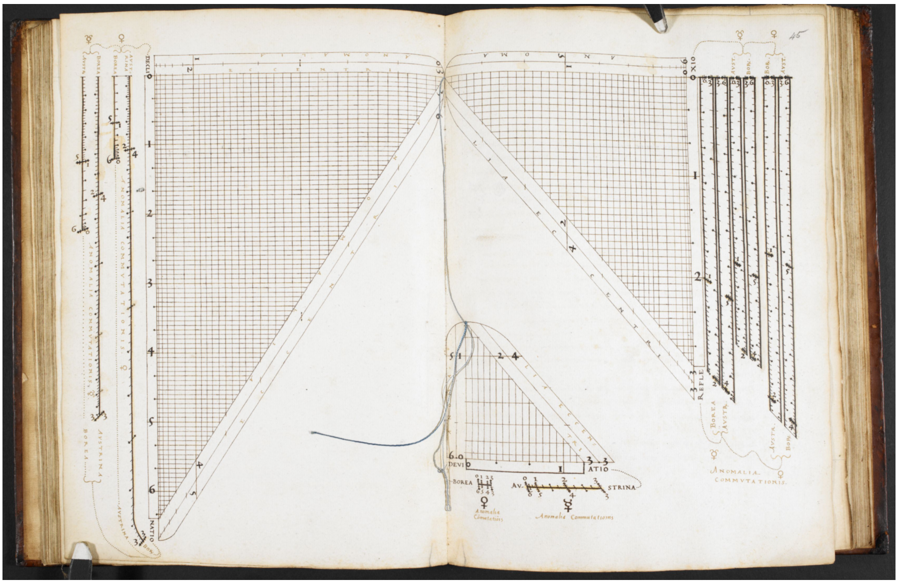
On early modern paper instruments, see Susan Dackerman (ed.), *Prints and the Pursuit of Knowledge*, New Haven, CT and London 2011; Suzanne Karr Schmidt, *Interactive and Sculptural Printmaking in the Renaissance*, Leiden and Boston, MA 2017; Boris Jardine, State of the Field. Paper Tools, in: *Studies in History and Philosophy of Science Part A* 64, 2017, 53–63.

4

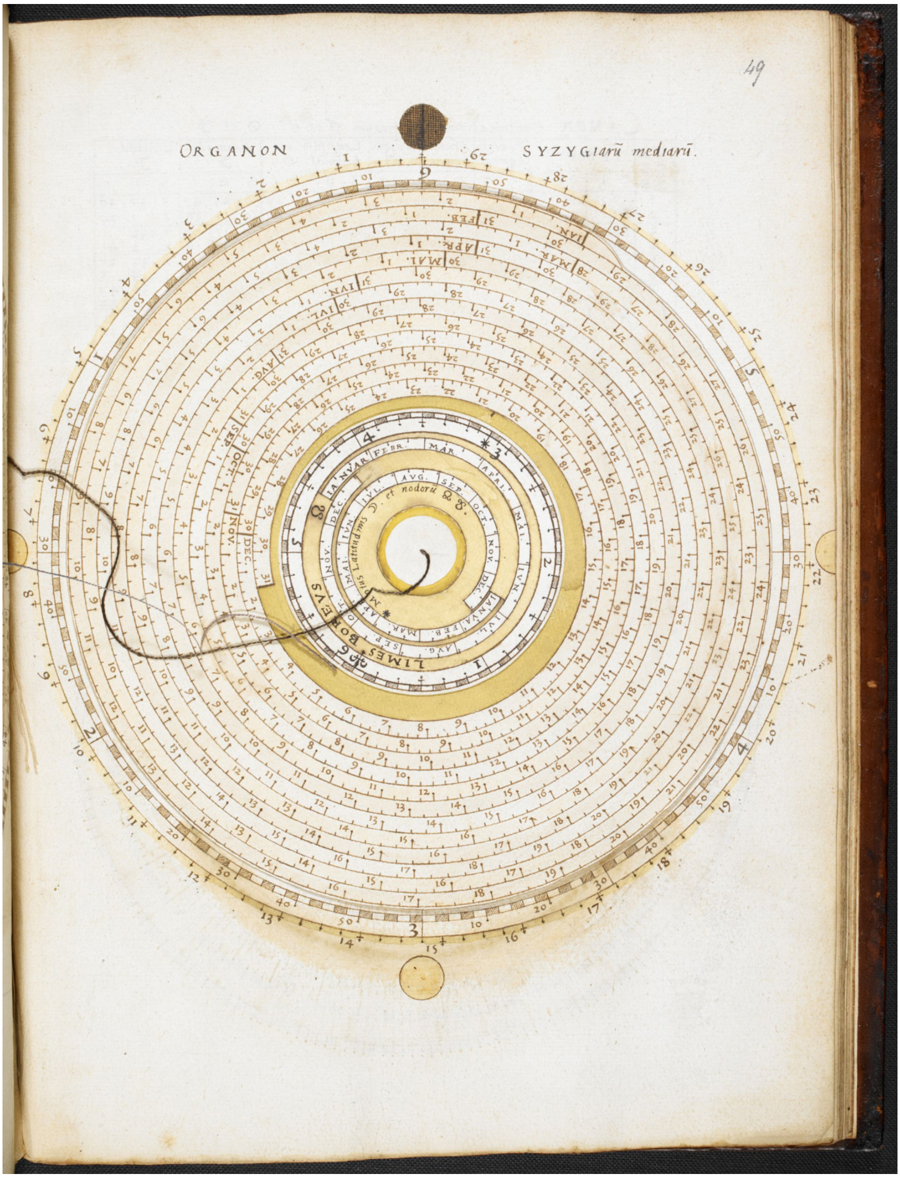
See James A. Bennett, Knowing and Doing in the Sixteenth Century. What Were Instruments For, in: *British Journal for the History of Science* 36, 2003, 129–50.



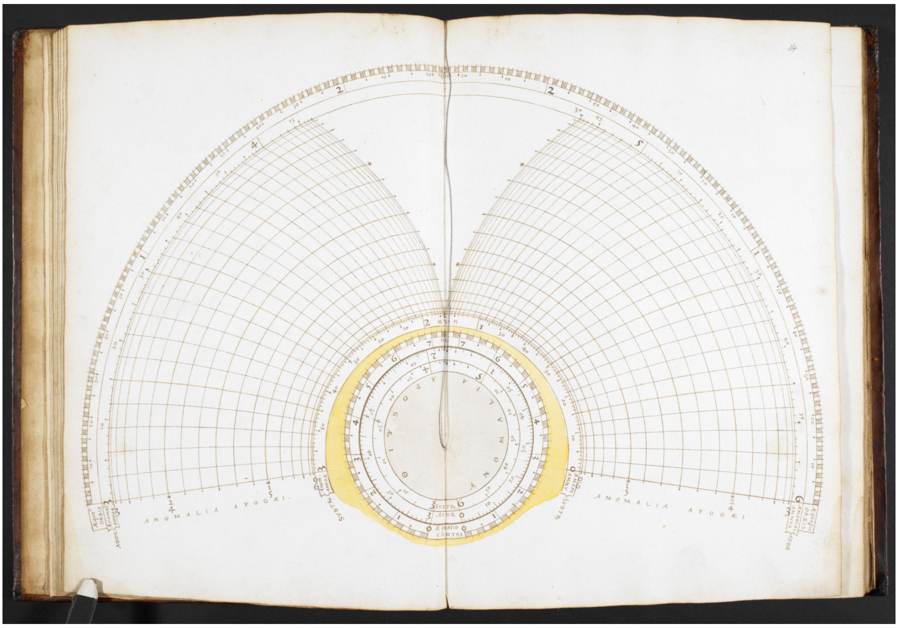
[Fig. 1]
Jean du Temps, *Organon Astronomicon ex hypothesibus Copernici extructum*, fol. 49v. London, The British Library [Harley MS 3263], http://www.bl.uk/manuscripts/FullDisplay.aspx?ref=Harley_MS_3263.



[Fig. 2]
Jean du Temps, *Organon Astronomicon ex hypothesibus Copernici extructum*, fol. 44v–45r. London, The British Library [Harley MS 3263], http://www.bl.uk/manuscripts/FullDisplay.aspx?ref=Harley_MS_3263.



[Fig. 3]
Jean du Temps, *Organon Astronomicon ex hypothesibus Copernici extructum*, fol. 49r. London, The British Library [Harley MS 3263], http://www.bl.uk/manuscripts/FullDisplay.aspx?ref=Harley_MS_3263.



