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Galileo's astrological philosophy

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*Within the history of science questions have been asked as to the source of Galileo's approach to his natural philosophy. This paper addresses these questions through a consideration of Galileo's astrological papers known as the *Astrologica nonnulla*. This paper argues that the Arabic style of astrology used by Galileo was in itself a challenge to Aristotle's physics. This style of astrology emerged in the 9th century in parallel with Islamic occasionalism and was focused on recording the changeability of the planets in the heavens and reducing them to a number value. This reductionism was undertaken to achieve a level of predictability in the believed incalculable Aristotelian sublunar realm. This paper suggests that this style of astrology provided Galileo with the thinking space which allowed him to work outside the Aristotelian dominant world view.*

In 1881 Antonio Favaro published the first works which discussed the judicial astrology of Galileo Galilei (1564-1642).¹ Since then Galileo's astrological papers have been the subject of different kinds of research. Swerdlow produced a detailed study of three of Galileo's charts drawn in his own hand in order to explore Galileo's date of birth as well as the accuracy of the ephemerides he was using.² In 2003, Campion and Kollerstrom edited a collection of papers, *Galileo's Astrology* and, in an article I wrote for this collection, I built on Swerdlow's work and investigated Galileo's astrological techniques in four of his horoscopes.³ In this current paper I present a philosophical approach to the analysis of Galileo's astrological techniques. Such an investigation aims to contribute to the question within the history of science on the origin of Galileo's philosophy of nature.

¹ Antonio Favaro, "Galileo astrologo secondo documenti editi e inediti," *Mente e Cuore*, 8, 1881, pp. 99-108; trans. Julianne Evans as 'Galileo, Astrologer', in *Galileo's Astrology*, ed. Nicholas Campion and Nick Kollerstrom (Bristol, UK: Cinnabar Books, 2003, pp. 9-16). Subsequent citations will refer to the English translation.

² N.M. Swerdlow, "Galileo's Horoscopes," *Journal for the History of Astronomy* Vol. 35 Part 2, no. 119 (2004).

³ Bernadette Brady, "Four Galilean Horoscopes: An Analysis of Galileo's Astrological Techniques," in *Galileo's Astrology*, ed. Nicholas Campion and Nick Kollerstrom (Bristol, UK: Cinnabar Books, 2003).

Galileo's approach to the natural world has been the cause of debate for a period of time. In 1936 Wiener concluded "...that the innovations in the contents of his physical doctrines were made by Galileo within the framework of a Platonic conception of the physical world."⁴ Wiener also considered that Galileo's ability to use thought-experiments and not solely rely on sense experience was further evidence of the influence of Platonist thinking within his methods.⁵ In 1943, Koyré argued that Galileo had to have a source for his inspiration and that his famous utterance that the Book of Nature was written in geometrical characters revealed that his inspiration was in fact Plato.⁶ In that same year, Olschki disagreed with Koyré by pointing out that Platonism, although evident in Galileo's work in his attempt to find abstract mathematical concepts, was not supported by his desire to use it to produce a "functional, concrete, and measurable reality".⁷ Olschki argued that there was indeed no philosophical background that supported Galileo's natural philosophy which "...developed into a science of quantities and relations" and that "the epistemological value of mechanics had never been anticipated, much less proclaimed and taught, by any one of his precursors."⁸ Olschki concluded that there was no source in science or philosophy which provided the inspiration for Galileo to use the principles of the movement of the heavens as a source for the quantification of the natural world,⁹ and this conclusion silenced the questions around the source of Galileo's philosophy. Since that time the debate appears to have shifted to the manner in which Galileo developed his ideas. This current debate is based on a detailed examination of Galileo's notebooks of his experiments, in the attempt to understand the development of his thinking, as well as the role that his experiments actually played in his final published works.¹⁰ However, this paper returns to Olschki's conclusion and suggests that there is a source for Galileo's philosophy and this source can be found in his astrological notebook, the *Astrologica nonnulla*.

Galileo thought and worked outside Aristotle's cosmology, but, as Olschki suggested, he also worked outside the Platonist cosmology. Galileo was able to contemplate the implications of denying the split between the supposedly immutable and unchanging heavens and the corruptible and changing sublunar world. In this way he saw both worlds as being subject to the same influences of change and corruptibility.¹¹ He applied

⁴ Philip Paul Wiener, "The Tradition Behind Galileo's Methodology," *Osiris* Vol. 1(1936): p.733.

⁵ Wiener, "The Tradition Behind Galileo's Methodology," p.738 - 9.

⁶ Alexandre Koyré, "Galileo and Plato," *Journal of the History of Ideas* Vol. 4, no. 4 (1943): p.419.

⁷ Leonardo Olschki, "Galileo's Philosophy of Science," *The Philosophical Review* 52, no. 4 (1943): p. 355.

⁸ Olschki, "Galileo's Philosophy of Science," p. 355 - 6.

⁹ *Ibid.*, p.357.

¹⁰ See Ronald H. Naylor, "Galileo's Method of Analysis and Synthesis," *Isis* 81, no. 4 (1990); Joseph C. Pitt, "Galileo, Rationality and Explanation," *Philosophy of Science* Vol. 55, no. 1 (1988).

¹¹ G. Galileo, *Dialogue on the Two Chief World Systems*, trans. Stillman Drake (Madison: University of Wisconsin Press, [1632] 1967), p. 37-48.

this way of thinking to his studies of motion, not of the heavens but to the movement of objects in the sublunar world. Aristotle considered motion to be a ceaseless, circular and perfect cosmological phenomenon which occurred in the heavens. The perfect motion of the heavenly bodies produced a temporary disturbance below the moon in all earthly objects. This temporary disturbance was believed to be an unwelcome influence on earthly objects, with the result that earthly objects sought to restore themselves to the perfect motion of the heavens. Motion, therefore, in the sublunar world was believed to be the pull towards perfection by an object and was deemed to be a philosophical or even spiritual phenomenon rather than a natural concept. To attempt to understand it through geometry or mathematics was, as Olschki pointed out, beyond the principles of Aristotelian cosmology.¹² Rather than altering Aristotle's physics, Galileo's ideas on motion dismantled it.

Galileo also dismissed the Pythagorean philosophy of the mystique of number by stating that numbers were about quantity and not quality. "I feel no compulsion to grant that the number three is a perfect number, nor that it has a faculty of conferring perfection upon its possessors".¹³ And in the *Assayer* he stated:

Before I proceed let me tell Sarsi that it is not I who want the sky to have the noblest shape because of its being the noblest body; it is Aristotle himself, against whose views Sig. Guiducci is arguing. For my own part, never having read the pedigrees and patents of nobility of shapes, I do not know which of them are more and which are less noble, nor do I know their rank in perfection. I believe that in a way all shapes are ancient and noble; or, to put it better, that none of them are noble and perfect, or ignoble and imperfect, except in so far as for building walls a square shape is more perfect than the circular, and for wagon wheels the circle is more perfect than the triangle.¹⁴

By demystifying number and shape (geometry) Galileo put them to work to understand the natural world. In his dialogue between Simplicio and Sagredo he wrote:

Simplicio: But I still say, with Aristotle, that in physical (*naturali*) matters one need not always require a mathematical demonstration.

