

## IT'S ALL GREEK: THREE OF KEPLER'S BOOK TITLES

Paul Gabor

Vatican Observatory, Specola Vaticana, 00120 Città del Vaticano, Vatican City State.  
E-mail: pgabor@specola.va

and

Katarina Petrovićová

Faculty of Arts, Masaryk University, Arna Nováka 1, 602 00 Brno, Czech Republic.  
E-mail: petrovic@phil.muni.cz

**Abstract:** Three of Kepler's major works have Greek words in their titles: *Astronomia nova αἰτιολόγητος*, *Dioptrice*, and *Harmonice mundi*. We perform a linguistic analysis, examine the usage of Greek terms in Neo-Latin literature, and conjecture Kepler's particular reasons for including these words prominently in his book titles. In particular, we show why the letter 'c' in *dioptrice* and *harmonice* should be pronounced as a hard 'k', and that the abbreviated title should be *Harmonice* and not *harmonices*. We pay special attention to Kepler's neologism *αἰτιολόγητος* (*aitiologetos*), examining its general context and the potential sources of Kepler's inspiration. We suggest that its least unfaithful English translation is 'etiological'.

**Keywords:** Kepler, Greek, learned Neo-Latin, *Dioptrice*, *Harmonice mundi*, *Astronomia nova aitiologetos*, *αἰτιολόγητος*

### 1 INTRODUCTION

Three very notable works by Johannes Kepler (1571–1630; Figure 1) contain Greek words in their titles. We shall propose some points for our usage, and especially for the abbreviated versions of these book titles. Why did Kepler resort to Greek terms in his Latin writing? We shall show that this practice was a combination of three things: necessity, style, and personal

choice. The latter merits closer scrutiny because, as we shall argue in the case of *αἰτιολόγητος*, a Greek word in a strategic place served Kepler to emphasize one of his central points.

### 2 THREE BOOK TITLES

We shall examine the 1609 work *Astronomia nova αἰτιολόγητο* (Figure 2), the 1611 work *Dioptrice* (Figure 3) and the 1619 work *Harmonice mundi* (Figure 4), leaving the first for last because it is the most intriguing.

#### 2.1 *Dioptrice*

Let us start with the most straightforward of Kepler's (more or less) Greek book titles. The title page announces:

Ioannis Kepleri S[acr]ae C[aesare]ae  
M[ajesta]tis Mathematici **Dioptrice** seu  
Demonstratio eorum quae visui & visibilibus  
propter Conspicilla non ita pridem inventa  
accidunt.

The core of the book title is the word *Dioptrice*. The context dictates that the word must be a noun in the nominative case. This is only possible if the word is Greek: Διοπτρική. A few pages further, as if to dispel all doubts that this is indeed a transliterated Greek word, Kepler's Preface is entitled, *Ioannis Kepleri in Dioptricen Praefatio ...* (Johannes Kepler *Gesammelte Werke*, henceforth *KGW*, Volume 4, 1941: 334). The Greek accusative ending *-ēn* (-ην) is unmistakable.

##### 2.1.1 A Note on Transliteration

Roman practice did not distinguish *eta* and *epsilon*, transliterating both as 'e'. The Romans preferred transliterating *kappa* as 'c'. Kepler