[Fig. 4]
Instrument for the sun. Jean du Temps, *Organon Astronomicon ex hypothesibus Copernici extructum*, fols. 13v–14r. London, The British Library [Harley MS 3263], http://www.bl.uk/manuscripts/FullDisplay.aspx?ref=Harley_MS_3263.

lated to take readings from the minutely graduated figures. This manuscript thus renders the data on which Copernicus' provocative hypotheses rest both delightful and useful.[5] In making it, du Temps deployed visual tactics to engage the reader, guiding them towards an appreciation both of the heavens' mathematically ordered beauty and of his own *ingenium* (wit; ingenuity).[6]

By the mid-seventeenth century, the manuscript had passed from France to England, where it came into the possession of the controversial Royalist astrologer, George Wharton (1617–1681).[7] Wharton's friend, the impoverished Royalist Edward Sherburne, who spent the Civil War translating Roman poets, listed du Temps amongst the worthy astronomers of the modern age in an appendix to his translation of Manilius' poem *The Sphere* (1675):

> JOHANNES TEMPORARIUS wrote an Astronomical Treatise, which he entitled Organum Astronomicum, grounded upon the Prutenick Tables, in which the whole Work of Astronomical Calculation is contracted to two Operations, to wit, only Addition and Substraction. All Proportional Scruples are laid aside, in the search after which much time is fruitlessly spent. The true Precession of the Equinox, which by the Alphonsine Astronomers is called the Motion of the Auges of the fixed Stars, is exposed to view for some Ages to come. The places as well of the Planets as the fixed Stars are with little or no trouble found for any time given. The Conjunctions and Defects of the Luminaries, with their Quantities and Durations, are most exquisitely defined, not only in one Climate, but in any Parallel whatsoever. The Parallaxes, whose invention gives trouble to the most experienced Artists, are by a wonderful compendious way found out and cleared, as to Latitude and Longitude, without the trouble of Calculation. Whence any one may frame to himself Ephem-

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For a similar but pre-Copernican set of paper instruments of comparable ambition, see Alexander Marr, Ingenuity in Nuremberg. Dürer and Stabius's Instrument Prints, in: *The Art Bulletin* 100, 2018, 48–79.

6
On early modern *ingenium*, see Alexander Marr, Raphaële Garrod, José Ramòn Marcaída and Richard J. Oosterhoff, *Logodaedalus. Word Histories of Ingenuity in Early Modern Europe*, Pittsburgh, PA 2018.

7
On whom see Allan Chapman, Wharton, George, in: *Complete Dictionary of Scientific Biography*, vol. 14, Detroit, MI 2008, 285–86. It is not clear when or where Wharton purchased the manuscript, but it was later acquired by the bookseller Nathanael Noel, who sold it to Edward Harley on 23 February 1719/20. It was purchased for the nation in 1753 and subsequently entered the British Library with the rest of the Harleian materials. See *A Catalogue of the Harleian Manuscripts in the British Museum*, 4 vols., London 1808–12, vol. 4 (1808), no. 3263; Cyril E. Wright and Ruth C. Wright (eds.), *The Diary of Humfrey Wanley 1715–1726*, 2 vols., London 1966, vol. 1, 196, n. 1; Cyril E. Wright, *Fontes Harleiani. A Study of the Sources of the Harleian Collection of Manuscripts in the British Museum*, London 1972, 254, 425. A second copy of the manuscript is recorded in the library of the Marques of Bute in the 1870s, described as "Organum Astronomicum, by Johannes Temporarius. A MS. on paper (109 leaves) of the early part of the 18th century. Illustrated with numerous diagrams, carefully drawn and coloured. One vol, 4to." *Third Report of the Royal Commission on Historical Manuscripts*, London 1872, 208–9.

> erides without any pains or labour. The Original Manuscript of which Work is at present in the possession of my worthy Friend, George Wharton Esquire.[8]

Here, Sherburne highlights several key values of du Temps' *Organon*: the difficulty and breadth of the operations it performs; its own ease of use; and the quality or finesse of the thing itself. These qualities all make du Temps remarkable to Sherburne and help us to locate the work within a larger tradition of thought about skill, intelligence and visual thinking in the sixteenth century.[9] In this article, we will present the manuscript for the first time, setting it within the context of early modern mathematical practice and epistemic image-making. The key questions that orient our inquiry are, first, what kind of skill or intelligence did it take to produce such an object? That is, on what grounds did Sherburne single out du Temps as an outstanding practitioner? Second, what is the relationship of du Temps' celebrated *ingenium* (that is, his exemplary wit) to the aesthetic choices he made in designing epistemic images? In seeking to answer this, we will consider the extent to which the epistemic function of the *Organon* enabled – demanded, even – visual playfulness and aesthetic freedom.

I. Du Temps' Outstanding Ingenuity

The *Organon Astronomicon* was a new device intended to save the labour of calculation. As du Temps introduced the work:

> Everything in all of astronomy pertaining to calculation is [in this work] brought down to two words: ADD and SUBTRACT. It has cast aside the minutes and arcs of proportions and the parts of proportions involved in multiplication, division and the like; finding and checking these numbers has lost a great amount of time.[10]

What Jean du Temps called the "tedium of calculation" (*calculi taedium*) was all too familiar to early modern expert astronomers, and since the thirteenth century ambitious practitioners had devised

8 Edward Sherburne, *The Sphere of Marcus Manilius Made an English Poem. With Annotations and an Astronomical Appendix*, London 1675, Appendix, 58.

9 On which see e.g. Jeffrey Chipps Smith (ed.), *Visual Acuity and the Arts of Communication in Early Modern Germany*, Burlington, VT 2014.

10 Jean I du Temps, *Organon Astronomicon ex hypothesibus Copernici extructum*, The British Library, Harley MS 3263, fol. 1v. "Universa totius Astronomici calculi πραγματεια contracta est ad duo verba: ADDE, SUBTRAHE : Reiectis scrupulis proportionum partiumque proportionalium multiplicationibus, divisionibus, et caeteris huiusmodi, In quibus conquirendis et coaptandis magna temporis iactura fiebat."

a range of instruments to ease that labour.[11] By inventing a new version of such an instrument, du Temps claimed for himself the role of an outstanding practitioner.

Little known today, du Temps was memorably dismissed by Joseph Scaliger as "that shitty Temporarius, a completely stupid and incompetent man", because he had dared to disagree with the great scholar himself.[12] In fact, du Temps was widely renowned in his lifetime as a highly skilled chronologer, mathematician, cartographer and antiquarian. In his 1682 *Histoire de Blois*, Jean Bernier described du Temps as a man of extraordinary ingenuity, full of the *esprit* and heavenly fire which marked the uncommon wit of polymaths.[13] He has left to posterity a posthumously published treatise on chronology – the *Chronologicarum libri tres* (1596; second edition 1600) – famed in the seventeenth century for calculating precisely how the earth was repopulated after the biblical Flood, based on the annual birth of twins to the children of Noah and illustrated with a "timeline".[14] Well integrated into the Republic of Letters, the Protestant du Temps presented a treatise on weights and measures to his co-religionist Jean Gosselin, French Royal Librarian.[15] He contributed a map of Blois to Maurice Bouguereau's celebrated atlas, the *Théâtre Françoys* (1594).[16] His library list of some 172 mathematical books has survived – a voluminous collection comprising treatises ancient and modern across the mathematical arts, including the first edition of Copernicus' *De revolutionibus*.[17]

In collecting a substantial library of all the major works of Renaissance mathematics, du Temps already marked his member-

11
See Emmanuel Poulle, *Les Instruments de la théorie des planètes selon Ptolemée. Equatoires et horlogerie planétaire du XIIIe au XVIe siècle*, 2 vols., Geneva and Paris 1980.

12
Anthony Grafton, *Joseph Scaliger. A Study in the History of Classical Scholarship*, 2 vols., Oxford 1983–93, vol. 2 (Historical Chronology), 498. On du Temps and chronology see also John O'Brien, Entre théologie et science. La 'Chronologia' de Joannes Temporarius, in: Emmanuel Noya, Jean Dupèbe, Franco Giacone et al. (eds.), *Esculape et Dionysos. Mélanges en l'honneur de Jean Céard*, Geneva 2008, 407–15; Jed Z. Buchwald and Mordechai Feingold, *Newton and the Origin of Civilization*, Princeton, NJ 2013, 166–67. For du Temps' mathematical activity, see Marr, Renaissance Library.

13
"[N]ez avec beaucoup d'espri et de feu, n'excellerent pas simplement en une science, mais qui par le bon employ qu'ils firent de ses dispositions, & d'une longue vie, se rendirent universels." Bernier, *Histoire de Blois*, 464.

14
See Daniel Roseberg and Anthony Grafton, *Cartographies of Time. A History of the Timeline*, Princeton, NJ 2013, 70–71.