¹² Olschki, "Galileo's Philosophy of Science," p.351.

¹³ Galileo, *Dialogue on the Two Chief World Systems*, p.11.

¹⁴ Galilei Galileo, "The Assayer," in *Discoveries and Opinions of Galileo*, trans. Stillman Drake (New York: Doubleday & Co. , [1623] 1957), p.263.

Sagredo: Granted, where none is to be had; but when there is one at hand, why do you not wish to use it? ¹⁵

Once Galileo had a mathematical insight to an expression of motion he proceeded in an axiomatic manner, bolting one axiom to another, building up his solutions to dynamic problems to produce theorems which in turn lead to predictability in the sublunar world. ¹⁶ He was both mathematical and mechanical and, as Girill argued, once he had devised a theorem he then used it for empirical predictions which in turn helped prove his original theory. ¹⁷

Galileo's use and application of number and geometry was unique. Previous to him, Robert Grosseteste (1175-1253) and Roger Bacon (d.1294) in their work in optics had both made what Crombie stated was a "quasi-quantitative account of Aristotle's explanation of colour as a mixture of light and darkness." ¹⁸ Crombie also points out that until the time of Galileo there had been no attempt to use number to measure amounts of change except in matters of astronomical observation, astrology and navigation. ¹⁹ Galileo's genius was that he freed number from quality and then used it to actually *measure* qualities.

Galileo's views that nature is the same in both the celestial and the terrestrial worlds, and that numbers and geometry are mundane, are indeed not comfortable within Plato's or Aristotle's philosophy. Galileo's philosophy appeared to be secular, pragmatic and expectant. His aim was to understand the workings of the physical world which for him seemed to be stripped of Platonic mystery. With this attitude he could put his celestial observations to the service of providing proofs for his findings in the terrestrial world, showing both change in the predictable heavens and predictability within the ever-changing earth.

In 1943 Olschki could not find any source for this way of treating the natural world. However, in early 17th century Europe there was a body of philosophy that did support a link between the movement of the heavens and the quantification of that movement to the natural world. This pragmatic, predictive-seeking, axiomatic approach to the physical world was, as will be shown in this paper, evident within astrological thought of that

¹⁵ Galileo, *Dialogue on the Two Chief World Systems*, p.14.

¹⁶ See for example G. Galileo, *Dialogues Concerning Two New Sciences*, trans. Henry Crew and Alfonso de Salvio (Buffalo, New York: Prometheus Books, [1638] 1991), p.153.

¹⁷ T. R. Girill, "Galileo and Platonistic Methodology," *Journal of the History of Ideas* Vol. 31, no. 4 (1970): p.520.

¹⁸ A.C. Crombie, "Quantification in Medieval Physics," *Isis* Vol. 52, no. 2 (1961): p.148.

¹⁹ Crombie, "Quantification in Medieval Physics," p. 149.

period. Indeed, when Girill commented on Galileo's research methodology by saying that Galileo "...introduced figures, numbers and abstractions into his theories for the essentially practical reason that they aided him in organizing and explaining the flux of phenomena...",²⁰ this description also aptly fits Galileo's astrological methodologies. Galileo's astrological papers reveal the use of figures, numbers and abstract quantification as he worked with his astrological methodologies in his attempt to predict or explain the "flux of phenomena" in the lives of his family, friends and associates.

In 1582, at the age of seventeen, Galileo became a student of medicine at the University of Pisa. It was in Pisa that he would have learnt, or consolidated, his astrology. Biographer James Reston commented that Galileo learned astrology at Pisa as part of his medical training, stating, "Ironically, medicine came under the heading of the arts, and this was apt since the profession still contained a large element of faith and hocus-pocus."²¹ Reston's reference to astrology as "hocus-pocus" is a 20th century opinion, yet in the early 17th century astrology was a respected subject within medical studies.²² Galileo did not finish his medical training but moved into the study of mathematics. In 1589, at the age of 24 years, he was appointed Professor of Mathematics at Pisa, and in 1592 to the same position at Padua University where he stayed until 1610. According to Favaro²³ and Sobel,²⁴ one of the duties of this chair was to teach astrology to the medical students; indeed it appears that most of the horoscopes in Galileo's personal papers were cast in this time period.

While at Padua he also undertook paid work as an astrologer. His own daily account books show that he recorded income received for astrological readings.²⁵ His reputation as an astrologer was well known and his services were called upon by the Grand Duchess Christina of Lorraine who implored him to find the true day of birth of the Duke by using judicial astrology.²⁶ His genuine interest in astrology is also revealed by his long standing correspondence with Ottavio Brenzoni, a professional astrologer in Verona with whom he discussed charts and sought astrological opinions over the course of his 18 years at Padua University.²⁷ Independent of Galileo's own papers there are also the records of the Inquisition. In April 1604 Galileo was summoned and tried for being too fatalistic in his

²⁰ Girill, "Galileo and Platonistic Methodology," p.520.

²¹ James Reston, Jr, *Galileo, a Life* (New York, USA: Harper Collins, 1994), p.13.

²² Robert S. Westman, "The Astronomer's Role in the Sixteenth Century: A Preliminary Study," *History of Science* Vol. 18(1980): p.118.

²³ Favaro, "Galileo, Astrologer," p.17-18.

²⁴ Dava Sobel, *Galileo's Daughter* (London, UK: Fourth Estate, 1999), p.52.

²⁵ Favaro, "Galileo, Astrologer," p.13-14.

²⁶ *Ibid.*, p.11.

²⁷ See Grazia Mirti, "Galileo's Correspondence," in *Galileo's Astrology*, ed. Nicholas Campion and Nick Kollerstrom (Bristol, UK: Cinnabar Books, 2003).

astrological forecasts for his clients. He was found to be a heretic and charged with “living as a heretic” but his position at Padua University probably protected him from further prosecution.²⁸ The implication of this trial will be considered later in this paper.

Central to my investigation are Galileo's own astrological notes and chart collection called the *Astrologica nonnulla*. These comprise some fifty pages of horoscopes and supporting astrological calculations in Galileo's own hand and form the first volume of the sixth part of Galileo's Manuscripts at the Biblioteca Nazionale in Florence. These are not the charts or astrological work prepared for clients but Galileo's personal collection of horoscopes of family members and friends which he maintained and annotated for his own use. The material researched for this paper is a photocopy of the *Astrologica nonnulla* consisting of 27/28 horoscopes, notes, drawings, and random calculations. Of these horoscopes, 19 consist of a single chart with or without planetary calculations, and 8 are charts accompanied by *Dominus Geniturae* tables.²⁹ Of these 8 charts, 2 have additional pages of predictive work. The dates of the charts range from 1505 to 1603, with one further chart constructed for a birth or event in 1624.

What is revealed in these papers is an astrology which is predominantly Arabic. It contains the quantification of qualities known as almuten tables³⁰ used for defining house rulers, as well as *Dominus Geniturae* tables, which are compound almutens built up as a series of astrological axioms to create a grand or larger theory. In addition there are variations to these axioms inserted by Galileo.