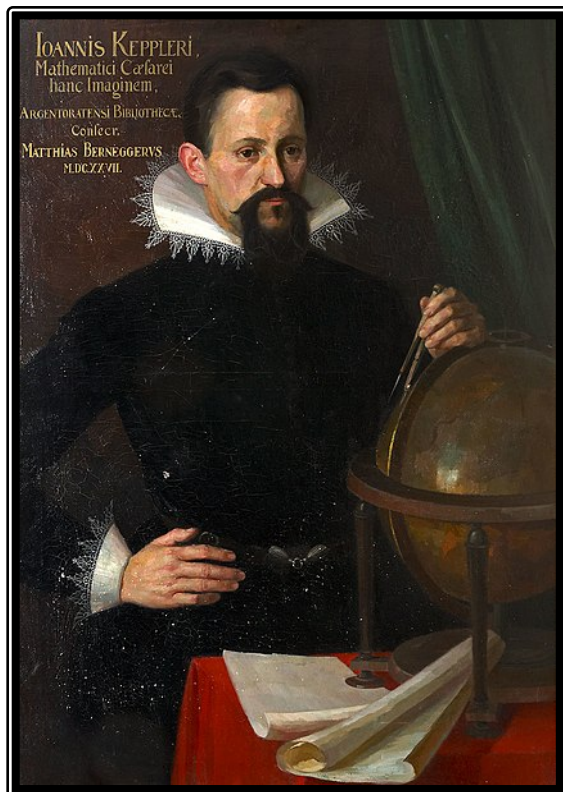


Figure1: A 1620 portrait of Kepler by an unknown painter ([https://en.wikipedia.org/wiki/Johannes\\_Kepler#/media/File:JKepler.jpg](https://en.wikipedia.org/wiki/Johannes_Kepler#/media/File:JKepler.jpg))

followed these practices. To alleviate ambiguity we shall indicate which 'e's are *etas* using the diacritic 'ë'. We shall use 'k', mainly for pronunciation's sake.

### 2.1.2 Degrees of Latinization

Kepler uses the nominative *dioptricē* and the accusative *dioptricēn*, transliterating them but retaining the Greek endings. In general, Greek words may be inserted into a Latin text with varying degrees of latinization. Let us illustrate this with the examples shown in Table 1.

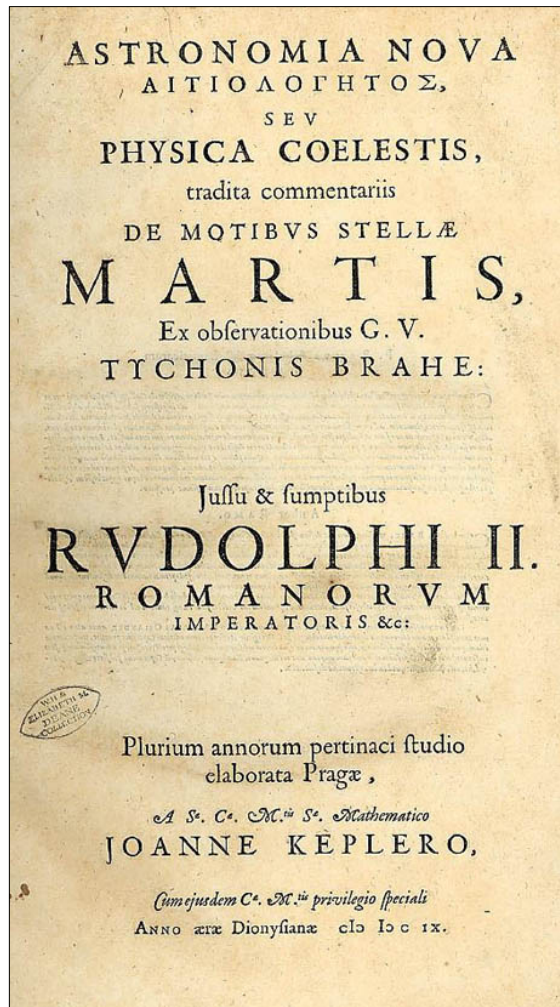


Figure 2: The cover of *Astronomia nova αἰτιολόγητο* (courtesy: Vatican Observatory).

Different approaches were preferable in different contexts. In a given situation, some forms sounded strange or were simply unacceptable. For our purpose we shall merely illustrate this phenomenon by listing a few analogous examples in English. English has kept the original plural of many Latin and Greek terms (in the nominative case only), e.g., *phenomenon* – *phenomena*, *apsis* – *apsides*, *amoeba* – *amoebae*. Some (also) take English plurals, e.g., *amoebae* or *amoebas*, *gymnasia* or *gym-*