15
Bibliothèque Nationale de France, MS Fr. 18509. See Marr, Renaissance Library, 432–33.

16
The map was engraved by Gabriele Tavernier in the second half of 1591. See François de Dainville, Le Premier Atlas de France, *Le Théâtre Françoys* de M. Bouguereau, 1594, in: *Actes du 85e Congrès national des Sociétés savantes*, Cambery 1960, 1–50.

17
Marr, Renaissance Library, no. 24.

ship in an expanding cadre of *amateurs* of the mathematical arts.[18] Even though du Temps never seems to have depended upon mathematics for his livelihood, among such lovers of mathematics he was a skilled practitioner.[19] More than half the works listed in the *Repertorium* of his library belong to astronomy – of those, most deal with the practical genres of interpreting astronomical signs, such as Ptolemy's *Tetrabiblos*, as well as the tools for measuring them, such as tables, calendars or astronomical instruments.[20] In early modern Europe, the most skilled mathematical practitioners usually had careers centred on the science of the stars. The widest use of astronomy was for time-keeping, whether in measuring the sun's movements through sundials or measuring from the location of the stars in the night sky. Keeping accurate times, not only of hours, but of days and years, especially mattered for physicians, who often demonstrated their mastery of disease through measuring the susceptibility of individual character and constitution to environmental influences such as the stars.[21] Predicting the timing of comets and eclipses was also valuable for those interested in climate, weather and catastrophe. Courts around Europe, especially after the fourteenth century, patronised learned astrologer-physicians as advisors.[22] Moreover, princes and merchants sponsored a new interest in maps and the practice of cosmographers, who used the projection techniques of Ptolemy's rediscovered *Cosmographia* to transfer longitudes and latitudes of the heavenly sphere onto

18
See Richard J. Oosterhoff, Lovers in Paratext. Oronce Fine's Republic of Mathematics, in: *Nuncius. Journal of the Material and Visual History of Science* 31, 2016, 549–83; Margaret Gaida, Reading *Cosmographia*. Peter Apian's Book–Instrument Hybrid and the Rise of the Mathematical Amateur in the Sixteenth Century, in: *Early Science and Medicine* 21, 2016, 277–302.

19
On the category of mathematical practitioner, see Stephen Johnston, The Identity of the Mathematical Practitioner in 16th-Century England, in: Irmgarde Hantsche (ed.), *Der "mathematicus". Zur Entwicklung und Bedeutung einer neuen Berufsgruppe in der Zeit Gerhard Mercators*, Bochum 1996, 93–120; for some later implications, see Lesley B. Cormack, Steven A. Walton and John A. Schuster (eds.), *Mathematical Practitioners and the Transformation of Natural Knowledge in Early Modern Europe*, Cham 2017.

20
A rough representation of topics related to astronomy is as follows: astronomical theory (24), practical astronomy (41), cosmography (9), astronomical tables (10), calendars or ephemerides (11), astronomical instruments (15), chronology (2). The remainder might be classified accordingly: arithmetic (20), geometry (22), perspective or architecture (14), music (1).

21
See Sara J. Schechner, *Comets, Popular Culture, and the Birth of Modern Cosmology*, Princeton, NJ 1997.

22
See Monica Azzolini, *The Duke and the Stars. Astrology and Politics in Renaissance Milan*, Cambridge, MA 2013; Darin Hayton, *The Crown and the Cosmos. Astrology and the Politics of Maximilian I*, Pittsburgh, PA 2015; Jean-Patrice Boudet, Martine Ostorero and Agostino Paravicini Bagliani (eds.), *De Frédéric II à Rodolphe II. Astrologie, divination et magie dans les cours (XIIIe–XVIIe siècle)*, Florence 2017.

earthly maps.[23] The skills of the mapmaker and surveyor built on those of the astronomer, and all these fields demanded graphic as well as mathematical aptitude.

The *Organon Astronomicon* shows du Temps deeply embedded in this astronomical culture. The *Organon* itself was intended to be comprehensive: it opens with terrestrial maps of the two poles and concludes with star maps of the two celestial hemispheres [Figs. 5 and 6]. Thus, it is a cosmographical compendium, encompassing the entirety of the two-sphere universe. The bulk of the *Organon* comprises a suite of tools for finding the locations of all the planets, including the moments of conjunction and opposition. In a prefatory survey of the contents, du Temps lists the work's major parts, which are the traditional techniques for positional astronomy: procession of the equinoxes; locations of the planets; syzygies (planetary alignments); eclipses; parallax; and ephemerides (accounts of planetary positions for given years). Du Temps included several additional instruments beyond those listed at the outset, such as an astrolabe, a quadrant and a number of tables for aligning historical chronologies with astronomical events. Its chronological charts cover an enormous date range, from 4000 BCE to 4000 CE. This means it could be used to calculate the positions of the heavenly bodies in deep history and well into the future. In a world where astronomy served the demands of time-telling, astrology and chronology, du Temps' manuscript was a useful tool for humanist history and biblical scholarship, as well as prognostication.

Undergirding the whole array of mathematical practices encapsulated in the *Organon Astronomicon* is the skill of calculating from tables. Tables captured the mathematical models that explained where the planets and stars had been at particular times in the past, and projected where they would be in the future.[24] In this world of practice, astronomical observation chiefly provided an input for a table, from which the desired information could then be read. Contriving tables was an intensely laborious process. First, the astronomer had to understand the geometrical theories of equants and epicycles that explained each planet's varying, retrograde motions; then, having mastered the parameters, the astronomer required the intestinal fortitude to work out trigonometric problems using sexagesimal arithmetic (base-60) thousands of times in order to produce tables of values. Users of such tables could not be faint of heart either, since they had to work out several calculations first to find the 'mean' or average motion for their chosen planet, and then add or subtract several times to make corrections for the precession of

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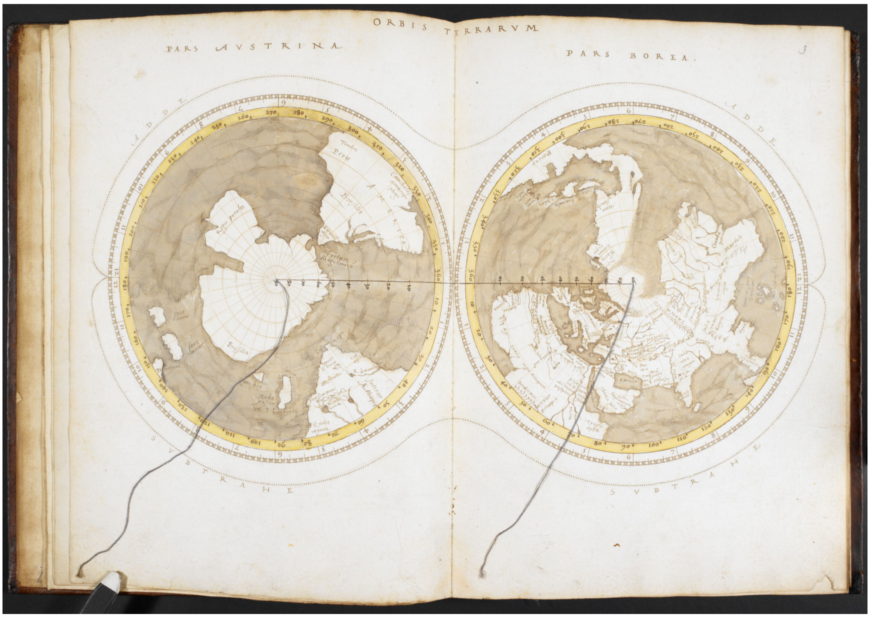
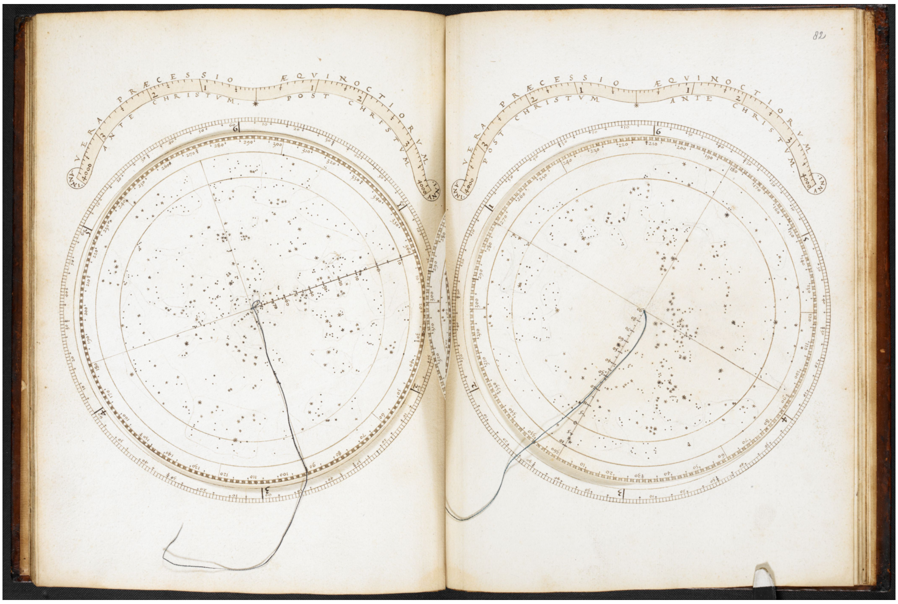
Richard J. Oosterhoff, A Lathe and the Material Sphere. Astronomical Technique at the Origins of the Cosmographical Handbook, in: Matteo Valleriani (ed.), *De Sphaera of Johannes de Sacrobosco in the Early Modern Period. The Authors of the Commentaries*, Cham 2020.