Arabic Astrology—the body of astrological works that had been written in Arabic within an Islamic cultural milieu—had been introduced into Europe through a series of translations into Latin made between the late tenth and the thirteenth centuries. The translation of these texts was concurrent with the development of theoretical medicine, and the conception of the doctor as acting in partnership with nature as a whole. He was no longer a ‘medicus’ but a ‘physicus’ (hence our term ‘physician’) who brought into consideration both the sublunar elements and the influence of the heavenly bodies in treating the human body, which was considered the microcosm within the macrocosm of the universe. Works like the *Centiloquium*, a collection of 100 astrological aphorisms believed to have been written by Ptolemy, were addressed equally to medical men and to

²⁸ See Antonino Poppi, “On Trial for Astral Fatalism: Galileo Faces the Inquisition,” trans. Martin Davies, of excerpts from *Creminini, Galilei e gli Inquisitore del santo a Padova* (Padua 1993) in *Galileo's Astrology*, ed. Nicholas Campion and Nick Kollerstrom (Bristol, UK: Cinnabar Books, 2003).

²⁹ *Dominus Geniturae* tables (Lord of the Chart Nativity) are tables in which planets are assigned quantitative values which are then computed to produce the planet ruling over the individual's life.

³⁰ Almuten tables are explained in more detail when considering Galileo's actual astrological papers.

astrologers and were used by the prognosticating doctor of the Middle Ages.³¹ The *Great Introduction to Astrology* of the Iranian-Afghan astrologer Abū Ma'shar (787 – 886), which was translated into Latin twice (in 1133 and 1140), included a whole section on the usefulness of astrology for doctors..³² According to French, the medical texts used in Europe prior to the introduction of Arabic astrology were “innocent of predictive astrology”. “With the new Arabic mathematical astrology”, he writes, “came the notion that celestial causes were linked to mundane effects in a necessary way, which implied that once the rulers were known prediction was guaranteed.”³³ How this was “guaranteed” will be discussed later when Galileo's astrology is addressed. However, this seeking for empirical prediction in the sublunar world presented challenges to Christian-Aristotelian cosmology.

Aristotelian physics relied upon an ordered hierarchical system. At the top of this hierarchy was God positioned as the primary cause; the planetary spheres and their movements provided additional secondary causes. The earth with its sublunar position received the commingling of both primary and planetary secondary causes. Within Aristotle's model, therefore, nature was not seen as an autonomous principle and thus consistent predictability in the sublunar realm was not feasible.³⁴ As described by Bostock, Aristotle did not seek an understanding in terms of predictable laws in his approach to nature but rather sought an explanation through the nature of the thing itself – a *who* rather than a *what*.³⁵ By the early 14th century Aristotle's cosmology had been adopted into Christian theology through the work of Saint Thomas Aquinas (c.1225 – 1274) and as a result, according to French, consistent predictability in the sublunar world was thought to be outside Aristotle's physics and even heretical.³⁶

However, within Islam, Aristotle's cosmology had varying levels of acceptance. The Persian philosopher Avicenna (c.980 – 1037) described God as being concerned with universals rather than particulars, and God knew of particulars only in a universal way. For Avicenna there was a fine theological distinction concerning the nature of universal

³¹ Roger French, "Foretelling the Future: Arabic Astrology and the English Medicine in the Late Twelfth Century," *Isis* Vol. 87, no. 3 (1996): p.458.

³² Charles Burnett, "The Certitude of Astrology: The Scientific Methodology of Al-Qabīṣī and Abū Ma'shar," *Early Science and Medicine* Vol. 7, no. 3 (2002): p.212; Lynn Thorndike, *History of Magic and Experimental Science Part 3* (New York, London: Columbia University Press, 1923), p.77.

³³ French, "Foretelling the Future: Arabic Astrology and the English Medicine in the Late Twelfth Century," p.458 - 9.

³⁴ See, for example, Aristotle, "Categories," in *The Complete Works of Aristotle*, ed. Jonathan Barnes (Princeton, NJ: Princeton University Press, 1984), 3b. 10-20.

³⁵ David Bostock, *Space, Time, Matter, and Form, Essays on Aristotle's Physics* (Oxford: Oxford University Press, 2006), p.76.

³⁶ French, "Foretelling the Future: Arabic Astrology and the English Medicine in the Late Twelfth Century," p.458, 75,79.

knowledge as distinct to knowledge of particulars. However, Avicenna's position allowed an element of human free will within the sublunar world and supported an Aristotelian cosmology of primary cause and the commingling of secondary causes.³⁷ But Avicenna's views were not universally accepted. From as early as the 9th century extreme opponents of causality within Ash'arite Sunnism promoted the doctrine that God was the sole cause of all events, thereby denying the existence of any secondary causes.³⁸ These views were supported by Abu Hamid al-Ghazālī (1058 – 1111) when he attacked Avicenna's philosophy and challenged the principle of causation, stating that Avicenna's God who knew *only* universals neither knew individual men nor their individual acts.³⁹ The Ash'arite doctrine of a world of no causation was further supported by al-Ghazālī's condemnation of the work of Plato and Aristotle in *The Incoherence of the Philosophers*.⁴⁰ Al Ghazālī's position, which became known as Islamic occasionalism, stated that God was the sole reason for the existence of all things and that there was in fact no causation.⁴¹

In parallel with these theological debates a development occurred within Islamic astrology that separated it, in techniques at least, from its Aristotelian/Ptolemaic foundation. According to Curry, the nature of astrological practice tends to be a reflection of its surrounding culture.⁴² If so, then it is difficult to think that the changes in Islamic astrology in the 9th century were totally isolated from the emerging philosophical or theological milieu of the period. These new developments appeared in the astrology of Omar of Tabaristan ('Umar ibn al-Farrukhan al-Tabari; died c. 816 C.E.) as an increasing emphasis on the idea of the almuten which eventually led to assigning quantitative values to the quality of planets in terms of their horoscopic position, a technique which will be described in detail later in this paper.⁴³ Other changes in Islamic astrology in this period were reflected in the work of Abū Ma'shar. These are listed by

³⁷ See Michael E. Marmura, "Some Aspects of Avicenna's Theory of God's Knowledge of Particulars," *Journal of the American Oriental Society* Vol. 82, no. 3 (1962).

³⁸ Ilai Alon, "Al-Ghazālī on Causality," *Journal of the American Oriental Society* 100, no. 4 (1980): p.399.

³⁹ Marmura, "Some Aspects of Avicenna's Theory of God's Knowledge of Particulars," p. 312.

⁴⁰ See ———, "Some Aspects of Avicenna's Theory of God's Knowledge of Particulars."

⁴¹ Alon, "Al-Ghazālī on Causality," does suggest that a more careful reading of his work raises questions around his doctrine on causation.

⁴² See Roy Willis and Patrick Curry, *Astrology Science and Culture, Pulling Down the Moon* (New York Berg, 2004), p. 77 - 86. This argument is also supported by an appraisal of the popularity of Western astrological techniques in the 20th century which moved from the post-Einstein quasi-science of Ebertin's Cosmobiology which was highly reductionistic and mechanical and gave way to the post-1960s psychological astrology of Arroyo, Greene and Sasportas, to name a few astrologers, with its more holist and reduced technical approach to chart reading.