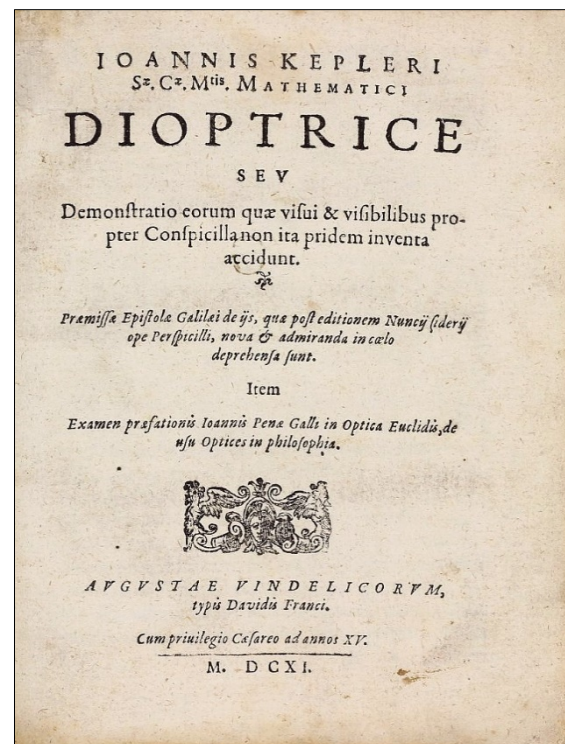


Figure 3: The title page of *Dioptrice* (courtesy: milestone-books.de).

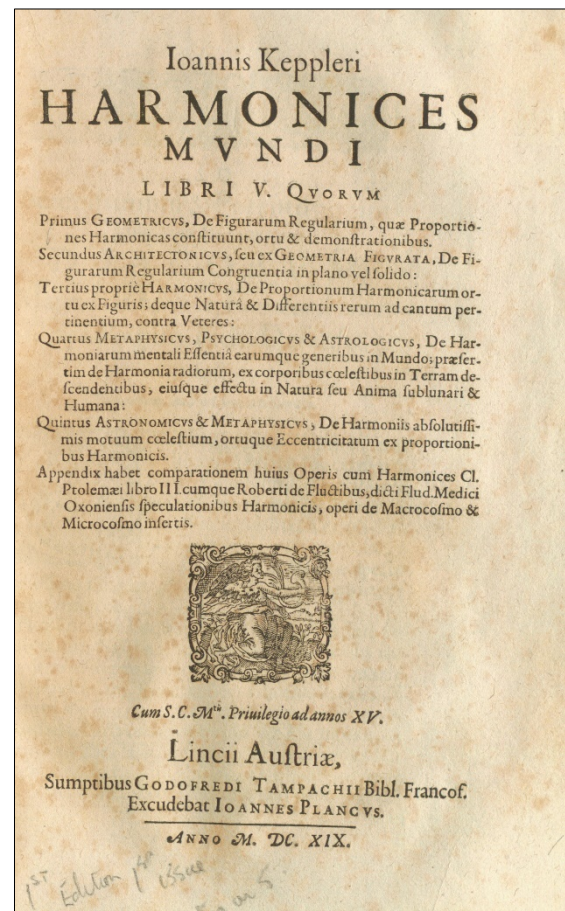


Figure 4: The front cover of *Harmonice mundi* ([https://upload.wikimedia.org/wikipedia/commons/f/f4/Harmonices\\_Mundi\\_0001-lg.jpg](https://upload.wikimedia.org/wikipedia/commons/f/f4/Harmonices_Mundi_0001-lg.jpg)).



Table 1: Varying degrees of Latanization of Greek words.

"Level 0"	"Level 1"	"Level 2"	Meaning
Greek alphabet, Greek inflection	Greek inflection, Latin transliteration	Latin transliteration, Latin inflection	
(ἡ) διοπτρική, (τῆς) διοπτρικῆς, acc. (τὴν) διοπτρικήν	<i>dioptrice, dioptrices, dioptricen</i>	<i>dioptrica, dioptricae, dioptricam</i>	dioptrics
(ἡ) ἁρμονική, (τῆς) ἁρμονικῆς	<i>harmonice, harmonices</i>	<i>harmonica, harmonicae</i>	theory of harmony
(ἡ) μάθησις, (τῆς) μαθήσεως	<i>mathesis, matheseos</i>	<i>mathesis, mathesis</i>	learning, (mathematics, astrology)