24
See Richard L. Kremer and Matthieu Husson (eds.), *Astronomical Tables in Late Medieval Europe*, special issue of *Journal for the History of Astronomy* 43, 2012.



[Fig. 5]
Terrestrial maps, centred on the two poles. Jean du Temps, *Organon Astronomicon ex hypothesibus Copernici extructum*, fols. 2v–3r. London, The British Library [Harley MS 3263], http://www.bl.uk/manuscripts/FullDisplay.aspx?ref=Harley_MS_3263.



[Fig. 6]
Star maps of the two hemispheres. Jean du Temps, *Organon Astronomicon ex hypothesibus Copernici extructum*, fols. 81v–82r. London, The British Library [Harley MS 3263], http://www.bl.uk/manuscripts/FullDisplay.aspx?ref=Harley_MS_3263.

the equinoxes, the equations of eccentrics and equants, and finally the latitude in question.

Labour, therefore, was a repeated topos for ambitious practitioners, who presented newly calculated tables to powerful patrons as a means of advertising their ability and availability. Du Temps' library was full of examples. The obvious case was the *Alphonsine Tables*, named for Alfonso X of Castile in the thirteenth century, whom astronomical writers never tired of citing as the preeminent example of a king made immortal through his patronage of astronomy.[25] The point is also made in the first two tables calculated from Copernican parameters, on which du Temps had based his *Organon*.[26] In his *Prutenicae tabulae* (the "Prutenick Tables" to which Sherburne referred in his praise of du Temps) Erasmus Reinhold wrote, "I trust other practitioners will attest my aim and the magnitude of my labour, as well as the work itself." He added, "Indeed the magnitude of labour can be judged from the fact that no one has ever produced tables with fewer errors."[27] One reason the tables were so good, he argued, was that he had worked from the new Copernican hypotheses, but he emphasised again the role of his labour, noting that like Virgil's famously slow, arduous writing of the *Aeneid*, he had taken seven years to complete the tables, painful years of war among the German electorates that had cost his wealth, health and family dearly.[28]

This is the context in which du Temps' claim of simplicity and ease belongs. Because such tables represented extreme labour, astrolabes and similar instruments helped to simplify these calculations. In notes introducing *equatoria*, the genre of instruments most closely related to du Temps' *Organon*, the word *taedium* was repeated over and again, while each new instrument was presented as an improvement upon the previous versions, successively simpler and capable of more.[29] Du Temps had a copy of Franciscus Sarzosius' 1526 manual for constructing an *equatorium*, which opened with the

25 *Divi Alphonsi romanorum et hispaniarum regis astronomicae tabulae*, Paris 1553 (Marr, Renaissance Library, no. 26). Of the Alphonsine Tables or related ephemerides, du Temps also owned those of Bianchini (no. 3), Regiomontanus (no. 48, no. 101), Schöner (no. 58d), Gaurico (no. 87) and Cyprian Leowitz (no. 102).

26 Johannes Stadius, *Tabulae Bergenses aequabilis et adparentis motus orbium coelestium*, Cologne 1560 (Marr, Renaissance Library, no. 8); Erasmus Reinhold, *Prutenicae tabulae coelestium motuum*, Tübingen 1562 (no. 97). Note that Stadius chiefly reproduced Reinhold's tables, first published in 1551.

27 Reinhold, *Prutenicae tabulae*, sig. α4r. "Artifices vero probaturos esse et voluntatem meam, et laboris magnitudinem, et opus ipsum confido. [...] Laboris vero magnitudo inde iudicari potest, quod nemo tot seculis tabulas emendatiores edidit."

28 Reinhold, *Prutenicae tabulae*, sig. α4r–v. For Kepler's comments on the labour involved, see Owen Gingerich, The Role of Erasmus Reinhold and the Prutenic Tables in the Dissemination of the Copernican Theory, in: *Studia Copernicana* 6, 1973, 43–62, here 45.

29 For these claims, see the evidence in Poulle, *Les Instruments*, vol. 2, 749–63.

same claims: Sarzosius had not invented the instrument himself, but found it "far superior to all those I had seen before". He then listed its virtues: "It converts the Alphonsine Tables with wondrous brevity, and with the easiest of calculations it indicates the motions of all the planets."[30]

In this tradition, du Temps' *Organon* is remarkably compendious. (It is also somewhat unusual as a non-Ptolemaic example, but more on that later.) Certainly, large metal and wooden instruments could be limited by size and weight, such as the early *equatorium* of Campanus, or even the brass version of Sarzosius' instrument.[31] But paper versions of such instruments – whether printed or manuscript – were widely available. Paper instruments had many other practical virtues. Advertising his own paper instrument (the *Imperial Astrolabe*, published 1515), the mathematician and Poet Laureate of the Holy Roman Empire, Johannes Stabius, explained:

> Continually the travels of his holy Majesty Caesar from province to province, of which you [Jacob Bannisius] are the most frequent companion in accordance with the demands of your duties, incur among its other nuisances this most bothersome one: that we are scarcely able to carry with us the necessary instruments of whose daily use we cannot be deprived, even after having left behind material made merely for beauty and ornamentation. So that we nonetheless would not be bereft of astrolabes and other astronomical instruments of this ilk, in which both of us take pleasure, I have recently contrived this instrument […] If it is placed in your traveling cases, it will be of no great weight. It does not pierce papers or clothes with its sharpness. It does not damage one's remaining instruments when it rubs [against them].[32]

Perhaps an even greater virtue of paper instruments produced within codexes, like that of du Temps, was their ability to incorporate much more information. In a book, such instruments could be presented alongside the simplified tables needed for their use, or repeated with variations in order to provide a complete range of instruments. Perhaps the most famous example was Peter Apian's