⁴³ Omar of Tiberias, *Three Books on Nativities*, trans. Robert Hand (Berkeley, Springs USA: Golden Hind Press, 1997), p.13.

Hand as the application of orbs, different aspect theory and quadrant houses.⁴⁴ However, it is the Arabic use of the almuten which suggests an astrology reflective of the spirit of the 9th century Ash'arite doctrine that God knows particulars, for the reductionism of qualities produced by the almutens was only logical to the astrologer if they concurred that the vagaries of the commingling of secondary causes were either greatly reduced or removed. Indeed Abū Ma'shar shows possible sympathy to the Ash'arite doctrine in his *The Great Introduction* when he responds to the second criticism against astrology which was that planets indicated universal things, but not particular things such as the lives of individuals. Abū Ma'shar refutes this by stating:

1.Genus, species, the four elements and coming –to-be and passing-away are found in every individual. 2.The planets indicate the genus, species, the four elements and coming-to-be and passing-away. 3. Therefore, the planets indicate separate individuals.⁴⁵

Burnett suggests that in this passage Abū Ma'shar was rejecting the existence of genera and species as Platonic forms, thus when a planet indicated a universal it also indicated the individual or particular.⁴⁶ Abū Ma'shar's astrological views on predictability were that "...although men have free choice and can deliberate and ask advice, their decisions are still determined by the stars, which have indications for their animal and rational souls as well as over their bodies".⁴⁷ Abū Ma'shar's statement was reflective of the views of Claudius Ptolemy (c.90-c.168) who in Book 1 *Tetrabiblos* suggested that it is this very multiplicity of changes created by Aristotle's cosmology that allowed room either for the inability of the astrologer to produce exact prediction and/or the free will of men.⁴⁸ However, one could extend Burnett's argument of Abū Ma'shar's rejection of Platonism and suggest that in practice the astrology being developed in this period with its concepts of quantifiable almutens pursued an astrology based more on a type of non-causal atomism than Aristotelianism.

The theological environment within Islam at this time may have created the breathing space for these new astrological techniques to emerge, techniques which pursued accuracy by providing greater repeatability and consistency in the analysis of the chart. If

⁴⁴ R. Hand, 'Introduction' in Omar, *Three Books on Nativities*, p. ii.

⁴⁵ Requoted from Burnett, "The Certitude of Astrology: The Scientific Methodology of Al-Qabīṣī and Abū Ma'shar," p. 207. The translation of the "Great Introduction" has not yet been published at the time of writing this paper.

⁴⁶ Ibid., p.207.

⁴⁷ Ibid., p. 208.

⁴⁸ Claudius Ptolemy, *The Tetrabiblos*, trans. Ashmand. J. M. (Mokelumne Hill, USA: Health Research, 1969), p.4.

there was no causation then God knew particulars and astrology could explore, in practice at least, the direct link between the heavens and the individual, without the interference of Aristotelian secondary commingling. This thinking space was unavailable to Western Christian astrologers whose philosophical and theological environment did not challenge Aristotle's cosmology.

How greatly the astrology of this period was influenced by Islamic occasionalism is a point for further research. However, as Campion notes, in the 11th and 12th centuries Islamic astrology "held out [to the Christian world] the seductive prospect of control over a natural world which was otherwise chaotic and threatening."⁴⁹ This form of astrology, as previously stated, reached Europe in the 12th century principally through the translations of Abū Ma'shar, Māshā'allāh and Al-Qabīṣī (Alcabitius) and was adopted into the study of medicine.

Roughly four hundred years later Galileo's astrological papers were firmly based in these Arabic techniques of the quantification of qualities. This style of astrology was probably used by Galileo due to his medical education both as a student and later as a tutor. Furthermore, within this tradition, he appeared to use astrology to make exact predictions within the sublunar world, a point used in the charge against him by the Inquisition in 1604. At that trial he was accused and found guilty of his astrology being too fatalistic. The transcription of the proceedings indicated the charge was the claim of seeking accurate prediction, not the practice of astrology itself.

Q: [From the Inquisitor] You said before that in the nativities that this Galileo makes, he calls his predictions certain; this is heresy..."

A: [From the person bearing witness against Galileo] I know that he said that and that he calls his predictions from the nativities certain, but I am not aware that this has been declared heresy.⁵⁰

For Galileo, as for any astrologer, the chart with its planets, zodiac signs, houses and aspects was a complex web of relationships. However, the use of the technique of Arabic almutens allowed the astrologer to reduce the quality of a feature of the chart to a numerical value, thereby working in a consistent manner to find the planet with the largest score over a house cusp or point. The actual scores allocated by Galileo were 5 points for house (*domus*) rulership, 4 points for the exalted ruler, 3 points for the triplicity ruler/s, 2 points for the term ruler and 1 point for the face ruler.

⁴⁹ Nicholas Campion, "The Concept of Destiny in Islamic Astrology and Its Impact on Medieval European Thought," *ARAM* Vol 1, no. Num:2 (1989): p.288.

⁵⁰ Requoted from Poppi, "On Trial for Astral Fatalism: Galileo Faces the Inquisition," p. 54.

These individual planetary or house cusp almutens were also added together to form compound almutens in order to find the planet with rulership over a particular subject matter. For example, a person's "faith" could be discovered or predicted, according to Omar of Tabaristan, by adding together the following list of individual almutens: the 9th house cusp, the lord of the 9th house, the term ruler of the 9th house lord, any planets in the 9th house and the Part of Faith.⁵¹ By the time of Guido Bonatti (d. ca. 1296) these tables had become quite complex and in his *Second Tractatus* he created what he called the *Almudebit* which was used to find the planet that ruled over the person's life-force and contained the combined almutens of 27 natal points and/or planets.⁵² Apart from creating new compound almutens focused on a particular subject, astrologers would, from time to time, add personal nuances to an already established formula. In the 12th century, Avraham Ibn-Ezra expanded the compound almuten for the Lord of the Nativity by including the natal houses of the planets and the phasing of the superior planets in relationship to the Sun.⁵³ Such nuances provide insights into the astrologer's thinking concerning the level of importance of certain horoscopic or celestial features in their final prognosis.

The combination of a precise set of almutens in order to produce a prognosis for a particular theme is an example of an astrological axiomatic technique. One component was resolved, e.g. the number value of a house cusp, and was then joined to other astrological axioms. For example, in Galileo's own chart his natal Venus was exalted in Pisces (see Figure 1) and assigned the number 4. With the quality of Venus' exaltation reduced to a number, Galileo could then add this number to other features of his Venus and eventually compare it with the numerical values of other planets to gain an understanding of its strength in his chart. The end result was a score for each planet in the chart with the highest scoring planet claiming rulership over the subject of the compound almuten. In this way number was not mystical but functional and used to measure a celestial quality in order for a more complex position to be understood—quality become quantity with this style of astrology.

Galileo constructed these Arabic astrological almuten tables and, in a similar way to Avraham Ibn-Ezra, he adjusted his tables in scoring as well as content to fit his thinking at the time. He used simple almutens to explore the different house cusps and he also

⁵¹ Omar of Tabaristan does not actually list his scoring system, only the points required to make the compound almuten.

⁵² Guido Bonatti, *Liber Astronomiae, Part 2.*, trans. Robert Zoller (Berkeley Springs, USA Golden Hind Press. , 1994), p. 105-06.

⁵³ Rabbi Avraham Ibn Ezra, *The Book of Nativities and Revolutions*, trans. Meira B. Epstein (ARHAT Publications, 2008), p.13-14.

used a compound almuten in searching for the *Dominus Geniturae* (Lord of the Nativity). Once these had been calculated Galileo could use the almutens to aid his predictive work, or predict character in the case of his *Dominus Geniturae* tables. In all, Galileo's notes have calculations for eight *Domini Geniturae*.

The following tables are three of Galileo's *Dominus Geniturae* tables. It is not known when he constructed these actual tables (they could have been redrawn from earlier notes). Figure 1 is the table for his own chart (16 February 1564, Pisa for a time of 15:43 LMT),⁵⁴ Figure 2 is the table for a chart drawn for 1 April, 1505, Padua for a time of 19:44 LMT, and given its presence in his personal papers shows his interest in a historical figure or event. Figure 3 is the table for Giovanfrancesco Sagredo (20 June, 1571, Padua 00:46 LMT), his close friend while he was working in Padua. All of Galileo's *Dominus Geniturae* tables are an expression of his use of an astrological axiomatic technique.

Galileo began his *Dominus Geniturae* tables in the conventional manner by listing the planets and then allocating the scores, as previously listed, for their different essential dignities. He then appeared to follow the astrology of Johannes Schoener (1477 – 1547) by including the speed of a planet as well as its direct or retrograde movement.⁵⁵ Schoener listed 33 ways, with scores, on how a planet could be strengthened (gain a positive score) and 34 ways that a planet could be weakened (gain a negative score). Galileo did not use all of these points but does follow Schoener's suggested scoring.⁵⁶ Within this system there was a strong bias in favour of motion. Direct or fast motion by a planet gained far more advantage than slower or retrograde planets. For example, in Figure 1 the final scores for each planet, although not tallied by Galileo, were:

⁵⁴ This is the modern dating and timing of the second horoscope listed on F.7r. This horoscope with an ascendant of 14° 33' Leo shows the Part of Fortune correctly calculated at 12° 31' Libra. The other horoscope maintains the ascendant in Leo but has moved the rising degree to match the degree and minute of the natal Venus. This chart with its ascendant of 21° 37' Leo, however, still has the Part of Fortune listed as 12° 31' Libra. If Galileo considered his natal ascendant was 21° 37' Leo, then the correct position for the Part of Fortune would have been 20° 33' Libra.

⁵⁵ Antonio Favaro recorded Galileo's library in detail and listed among his astrological works a work of Filippo Melantone. Filippo Melantone is the Italian form of Philipp Melanchthon, the famous Lutheran scholar, who defended astrology on Christian grounds. He wrote an introduction to Johannes Schoener's astrological work *Opusculum Astrologicum* which was published with the work of Antonius de Montulmo *On the Judgement of Nativities* (1390). Schoener's work is a compendium of astrology whereas Montulmo's is an approach to delineation. Johannes Schoener was also responsible for bringing to prominence the work of the German astronomer Regiomontanus (Johannes Müller von Königsberg, 1436-1476) who developed the house system used by Galileo. Furthermore Schoener was active in astronomical circles as he was one of the people who urged Copernicus to publish his work on heliocentric astronomy. It would be difficult, therefore, to imagine that Galileo had not encountered the work of Schoener, directly or indirectly, given his involvement in the world of astronomy and the presence in his library of a work by Filippo Melantone.

⁵⁶ Johannes Schoener, *Opusculum Astrologicum*, trans. Robert Hand (Berkeley, Springs USA: Golden Hind Press, 1994), p.60.

Sun	Moon	Saturn	Jupiter	Mars	Venus	Mercury
2	11	-3	8	8	9	-7

The values ranged from -7 to +11 and a planet's position on this scale was dependent upon the consideration of 9 - 13 different chart points.⁵⁷ Following Schoener's work, Galileo allocated 4 points for direct motion (see Figure 1, Mars, Venus and Mercury columns). However, if a planet was retrograde he subtracted 5 points (see Figure 1 Saturn and Jupiter columns). Therefore any retrograde planet was automatically 9 points behind any planet that was direct. For instance, ignoring the Moon on 11 points as it cannot be retrograde, Venus is the highest scoring planet at 9 points. If retrograde, Venus would lose the 4 points for direct motion and then another 5 points for being retrograde, so its tally on the scale would be zero.

Although Galileo had not devised these individual scores he would have undoubtedly noticed their bias. He maintained this bias which favoured motion over the essential dignities in all his *Dominus Geniturae* tables and also extends it to the luminaries. If the Sun or the Moon were moving fast then he allocated a score of 2 points. However, the penalty for slow movement was -2 points, so a fast moving luminary had an advantage of 4 points. This was double the emphasis allocated by Schoener who gave -1 for slow and 1 for fast moment.

Furthermore, each of the three *Dominus Geniturae* tables shown display small alterations in their construction. In Figure 2 Galileo allocated only 1 point for a planet being in its own terms instead of 2 points (see Figure 2, Mars and Mercury columns). In Figure 3 Galileo has included a greater number of objects within his calculations. He added points for aspecting and house position, as well as a fixed star aspect. The Jupiter column in Figure 3 is a good example of where values are gained and lost for aspects, as well as deducted for Jupiter's position in the 12th house of the natal chart. This more complex table as shown in Figure 3 is also repeated for the tables (not shown in this paper) drawn up by Galileo for his two daughters and Cesare Galli. Whether he was developing these more complex tables or whether he was simplifying these complex tables to the reduced version of Figure 1 and 2 is unanswerable. Indeed no two of his tables are identical in either the chart points used, the nature of the essential dignities employed, or the

⁵⁷ In Galileo's own table these points are 1) house rulership, 2) exaltation, 3) triplicity rulership, 4) term rulership, 5) face rulership, 6) its orb with regard to the Sun, 7) its orientation to the Sun, 8) speed, and 9) mutual reception. However, in the other two tables additional points are considered, such as 10) aspecting, 11) fixed stars, 12) Joys of the planets and even 13) the Almuguea.

quantitative values assigned to these points. Galileo was either a highly inconsistent individual or he was working with different astrological axioms in his efforts to attain greater predictability.

[illegible]

Figure 1 - Galileo's *Dominus Geniturae* table for his own chart. (16th February 1564, Pisa at a time, according to his calculated chart, of 15:42 LMT). *Astrologica Nonnulla* from the Biblioteca Nazionale, Florence. Below is the table reproduced with the astrology clarified.