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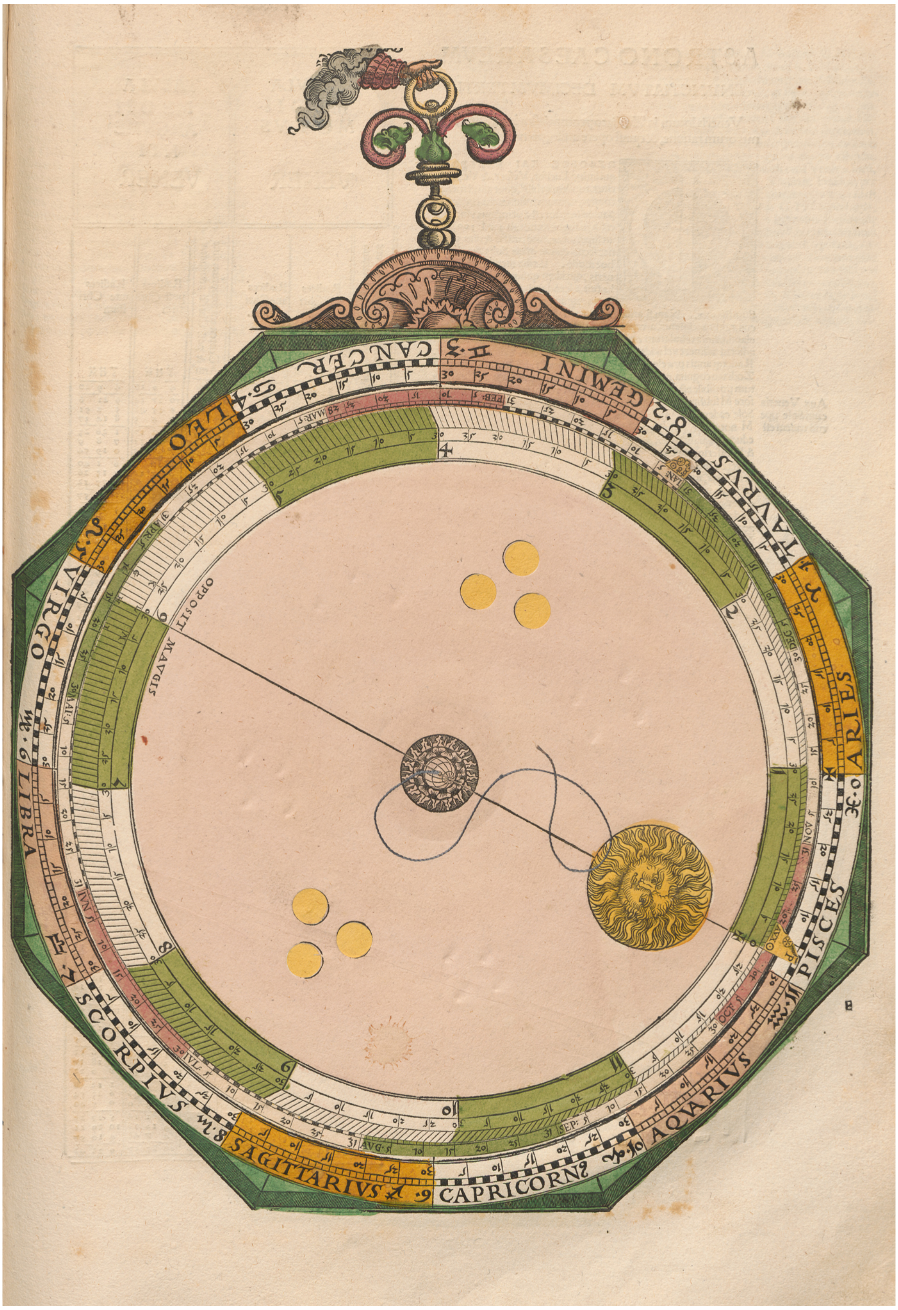
Franciscus Sarzosius, *In aequatorem planetarum, libri duo. Prior, fabricam aequatoris complectitur. Posterior, usum atque utilitatem, hoc est veros motus, ac passiones in zodiaci decursu contingentes, aequatoris ministerio investigare docet*, Paris 1526, fol. 2r. "long omnium (quos ante videre contigerat) meo iudicio praestantissimum. Qui Alfonsi tabulas miri brevitate praevertens, supputatione multo facillima, omnium planetarum motus ostendit." For more on Sarzosius, see Emmanuel Poulle and Francis Maddison, Un équatoire de Franciscus Sarzosius, in: *Physis* 5, 1963, 43–64.

31
Now in the Billmeir Collection in the Museum of History of Science in Oxford, no. 57–84/176.

32
Johannes Stabius, *Imperial Astrolabe*, quoted in Marr, Ingenuity in Nuremberg, 56–57.



[Fig. 7]
Instrument for the sun. Peter Apian, *Astronomicum Caesareum*, Ingoldstadt 1540. Zürich, ETH-Bibliothek [Rar 4287], https://doi.org/10.3931/e-rara-8724.

Astronomicum Caesareum (1540) [Fig. 7]. Apian's work is really a set of instruments, each performing the function of a particular set of tables: as with du Temps' *Organon*, he gave corrections for each of the planetary longitudes and latitudes, eclipses and other conjunctions. Apian also included calendrical advice, notes on finding critical days in medicine, observations on several comets and even a *meteoroscopion*, Apian's diagram for finding chords and sines of trigonometry. Although the *Organon* did not mirror these contents exactly, the family resemblance is close enough.

So far, we have been arguing that du Temps' *Organon* was not that unusual in its contents, and in fact fit the profile of a mathematical practitioner. But the work actually constitutes a claim of outstanding ability precisely because it fits within this tradition, ingeniously working within certain constraints to produce a novel and visually distinctive product. The reason for making an *equatorium* was not primarily its usefulness. True, makers such as Sarzosius argued that their devices would be of "public utility". As Sarzosius put it, "I was moved to write this not so much to capture an account of this instrument, but for its shared utility to students. Indeed, I rashly persuaded myself that it would be exceptional in its public utility."[33] But in fact, such instruments were often much less precise than their tables. Du Temps never claims that his *Organon* is particularly accurate. Indeed, he would have been aware that the point of an *equatorium* was not its accuracy, in the main. Such instruments were, with armillary spheres, useful for teaching the principles of astronomy, not least because their moving parts gave students an intuitive sense of how the geometric models might relate to the observations of the cosmos.[34] With this in mind, it is entirely possible that du Temps' *Organon* had a pedagogic function in mind, perhaps for a member of France's courtly elite. Practitioners themselves were widely aware that such instruments were often too small to allow users to gauge fine results: what was gained in ease was lost in precision. Jacques Lefèvre d'Étaples advised his ambitious students to use tables themselves: "You will scarcely find", he wrote, an instrument "made with such artful ingenuity that it can show plainly enough the divisions, small and large, of the arcs of ascensions. For that reason, to set everything out more clearly, one will often consult tables."[35] Indeed, Copernicus' student Georg Rheticus famously

33
"Movit itaque me ad scribendum, non tam aucupandi nominis ratio [...] quam communis studentium utilitas. [...] Nostra quidem temeritas aequatoris planetarum struturam et usum, his duobus libris, non sine publica utilitate, praestitisse sibi persuadet." Sarzosius, *In aequatorem planetarum, libri duo*, fol. 2r.

34
Adam Mosley, Spheres and Texts on Spheres. The Book–Instrument Relationship and an Armillary Sphere in the Whipple Museum of the History of Science, in: Liba Taub and Frances Willmoth (eds.), *The Whipple Museum of the History of Science. Instruments and Interpretations*, Cambridge 2006, 301–18.

35
Jacques Lefèvre d'Étaples, *Textus de sphaera*, Paris 1538, fol. 17r. "vix tamen tanto ingenio tamque fabrefactum invenias, quae arcuum ascensionum, tum parvorum tum magnorum

dismissed Apian's volvelles as an "art of threads", slighting both the fussy elaboration of these instruments with moving parts along with the manipulation they required – an inferior, mechanical way of proceeding, in contrast to the mental (and more precise) art of calculating from tables.[36]

What compelled one to make an equatorial instrument, then, was the inventor's desire to claim mastery over the science of the stars – and its fundamental tables – and to mark their own outstanding ingenuity. Even those astronomers who most despised such tools nevertheless recognised the ability they represented. Johannes Kepler offered a summary judgement of Apian's famous *equatorium*:

> Now who will offer me a fountain of tears, by which to bewail the deplorable, wretched industry of Apian, who out of his own mind followed Ptolemy and spent so many good hours in his *Astronomicum Caesareum*, who lost so many speculations too ingenious, so that he might in twists and folds and spirals and scrolls express human fictions through that labyrinthine universe of curves, which the nature of things plainly did not recognise as its own? That man shows us that he, through the divine gifts of his extremely sharp wit, could have been the equal of nature. Still, he entertained his mind in these tricks (in which he challenged nature itself), so mightily carried out and conjectured in diagrams, and he has achieved the palm of eternal fame, whatever fortune may bring to these works.[37]

Kepler makes clear that his judgement was double-sided: Apian's "wretched industry" and "speculations too ingenious" were misleading, but they marked praiseworthy ability.

II. Copernican Visual Liberty

If in making the *Organon Astronomicon* du Temps took part in a longer tradition of practitioners, the aesthetic qualities of his instru-

discrimina satis aperte monstret. Quapropter, ut dilucidius omnia pateant, saepius ascensionum tabulae consulendae erunt."

36 Cited in Jesse Kraai, *Rheticus' Heliocentric Providence. A Study Concerning the Astrology, Astronomy of the Sixteenth Century*, PhD Dissertation, Ruprecht-Karls-Universität Heidelberg 2003, 82 n. 18.