<i>Sun Pisces</i>	<i>Moon Taurus</i>	<i>Saturn Cancer</i>	<i>Jupiter Cancer</i>	<i>Mars Taurus</i>	<i>Venus Pisces</i>	<i>Mercury Pisces</i>
Ruled by Jupiter	Ruled by Venus	Ruled by the Moon	Ruled by the Moon	Ruled by Venus	Ruled by Jupiter	
Exaltation Venus	Its own exaltation = 4	Exalted ruler Jupiter	Its own exaltation = 4	Exalted ruler Moon	Its own exaltation = 4	Ruled by Jupiter
Triplicity rulers: Mars, Moon, Venus	Its own Trip ruler = 3	Trip rulers: Mars, Moon, Venus	Trip rulers: Mars, Moon and Venus	Trip rulers: Moon and Venus	Its own Trip ruler = 3	Trip rulers: Mars, Moon and Venus
	Bounds of Venus	Bounds of Venus	Bounds of Saturn	In his own Bounds = 2	Bounds of Mars	In its own Bounds = 2
Bounds of Venus	“corpento”	“decur”	“facie” [Seeing]	“decur”	Reception with the Moon = 2	“decur” [division of ten] Face of Jupiter
“decur”	[unknown meaning]	[division of ten]	Reception with the Sun = 2	[division of ten] Face of Saturn	“decur”	
[division of ten] Face of Saturn	“decur”	Face of Moon	“decur” [division of ten] Face of Moon	Free of the Sun = 5	[division of ten] Face of Mars	Not free of the Sun
Fast moving	[division of ten] Face of Mercury	Free from the Sun = 5	Free of the Sun = 5	Orient of Sun = 2. Direct = 4	Not free of the Sun	Direct = 4
	Waxing = 2	Orient of	Orient Sun = 2		Direct in motion = 4	Fast in moving = 2

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= 2 Sextile Moon	Fast moving = 2 Applying sextile to Sun	the Sun, = 2 Square Mars Conjunct Jupiter	Square Mars Conjunct Saturn	Average Square Jupiter and Saturn	Fast moving = 2	
		In detriment = -5 Retrograde = -5	Retrograde = -5	In detriment = -5	Under the Sun = -4 Orient of Sun = -2	In detriment = -5 In fall = -4 Under the Sun = -4 Oriental = -2

Dom. 07 Espal. sua. 4 Imp. sua. 3 Term. 8 Secu. sua. 1 0 8 □ 5 Δ 7	D. m Dom. 07 Espal. 0 Imp. sua. 3 Ter. 8 0 8 □ 7 Δ 07	3 00 Dom. D. Espa. 7 Imp. 07D Ter. 8 Ab. — 5 Dir. — 4 0 8 □ 0 8 * 8 Δ 8 Δ 07	7. 5 R Dom. 0 Espa. Imp. sua 3 Ter. 8 Ab. 0. 1 0 8 Δ 0 8 □ 8 □ 8	07. X. Dom. 7 Espa. 4 Imp. 07D. 3 Ter. suo. 1 Secur. — 1 Ab. — 5 Oxi. 2 Dir. — 4 Velo. — 2 Δ 8 * 8 Δ 8	8. Dom. sua. 5 Espa. 8 Imp. sua. 3 Ter. 7 Gau. 0 — 1 Ab. — 5 Oxi. 2 — 2 Dir. — 4 Velo. — 2 * 8 0 8 □ 8 * 07	8. R Dom. 07 Espa. 0 Imp. 80 Ter. suo. 1 Oxi. 2 — 2 0 8 □ 8 0 8	8. X. Dom. 7 Espa. 8 Imp. 07D Ter. 8
2	Deiectio: 4 Am. dia. 2 tard. — 2	in exilio 5 Oxi. 2 2. tard. — 2	Oxi. 2 2. R. — 5		Oppressus. 4 R. — 5		

Figure 2 - Galileo's *Dominus Geniturae* table a historical chart set for 1 April, 1505, Padua, 19:44 LMT. *Astrologica Nonnulla* p.14 from the Biblioteca Nazionale, Florence. Below is the table reproduced with the astrology clarified.

<i>Sun Aries</i>	<i>Moon Scorpio</i>	<i>Saturn Cancer</i>	<i>Jupiter Leo Retrograde</i>	<i>Mars Pisces</i>	<i>Venus Taurus</i>	<i>Mercury Aries Retrograde</i>	<i>Node Pisces</i>
Ruled by Mars Its own exaltation = 4 Its own Trip ruler = 3 Bounds of Venus Its own Face = 1 Conj Mercury Square Saturn Trine Jupiter	Ruled by Mars Exalted nil Its own Trip ruler = 3 Bounds of Venus Opposite Venus Trine Saturn Square Jupiter Trine Mars	Ruled by the Moon Exalted ruler Jupiter Trip rulers Mars, Moon Bounds of Venus Free from the Sun = 5 Direct = 4 Square Sun and Mercury Sextile Venus Trine Moon Trine Mars	Ruled by the Sun Exalted nil Its own Trip ruler = 3 Bounds of Mercury Almuguea of Sun = 1 Free of the Sun = 5 Trine Sun Mercury Square Venus Square Moon	Ruled by Jupiter Exalted rule Venus Trip ruler Mars and Moon = 3 Own Bounds = 1 Own face = 1 Free of the Sun = 5 Orient of Sun = 2 Direct = 4 Fast in motion = 2 Trine Moon, Sextile Venus, Trine Saturn	In its own rulership = 5 Exalted of Moon Its own Trip ruler = 3 Bounds of Jupiter In its own Joy = 1 Free of the Sun = 5 Occidental = 2 Direct in motion = 4 Fast in motion = 2 Sextile Saturn, Opp. Moon, Square Jupiter, Sextile Mars.	Ruled by Mars Exalted ruler: Sun Trip rulers: Jupiter, Sun In its own Bounds = 1 Occidental = 2 Conjunct Sun Square Saturn	Ruled by Jupiter Exalted ruler: Venus Trip rulers : Mars, Moon Bounds of Venus
Slow in motion = - 2	In fall = - 4 Waning = -2 Slow in motion = - 2	In Detriment = -5 Occidental = -2 Slow in motion = -2	Occidental = -2 Retrograde = -5			Under the Sun = -4 Retrograde = -5	

0.00	D. II	5 5 7	7 11	07 II	7 8	7 8	8 8
Domo D.	Domo. 8	Domi. 9	Domo sua 9	Domo 8	Domo sua. 5	Domo. 0	Domo. 0
Epul. 7.	Epul. 00	Epul. sua. 4	Epul. 9	Epul. 0.	Epul. D	Epul. 12. 4	Epul. 0
3fl. 07 29	3fl. 75	trifl. sua 3	trifl. 07 29	3fl. 75	3fl. sua 3	trifl. 70	3fl. 70
term. 7	term. 7	term. 07	term. 07	term. 7	term. 5	term. 5	term. 8
~~term. 7~~	~~term. 7~~	~~term. 7~~	~~term. 7~~	~~term. 7~~	~~term. 7~~	~~term. 7~~	~~term. 7~~
vacunia 9	vacunia. 07	vac. 7	vac. sua 1	vac. 7	vac. 5	Almug. 01	vac. 0
A. 7 — 4	□ 7	lib. 5	lib. 5	lib. 5	Gaudia: 1	Dec. 7.	lib. 5
A. 5	* 7 — 1	Δ. D — 1	orient. 0. 2	orient. 0. 2	lib. 5	lib. 5	lib. 5
in 3 ^a — 1	Δ. 5 — 1	Δ. 0	Dir: V. — 6	Dir: V. — 6	Dir: V. — 6	Dir: V. — 6	Dir: V. — 6
"	in 2 ^a — 3	Δ. 07	* 7 — 3	* 7 — 3	* 7 — 3	* 7 — 3	* 7 — 3
term. — 5	term. di mi. 5	o. d. 0. 2	o. d. — 3	o. d. — 3	orient. 0. 2	o. d. — 3	o. d. — 3
	term. di a. 2	o. d. — 5	in 12 — 5	in 12 — 5	cap. medu. 5.	in 12 — 5	in 12 — 5
	o. 07. — 5	□ 7	in 6. 9 — 4	in 6. 9 — 4	in 6. 9 — 4	in 6. 9 — 4	in 6. 9 — 4
	Feb. 7	Feb. 7	Feb. 17	Feb. 17	Feb. 17	Feb. 17	Feb. 17

Figure 3 - Galileo's *Dominus Geniturae* table for Sagredo, chart constructed for 20 June, 1571 at 00:46 LMT, Venice. *Astrologica Nonnulla* p.13 from the Biblioteca Nazionale, Florence. Below the table has been reproduced with the astrology clarified.

<i>Sun Cancer</i> Ruled by Moon Exalted: Jupiter Triplcity rulers: Mars, Moon, Venus Bounds of Jupiter Face : Venus Trine Jupiter = 4 Trine Saturn In the 3 rd house = 1	<i>Moon Gemini</i> Ruled by Mercury Exalted: Node Trip rulers: Mercury, Saturn Bounds of Jupiter Face : Mars Square Jupiter Sextile Mercury = 1 Trine Saturn = 1 In the 2 nd house = 3	<i>Saturn Libra, Retrograde</i> Ruled by the Venus In its own exaltation = 4 In its own Trip rulers = 3 Bounds of Mars Face: Jupiter Free from the Sun = 5 Trine Moon = 1 Trine Sun Trine Mars	<i>Jupiter Pisces</i> In own rulership = 5 Exalted: Venus Trip rulers: Mars, Moon, Venus Bounds of Mars Face :Mars Free of the Sun = 5 Oriental of the Sun = 2 Direct = 4 Sextile Venus = 3 Trine Sun = 3 Trine Mercury = 3	<i>Mars Gemini</i> Ruled by Mercury Exalted: Node Trip rulers: Mercury, Saturn Bounds of Venus In its own face = 1 Free of the Sun = 5 Orient of Sun = 2 Direct, and fast = 6 Trine Saturn In 2 nd house = 3	<i>Venus Taurus</i> In its own rulership = 5 Exalted: Moon In its own Trip ruler = 3 Bounds of Saturn Face: Saturn Free of the Sun = 5 In its own Joy = 1 Direct in motion, and fast = 6 Sextile Jupiter = 3 In the 1 st house = 5	<i>Mercury Leo</i> Ruled by Sun ?? = 4 Trip rulers: Jupiter, Sun Bounds of Saturn Almuguea of Sun = 1 Face: Saturn Free of the Sun = 5 Occidental = 2 Direct and fast = 6 Sextile Moon = 1 Sextile Venus = 3 Trine Jupiter = 4	<i>Node Leo</i> Ruled by Sun Trip rulers: Jupiter, Sun Bounds of Mercury Face... Part of Fortune nd cdb (not trustworthy?) 5
Slow in motion = -2	Waning = -5 Slow in motion = -2 Conjunct Mars = -5	Occidental = -2 Retrograde = -5 Square Mercury In 6 th house = -4	Square Mars = -3 Square Moon In 12 th house = -5	Square Jupiter	Oriental of Sun = -2 Conjunct Algol = -5	Square Saturn = -5	In 12 th house = -5
5		-7	17	17	21	21	

Time, Motion and Measurement

A general feature of astrology, both in Galileo's time as well as today, is the philosophy that time is linked to the velocity of a planet and both need to be measured in order to produce a prognosis. The planets are seen as dynamic and their relationship to one another undergoes changes via their different speeds. Questions of how fast a planet was moving and how long it would take to move through a combust situation, or in or out of aspect, were all key points for reading the horoscopes.⁵⁸ Galileo saw these changing relationships as different quantitative values assigned to the planets within his tables. For instance, a planet was either free from the Sun's influence or it was "oppressed": this judgement greatly altered the score of the planet, as it could change its score by 9 points (see for example Figure 2, Venus and Mercury columns). Additionally when considering aspects, a faster moving planet could move into the orb of a slower moving planet and

⁵⁸ See Masha'allah, *On Reception*, trans. Robert Hand (Berkeley Springs, USA: Arhat Publications, 1998), p. 5; Rabbi Avraham Ibn Ezra, *The Beginning of Wisdom*, trans. Meira B. Epstein (Arhat Publications, 1998), p. 116-26; abū Ma'shar, *The Abbreviation of the Introduction to Astrology*, trans. Charles Burnett (Arhat Publications, 1994), p. 24.

gain a score reflecting its increase or decrease in effectiveness (see for example Figure 3, Jupiter).

These planetary dynamics were also the principle of some astrological predictive techniques. The astrologer would apply a variable or fixed velocity to all, or part, of the horoscope in order to draw parallels between arcs of planetary or point movement, velocity of that movement, and the time as to when the alignment to a natal point became exact. These parallels were then equated form a combined prognosis of quality and time. For example, Figure 4 contains Galileo's calculations of primary directions for Sagredo. The three sets of figures represent the directing of Sagredo's ascending degree of $4^{\circ}45'$ Taurus (left hand column). The middle set of figures is for the directing of his Midheaven at $17^{\circ}20'$ Capricorn and the set of figures on the right are for the directing of his natal Moon. Galileo was using an established technique discussed by Ptolemy in the *Tetrabiblos* Book II chapter XIII although in such an obscure manner as to cause constant debate amongst subsequent generations of astrologers. Briefly, the method of primary directions is that a point or planet is moved forward in a way which was reflective of the rotation of the earth in the first six or so hours after birth. This movement was in degrees of right ascension⁵⁹ at the rate of 1° per year⁶⁰ of the person's life. The dynamic point or planet was observed as it travelled through the initial geometrical pattern (natal chart). As it encountered places in the geometry that were linked to other qualities (planets) then an event could be predicted, both in quality as well as timing. Thus the speed of the moving point was directly related to the timing of when the event would occur and how long it would last.⁶¹

In Figure 4 this movement can be seen in Sagredo's primary directed Ascendant listed in the left hand column. It moved by direction a distance of 8° from a sextile to Jupiter (a 60° arc of separation) to form a new sextile to Venus (highlighted in figure 4). Galileo calculated this to take 8 years and 9 months and to be effective in Sagredo's life when he was 19 years and 4 months old. The length of time this celestial geometry was in effect, which may have an orb of a month before and after, would have been a factor of the measurement of the velocity of the directed Ascendant and what orbs Galileo considered were required.