37 "Iam quis mihi fontem porriget lacrymarum, quibus ex mentu suo deplorem miserabilem APIANI industriam, qui in suo OPERE CAESAREO Ptolomaei fidem secutus tot bonas horas impendit, tot ingeniosissimas meditationes perdidit, ut spiris et corollis et helicibus et volutis et universo illo intricatissimorum flexuum labyrintho figmenta hominum exprimeret, quae natura rerum pro suis plane non agnoscit? Sed ostendit nobis vir ille, se divinis ingenii perspicacissimi dotibus facile naturae parem esse potuisse. De cetero animum oblectavit suum praestigiis hisce (in quibus naturam ipsam provocaberat) fortissime superatis et in schemata coniectis, palmamque in de famae perennis est adeptus, quicquid Operibus ipsis fortuna ista detrimenti attulerit." Johannes Kepler, *Astronomia Nova*, Heidelberg 1609, 82.

ments were anything but conventional. Unlike most *equatoria*, du Temps largely avoids simple circular forms in favour of highly idiosyncratic curves, spirals and semi-circles. Compare his instrument for the sun [Fig. 4] with the counterpart of Peter Apian [Fig. 7]. Apian's instrument is straightforward and intuitive, with the sun moving around a central earth.[38] The object shares a neat homology with what it represents. In contrast, du Temps' instrument gives no hints at the physical order of the universe. The procedure is similar, if slightly more complicated by the fact that Copernicus' model allowed for the shifting orientation (apogee) of eccentricity over time. Having found the values of the sun's mean movement on a given date, one calculated longitude, anomaly and apogee in a two-step process – using the circular scale first, followed next by the scale shaped as two wings fanned out over a semi-circle. The combination of these scales provided the "true" location of the sun.

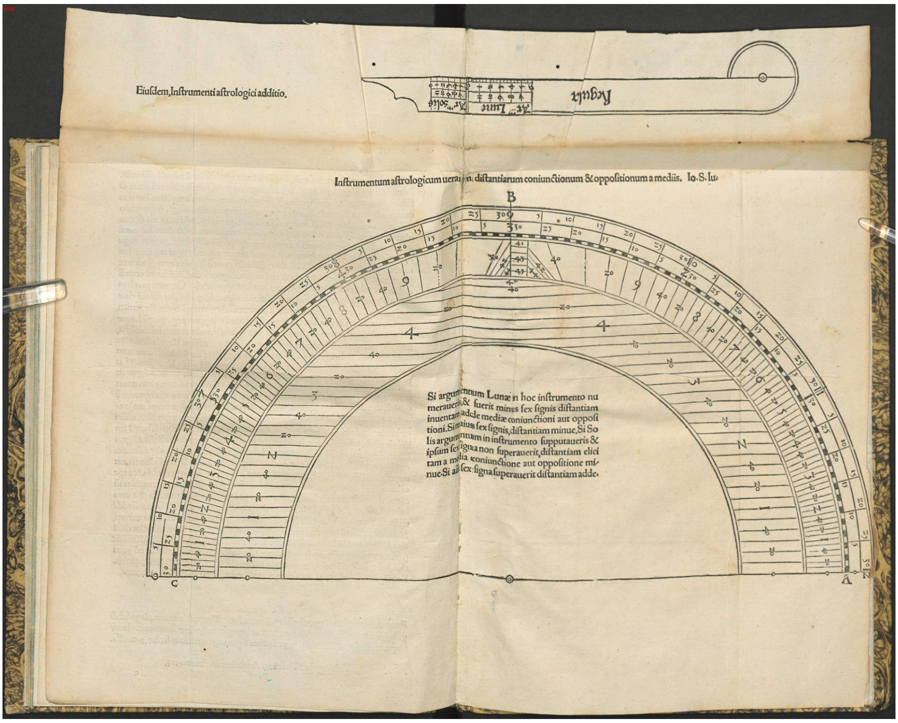
Except that, of course, the sun has no orbit in the Copernican system. Graphically speaking, du Temps' diagram is what Emmanuel Poulle called a "mathematical" instrument, in which the device for calculation isolates mathematical functions, rather than the "geometrical" *equatoria*, which function as scale models of geocentric diagrams.[39] This graphical difference would seem to follow from the fact that du Temps' instrument is Copernican, or "constructed from the hypotheses of Copernicus" (*Ex hypothesibus Copernici extructum*), as he noted on the title page. But this by no means indicates that du Temps was committed to the Copernican world system. For one thing, the *Organon* itself provides ambivalent evidence. In both geocentric and heliocentric systems, the moon circles the sun, yet du Temps offered a lunar instrument that followed precisely the same winged form – as did the analogous instrument for every planet in his manuscript.

Moreover, this graphical form has a pre-Copernican precedent, in an instrument for finding syzygies (oppositions and conjunctions of planets) by Johannes Stöffler, printed in 1514 [Fig. 8].[40] Finding syzygies was perhaps the most laborious of all calculations, because it required combining the corrections for two planets at once. Richard Kremer has argued that Stöffler's instrument drew on a fifteenth-century innovation in planetary *equatoria*, in which the corrections for the eccentricity of planetary orbits are read from a grid

38
The outer scale represents the zodiac along the starry sphere. The slightly off-set scale within the perimeter represents the sun's eccentric movement. The string represents the viewer's observation from earth. The user simply reads the sun's location from a table of computed values for given times, lines up the string to that value on the outer scale, and reads off the sun's "true" location from the inner offset circle.

39
Poulle, *Les Instruments*, vol. 1, 38. A good example of a "mathematical" instrument is Richard of Wallingford's *Albion*: John North, *God's Clockmaker. Richard of Wallingford and the Invention of Time*, London 2005, 351ff.

40
Johannes Stöffler, *Tabulae astronomicae. Verarum mediarum coniunctionum & oppositionum Solis & Lunae exactissima supputatio pro omni tempore*, Tübingen 1514.



[Fig. 8]
Instrument for finding syzygies. Johannes Stöffler, *Tabulae Astronomicae*, Tübingen 1514, sigs. e2v–e3r. München, Bayerische Staatsbibliothek [Res/2 Eph.astr. 33], urn:nbn:de:bvb:12-bsb00001937-6.

of oblique lines cutting across two circles.[41] The key innovation is that the circles do not represent planetary orbits, offset from their centre (the earth) as was thought to be the physical reality; rather, the circles represent each planet's eccentricity by varying the size of the epicycle.[42] In 1514, Stöffler's printed version of the syzygy instrument enabled the same calculation yet one more step removed from the "geometrical" instrument, allowing one to set a pointer to the input value along the outer semicircle, and then read off the solar and lunar corrections from two separate inner scales. Kremer indicates that the circular version of the syzygy instrument was never printed and Stöffler's work is not listed in du Temps' *Repertorium* – such tools were not widely available, but it is possible that du Temps had access to this decidedly non-geometrical tradition of equatorial instruments. Moreover, du Temps applied this visual form to his *planetary* instruments, while offering a circular instrument for syzygies. If anything, this suggests du Temps was outdoing this tradition of instruments rather than simply imitating earlier examples. In any event, whether or not du Temps was influenced by this tradition, it remains true that Copernican theory was not needed to sever the link between physical theory and equatorial geometry.

More generally, *hypotheses Copernici* meant, in late sixteenth-century Europe, the Copernican parameters for calculation. Certainly, this was how Copernicus was used by du Temps' source, Erasmus Reinhold's *Prutenic Tables* (1st ed. 1551), and by the broader "Wittenberg school" that depended upon him.[43] The very word 'hypothesis' came to reflect the uncertain physical status of Copernicus' model. In unpublished work, Reinhold tried to reconcile Copernican parameters with geocentrism; this was expanded upon by his son-in-law Caspar Peucer and published as *hypotheses astronomicae*.[44] Meanwhile, the Paris-based educational reformer Peter Ramus, who praised the astronomical sagacity of these German astronomers, similarly expressed his appreciation for Coperni-

41
Richard L. Kremer, Experimenting with Paper Instruments in Fifteenth- and Sixteenth-Century Astronomy. Computing Syzygies with Isotemporal Lines and Salt Dishes, in: *Journal for the History of Astronomy* 42, 2011, 223–58, here 226–42. The outer circle represents the correction for the sun's anomaly, the inner circle representing correction for the moon's anomaly. Adding these two anomalies for a given time offers the total correction needed to the mean motions of the planets.

42
Poulle, *Les Instruments*, vol. 2, 375–404; Kremer, Experimenting with Paper Instruments, 232–33.

43
Robert S. Westman, The Melanchthon Circle, Rheticus, and the Wittenberg Interpretation of the Copernican Theory, in: *Isis* 66, 1975, 164–93; Gingerich, Role of Erasmus Reinhold, 123–25.