⁵⁹ At other times an astrologer may use degrees of the ecliptic or oblique ascension or indeed any other movements within the celestial sphere.

⁶⁰ Astrologers experimented with using different ratios between the movement of the celestial sphere and the link with time in the sublunar world.

⁶¹ For more information on this subject see Martin Gansten, *Primary Directions, Astrology's Old Master Technique* (Bournemouth, UK: Wessex Astrologer, 2009).

Indeed René Descartes (1596-1650) criticised Galileo's experimentation by saying "Everything Galileo says about the philosophy of objects falling in empty space is built without foundation: he ought first to have established the nature of weight".⁶⁴ The problem for Descartes was that Galileo linked time to motion and used it to measure motion. Descartes, however, defined motion as:

But motion (that is, local motion, for no other occurs to my thinking, nor, therefore, do I think that any other should be established in the nature of things), motion, I say, as it is commonly taken, is nothing other than the *action by which some body is transferred from one place to another*.⁶⁵

The key statement in Descartes words is that motion is "nothing other" than the movement from one place to another and therefore did not require measurement. However, Galileo differed.

In his treatment of free fall, Galileo produced diagrams published in the Third Day of his *Two New Sciences* which linked time, space and velocity and allowed for measurement. Using Galileo's graphs or tables one could measure the movement and one could also measure the time taken by this movement.⁶⁶ Galileo's thinking on time and measurement had, according to Grosholz, "wrested geometry from the geometer's preoccupation with extension, and put it in the service of the essentially temporal processes of physics".⁶⁷ Such diagrams, Grosholz argued, had no counterpart in Descartes' geometry. For Descartes, the temporal and dynamic dimensions of the subject matter of free falling bodies were irrelevant.⁶⁸ Greek scientific thinking believed that Ptolemy's mathematical astronomy could predict celestial motions (via epicycles) but could not explain *why* the planets moved. Aristotle's physics explained the quality of motion in the sublunar world but could not predict it. Crombie points out that Aristotle's physics was a distinctly separate field of enquiry to Ptolemy's astronomy.⁶⁹ What was valid in one field could not

⁶⁴ Requoted from E.N. da C. Andrade, "Galileo," *Notes and Records of the Royal Society of London* Vol. 19, no. 2 (1964): p. 121.

⁶⁵ René Descartes, *Principles of Philosophy*, trans. Valentine Rodger Miller and Reese P. Miller (New York: Springer, [1644]1984), Part II, Paragraph 24.

⁶⁶ Galileo, *Dialogues Concerning Two New Sciences*, p.173-4.

⁶⁷ Emily R. Grosholz, "Geometry, Time and Force in the Diagrams of Descartes, Galileo, Torricelli and Newton," *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association* 1988(1988): p.242.

⁶⁸ Grosholz, "Geometry, Time and Force in the Diagrams of Descartes, Galileo, Torricelli and Newton," p.242-45.

⁶⁹ Crombie, "Quantification in Medieval Physics," p.146.

be applied to the other. Galileo disagreed with this argument.⁷⁰ So, too, did the practice of Arabic astrology.

To the astrologer, the heavens *were* a constantly changing canvas. The orbits were supposed to be perfect and circular, making them predictable, but the astrologer was aware of daily changes. Planets varied in speed and direction; the movement of the sky around the earth varied throughout the day. There were constant changes in the astrological quality of the planets, with shifts of power and expression through the essential dignities. Arabic astrology emphasised these changes, scoring and tabulating them so none would be overlooked. To the practitioner of Arabic astrology, such heavenly changes were noted and measured, and although the astrologer may have believed in the perfection of the heavens and that such changes were the result of the planet's influence on the sublunar world, when we consider a passage such as this from Guido Bonatti:

Saturn, Jupiter and Mars after they go out from under the rays of the Sun... are said to be increased in strength up until they are then elongated from the Sun... just as a sick man who after a crisis, is increased in his strength and full health, until he resumes his former vigor...⁷¹

Bonatti's use of metaphor implied that it was the planets themselves which were changing rather than their influence on the sublunar world. This suggests, even if only at the vernacular level, that the practice of this style of astrology, which used the changeable heavens to seek understanding of the sublunar realm, was a subtle challenge of the Platonistic position of the perfect unchanging heavens and the imperfect, unknowable, sublunar world.

Weiner and Koyré both place Galileo within a Platonist philosophy primarily because he was not Aristotelian. Olschki argued that Galileo did not have Aristotelian nor Platonist credentials because of his denial of the split between the super and sublunar world and his use of number to quantify his natural philosophy. Yet Olschki could offer no explanation as to a source of Galileo's thinking about time, motion and velocity which would allow him to apply the mechanics of the heavens to his natural philosophy. Additionally Biagioli suggested that Galileo was a great bricoleur, being able to use whatever was available to gain what he needed. Biagioli used this term disparagingly, suggesting that Galileo's method of securing the patronage of the Medici family pandered

⁷⁰ See, for example, Galileo, *Dialogue on the Two Chief World Systems*, Day One.

⁷¹ Guido Bonatti, *Book of Astronomy*, trans. Benjamin N. Dykes (Golden Valley, Minnesota: The Cazimi Press, 2007), p.207-8.

to the Medici family's sense of divine destiny and their believed link to the planet Jupiter.⁷² Yet within Galileo's astrological notes are drawings of spheres with arcs of movement of projectiles, and within his original drawings of the surface of the Moon made for the *Sidereus Nuncius* he also drew two rough charts for Cosimo II de Medici.⁷³ So Biagioli's label of "bricoleur" may be apt, not in questioning Galileo's ethics, but rather in showing him as a man who knew no boundaries in his thinking.

It is unlikely that Galileo's Arabic astrology directly informed the innovations within his mathematical methodologies, for there is no evidence of his astrology in his mathematical publications. Nevertheless what this paper suggests is that his astrology provided him with a different place to think. It was a subject which, for Galileo, contained the quantifying of qualities, the implication of a changeable heaven, and an expectation of exact prediction in the sublunar world, as well as the concept of motion being associated with time through velocity.

As Galileo shifted between his astrological work and his study of motion in the sublunar world it is reasonable to assume that his mathematical mind carried his astrological philosophy into his physics, providing breathing-space for his thoughts and colouring his creative dreaming.

⁷² Mario Biagioli, "Galileo the Emblem Maker," *Isis* Vol. 81, no. No. 2 (1990): p.258.

⁷³ Guiseppi Righini, "Galileo's Horoscope for Cosimo II De Medici," trans. Julianne Evans of 'L'Oroscopo galileiano di Cosimo II de Medici', *Annali dell' Istituto e Museo di Storia della Scienza di Firenze*, 1, 1976, pp. 28-36, in *Galileo's Astrology*, ed. Nicholas Campion and Nick Kollerstrom (Bristol, UK: Cinnabar Books, 2003), p.60.

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