44
On Reinhold's manuscript papers, see Peter Barker, The *Hypotyposes orbium coelestium* (Strasbourg, 1568), in: Miguel Ángel Granada and Édouard Mehl (eds.), *Nouveau ciel, nouvelle terre. La Révolution Copernicienne dans l'Allemagne de la Réforme (1530–1630)*, Paris 2009, 85–108. Caspar Peucer, *Hypotheses astronomicae ex Ptolomaei doctrina accomodatae*, Schwertel 1571.

cus' tables, but decried the claim of a moving earth – better, he said, to have developed an astronomy entirely "without hypotheses".[45] Indeed, the reception of Copernicus in late sixteenth-century French culture appears to have been deeply ambivalent, with wide respect for his mathematical accomplishment, but general scepticism regarding his physical theory. Recent commentators have, in the context of the Wars of Religion, summed up the landscape with Montaignian scepticism.[46] As Montaigne himself said: "In our day Copernicus has grounded this doctrine [geocentrism] so well that he uses it very systematically for all astronomical deductions. What are we to get out of that, unless that we should not bother which of the two [world systems] is so?"[47]

There is thus no reason why a Copernican *equatorium* should imply geocentrism. In fact, the very notion of the sun having a "true location" assumes a geocentric observer, and all Copernican *equatoria* necessarily treat the sun as moving with respect to the earth. Other Copernican *equatoria* retain systems of full circles to calculate planetary positions. Ottavio Pisani, a Neapolitan working in Antwerp, made one magnificent example. Pisani wrote Galileo in 1613 and 1614, and his *equatorium* includes small visual references to the recent Galilean observations of irregularities on the moon's surface [Fig. 9].[48] The instrument itself, though, is a triumph of the geometry of perfect circles.[49]

Du Temps' *Organon* differs from other Copernican *equatoria*. With the graphical move away from circles, du Temps broke sharply with a pedagogical tradition.[50] This can be seen even in the figures for calculating the precession of the equinoxes, or the slow rotation over millennia of the celestial sphere as seen from earth [Fig. 10]. The tool is much like a slide rule, allowing one to measure

45
Peter Ramus, *Scholarum mathematicarum, libri unus et triginta*, Basel 1569, II.47.

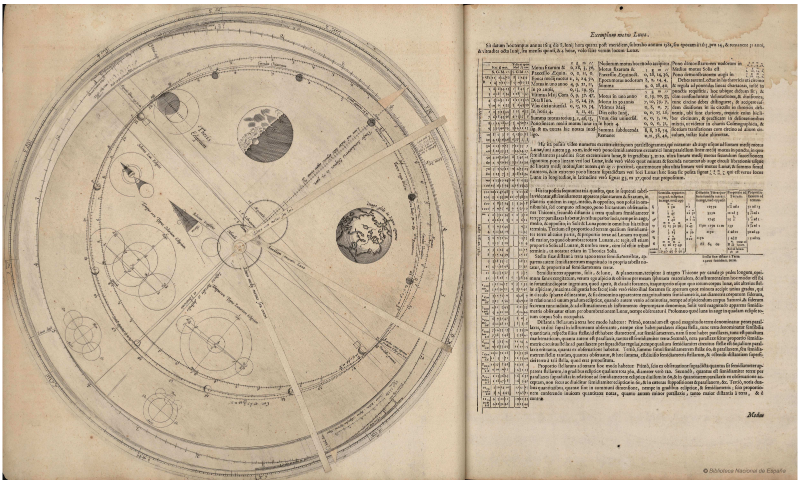
46
Frederic J. Baumgartner, Scepticism and French Interest in Copernicanism to 1630, in: *Journal for the History of Astronomy* 17, 1986, 77–88; Henry Heller, Copernican Ideas in Sixteenth Century France, in: *Renaissance et Réforme* 20, 1996, 5–26; Pietro Daniel Omodeo, *Copernicus in the Cultural Debates of the Renaissance. Reception, Legacy, Transformation*, Leiden 2014, 31–34.

47
Michel de Montaigne, In Defence of Raymond Sebonde, in: *Complete Essays*, trans. Donald Frame, Stanford, CA 1965, 429.

48
Antonio Favaro, Amici e correspondenti di Galileo Galilei. Ottavio Pisani, in: *Atti del reale Instituto Veneto di Scienze, Lettere e Arti* 7, 1895–96, 411–40.

49
For other examples, see John D. North, A Post-Copernican Equatorium, in: *Physis* 11, 1969, 418–57.

50
For more on this tradition, particularly in relation to the *Sphaera* of Sacrobosco, see Kathleen M. Crowther and Peter Barker, Training the Intelligent Eye. Understanding Illustrations in Early Modern Astronomy Texts, in: *Isis* 104, 2013, 429–70. More generally, see Isabelle Pantin, L'illustration des livres d'astronomie à la renaissance. L'évolution d'une discipline à travers ses images, in: Fabrizio Meroi and Claudio Pogliano (eds.), *Immagini per conoscere. Dal Rinascimento alla Rivoluzione scientifica*, Florence 2001, 3–42.



[Fig. 9]
Ottavio Pisani, *Astrologia, seu motus et loca Siderum: cum figuris aeneis*, Antwerp 1613, s.p. Madrid, Biblioteca Nacional de España [GMG/113]. Images property of the Biblioteca Nacional de España.

[Fig. 10]
Instrument for correcting the precession of the equinoxes. Jean du Temps, *Organon Astronomicon ex hypothesibus Copernici extructum*, fols. 7v–8r. London, The British Library [Harley MS 3263], http://www.bl.uk/manuscripts/FullDisplay.aspx?ref=Harley_MS_3263.

the change in the longitude of the sun at the vernal equinox (i.e. at the beginning of spring) as it recedes by one degree through the zodiac every one hundred years.[51] Such a rule could be any shape – du Temps was constrained by nothing except the space of the page.[52] In this instance, he rendered the ruler as a roughly oval, irregular coil, measurable through the use of a string, anchored at the centre. The instrument is akin to a winding path, which tracks the heavens' slow regress over the centuries. This visual simile is apt for the work of a scholar who was committed to pedagogy, to leading his pupils through the labyrinthine ways of mathematical astronomy.[53] As one of his disciples wrote, in an elegy on the death of du Temps:

> You were for me at my earliest age the dance-leader / In the dance-circle of the Muses; Without you I could not have followed higher paths. / I scarcely follow them yet, but you with your keen mind / Ran here over the heavens and the heavenly habitations; / We follow the arts that lazy leisure teaches / And [?] we lift our faces to heaven's path.[54]

The key point here is that this kind of mathematical work entailed a kind of *ductus*, as the mind worked its way through a set of problems, in this case following the specific route provided by the instrument with eye and hand. Thus, Du Temps' diagram demands a tactile and kinetic engagement, choreographing mind and body.

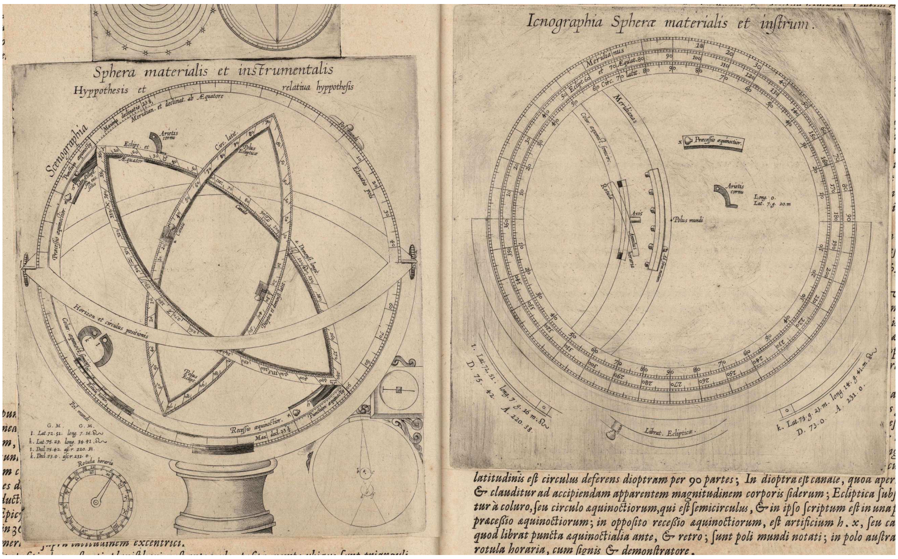
But this tactile, kinetic order differed from more standard pedagogy. Pisani designed his Copernican tool for the precession of the equinoxes as a perfect circle [Fig. 11, right]. This placed the precession of the equinoxes within a traditional pedagogical conceit for representing the heavens, an armillary sphere [Fig. 11, left]. To consolidate the conceit, Pisani includes a small crank, and pins on which the device can turn. Such a 'material sphere' belies a Copernican order, for it physically replicates the basic structure of Ptolemy's two-sphere universe, even if it calculates from new parameters. Du Temps does away with this form of pedagogy; his student no longer should rely upon the homology of physical order and

51 Note that this value is the same as given by Ptolemy, which was unchanged by Copernicus.

52 In visual form the instrument shares most with later spiral logarithmic rules by Henry Sutton, of which a print is discussed in Boris Jardine, Reverse-Printed Paper Instruments (with a Note on the First Slide Rule), in: *Bulletin of the Scientific Instrument Society* 128, 2016, 36–42, here 41.

53 For similar claims about Johannes Stabius' paper instruments, see Marr, Ingenuity in Nuremberg, 69–72.

54 "Musarum ad choream mihi p[rima]a aetate fuisti / Praesultor; sine te non potui alta sequi [.] / Vix etiam sequor illa, polum tu mente sagaci / Hic percurrebas aethe[r]iasque domos [;] / Nos artes sectamur iners quas educat umbra [...]." Quoted in Marr, Renaissance Library, 434.



[Fig. 11]
Instrument for the celestial sphere, correcting precession. Ottavio Pisani, *Astrologia, seu motus et loca Siderum: cum figuris aeneis*, Antwerp 1613, s.p. Madrid, Biblioteca Nacional de España [GMG/113]. Images property of the Biblioteca Nacional de España.

graphic representation. In place of the familiar circles within circles of the celestial spheres, the *Organon* offers a series of lines and shapes, formed by the reconfiguring of data abstracted from astronomical tables. Significantly, the designs du Temps settled on are not, strictly speaking, determined by those data, but were rooted in aesthetic choice. The Copernican movement and its 'hypotheses' seem to have given du Temps an opportunity for freedom: a space for play, unconstrained by the circular symmetries of the *equatoria* genre. Of course, this was not an absolute freedom, since all epistemic images must work within an informational constraint.[55] Moreover, certain of his predecessors (Johannes Stabius most prominently) had indulged in similarly liberal exercises of their mathematical-cum-visual imaginations in devising paper instruments of novel form. Yet the very open-endedness of the Copernican hypotheses – a dynamic, still-evolving set of calculations and questions – seems to have prompted du Temps to think in novel ways about the form of astronomical instruments.

Du Temps' *Organon* offered immediate and simple-to-use tools for problem solving, which, because further abstracted from the physical form of the cosmos, invited a deeper induction into the *habitus* of the mathematical arts. This induction was visually led: the coils and semi-circles of du Temps' manuscript insinuate themselves into the mind of the reader, who is encouraged to 'join the dots' between diagram and calculation, between space and time. Notably, the instrument's purposeful disjuncture with the physical order of the cosmos obviates the need for fretful reflection on world systems and their theological implications. Instead, this is a form of mathematical play, in which ingeniously devised epistemic images move the wits of the reader to new positions of mathematical understanding and aesthetic appreciation.[56] That is to say, both process and effect were intended to be profitable and pleasurable, or – to use the period's vocabulary – "curious and useful".[57]

Underpinning these elements is the notion that mathematics itself has an aesthetics, which therefore necessitates stylistic choice

55
See Marr, Ingenuity in Nuremberg, 52; Jim Elkins, Art History and Images That Are Not Art, in: *The Art Bulletin* 77, 1995, 553–71. The kind of 'freedom' of du Temps' *Organon* is thus quite different to other forms of aesthetic and personal liberty, such as those discussed in Mitchell B. Merback, Nobody Dares. Freedom, Dissent, Self-Knowing, and Other Possibilities in Sebald Beham's Impossible, in: *Renaissance Quarterly* 63, 2010, 1037–105.

56
See, in addition to Marr, Ingenuity in Nuremberg, Richard L. Kremer, Playing with Geometrical Tools. Johannes Stabius's *Astrolabium imperatorium* (1515) and its Successors, in: *Centaurus* 58, 2016, 104–34. For the wider implications of play and difficulty in image and artefact, see Brett L. Rothstein, *The Shape of Difficulty. A Fan Letter to Unruly Objects*, Philadelphia, PA 2019.

57
On which see e.g. Alexander Marr, 'Curious and Useful Buildings'. The 'Mathematical Model' of Sir Clement Edmondes, in: *The Bodleian Library Record* 18, 2003, 108–50.

in its visual rendering.[58] In relation to Copernicanism, this idea has usually been treated in relation to telescopic astronomy and the graphic presentation of its results, or to visualisations of planetary motion. The *loci classici* are Galileo's deployment of *chiaroscuro*, informed by his immersion in the Florentine culture of *disegno* and Kepler's witty application of regular geometrical figures to elliptical planetary orbits, fashioned as a model of nested polyhedra.[59] Du Temps' *Organon*, earlier and situated in the long tradition of planar astronomical instruments, is similarly inventive but epistemically different. Rather than 'modelling' the heavens, it abstracts from them, distilling complex calculations into elegant and useful visual forms.[60] By working through and with these images, the reader is not *shown* a remote object or a set of physical laws, but is rather *led* along pathways of mathematical knowledge that rest on a bedrock of calculation. As du Temps' sons, Jean II and Adam, explained shortly after their father's death:

> [W]hen he was seeking out the movements of the heavens with wonderful skill, he transmitted his easy understanding of them in several diagrams, so that he might make straightforwardly known to those versed in the understanding of numbers whatever heavenly matters might be hidden.[61]

This was a form of *ductus* rooted in pedagogy, situated within the conventions of humanist mathematical education to which du Temps was heir, and in which acclaim rested not on radical natural philosophical claims but on skilful invention within a tradition. In short, du Temps' achievement was a specific kind of mathematical *ingenium* or *esprit*, in which intelligence (immaterial yet embodied wit) is deployed to distil vast quantities of data into elegant and succinct visual form: the *ingenia* that are, according to period

58
On which see e.g. Lorraine Daston and Michael Otte (eds.), *Style in Science*, special issue of *Science in Context* 4, 1991; Alexander Marr, *Between Raphael and Galileo. Mutio Oddi and the Mathematical Culture of Late Renaissance Italy*, Chicago, IL 2011, 23–28; for a more minimalist account of mathematical style, see David Rabouin, Styles in Mathematical Practice, in: Karine Chemla and Evelyn Fox Keller (eds.), *Cultures without Culturalism. The Making of Scientific Knowledge*, Durham, NC 2017, 197–223.

59
There is a substantial literature on Galileo's visual techniques. See the classic study by Erwin Panofsky, *Galileo as a Critic of the Arts*, The Hague 1954; Horst Bredekamp, *Galilei der Künstler. Der Mond. Die Sonne. Die Hand*, Berlin 2007.

60
On astronomical instruments and 'modelling' the heavens, see Adam Mosley, Objects of Knowledge. Mathematics and Models in Sixteenth-Century Cosmology and Astronomy, in: Sachiko Kusukawa and Ian Maclean (eds.), *Transmitting Knowledge. Words, Images, and Instruments in Early Modern Europe*, Oxford 2006, 193–216.

61
"Et cum coelorum motus mirabili solertia disquireret, horum cognitionem aliquot diagrammatis adeo facilem tradidit, ut vel mediocriter versantibus in numerorum cognitione, quaecunque sint coelorum arcana nota fecerit." Joannes Temporarius, *Chronologicarum demonstrationum libri tres*, Rochelle 1600, sig. ãijr.

usage, both works of art and 'devices'.[62] Moreover, while intended to be used in teaching and learning, du Temps' *ingenia* were not simple tools of practice, but were instead conduits of wit that bound together maker and reader in the bonds of learned *amicitia*. As Edward Sherburne's comments about the manuscript remind us, roughly a century after its creation du Temps' *Organon* remained an object of appreciation, discussed and fêted by comrades in the Republic of Letters.

Conclusion

Du Temps' originality did not lie in novel claims about the structure of the cosmos. His paradigm is not that of new knowledge claims about the universe, but a very different episteme: one in which astronomical information served the chronologer, the biblical scholar and the astrologer. For the likes of Galileo and Kepler, *De revolutionibus* offered a radically new physics, the aesthetics of which were bound up with *chiaroscuro* and perspective in telescopic astronomy and the elliptical shape of planetary orbits. Instead, for Jean du Temps, Copernicus provided the occasion for reimagining a certain genre of instrument. *Equatoria* had always required a kinematic exercise of the mind, to connect the dots of tabular values into a visual form that allowed one to cast backwards and forwards in time. But this process had always been joined with an imagination of the physical shapes of the Ptolemaic cosmos. Du Temps reimagined these calculations with no intimation of their physical referent. This was liberating. It enabled Du Temps to deploy Copernicus in a *jeu d'esprit mathématique*, the ingenuity of which lay in concision, spare elegance and immediate utility. For his audience – be they a pupil, a prince or a scholar – these images promised immediacy, not drudgery: the swift grasping of information by visual and tactile means.

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62 See, in addition to Marr et al., *Logodaedalus*, Stefano Gensini and Arturo Martone, *Ingenium propria hominis natura*, Naples 2002; Raphaële Garrod and Alexander Marr (eds.), *Descartes and the* Ingenium. *The Embodied Soul in Cartesianism*, Leiden and Boston, MA 2020.

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