*nasiums, indices* or *indexes*. Other expressions, more fully anglicized, keep their original nominative singular endings but do not retain any trace of their original inflected forms, e.g., *campus* (Lat. pl. *campi*), *bonus* (Lat. pl. *boni*), *sinus* (Lat. pl. *sinūs*). Fully anglicized words have lost their original endings entirely, e.g., *form* (Lat. *forma*), *center* (Lat. *centrum*, Gr. κέντρον), *cycle* (Lat. *cyclus*, Gr. κύκλος). Similarly, an English-speaking scholar may decide to maintain the German plural *Urerzählungen* of the word *Urerzählung*, rather than to coin an Anglicized plural, *Urerzählungs*.

Generally, in Latin as in English, a borrowed word seems less alien with frequent use, and the original endings are replaced with Latin or English ones (e.g., φιλοσοφία, φιλοσοφίας became *philosophia, philosophiae*). Conversely, less common borrowed words tend to retain the endings of their linguistic homeland.

### 2.1.3 Names of Intellectual Disciplines

In Greek, names of intellectual disciplines are mostly substantivized adjectives, adopting the gender of the implied noun according to context, e.g., ἡ λογική (τέχνη, ἐπιστήμη; logical art, science), ἡ φυσική, μαθηματική, θεολογική (ἐπιστήμη, θεωρία; physical, mathematical, theological science, theory), τὸ λογικόν, τὸ φυσικόν, τὸ ἠθικόν (μέρος τῆς φιλοσοφίας; logical, physical, ethical part of philosophy; see *Diogenes Laertius, Lives of Eminent Philosophers*, 1.18: μέρη δὲ φιλοσοφίας τρία, φυσικόν, ἠθικόν, διαλεκτικόν: "philosophy has three parts: physics, ethics and dialectics"). The collective or abstract notion is often designated by substantivized adjectives in the neuter plural form (with no implied noun). In our context, this is a common way of creating book titles (τὰ μεταφυσικά; the metaphysical [writings]). In Latin, fully Latinized Greek names of disciplines are no longer adjectives but rather Latin feminine nouns, with the Latin 1<sup>st</sup> declension ending *-a* attached to the Greek root (*logica, physica, mathematica*). Note that these Latin feminine nouns in the nominative case may appear identical to the Greek collective/abstract neuter plural forms (*physica* – τὰ φυσικά) but this is mere homonymy. The illusion is dispelled as soon as the word is

employed in a sentence and it becomes clear that the former is a feminine singular, whereas the latter is a neuter plural.

Hence, *dioptrica* would, indeed, be a legitimate Latinized version of διοπτρική. And yet Kepler preferred the intermediate approach ('Level 1' in our classification introduced above), transliterating the word into the Latin script but maintaining its Greek inflexion in full. We can only conjecture that he rightly recognized the word as insufficiently domesticated in Latin.

### 2.1.4 Pronunciation

This brings us to the word's pronunciation. Those who assume *dioptrice* to be a Latin word would use their respective received Latin pronunciation of the *-ce* ending: the Italian *ce* as in 'cheddar', the French *ce* as in 'seven', the German *ce* as in 'tsetse fly', etc. Still falsely assuming that the word is Latin, those who pay attention to vowel quantity, would add insult to injury by mistaking the vowel in the ending for a short one as appropriate in Latin. Those, however, who would correctly identify the word as Greek, would pronounce the Latin letter *c* as a transliterated Greek letter *kappa* (as 'k' in 'king') and the *e* as a transliterated *eta*, a long open vowel similar to the one in the English word 'bad'.

### 2.1.5 Meaning

What is the meaning of the Greek substantivized adjective ἡ διοπτρική?

**διοπτρικός**, ἡ, ὄν, *of, belonging to the use of the διοπτρα* I., ὄργανον δ. [διοπτρικόν], = διοπτρα, Str. 2.1.35 [Strabo, *Geographica*]; τὰ δ. [διοπτρικά] *the science of dioptrics*, Plu. 2.1093e [Plutarchus, *Non posse suaviter vivi secundum Epicurum*]; also **διοπτρική**, ἡ, Procl in Euc. p. 42 Friedlein [Proclus, *In primum Euclidis elementorum librum commentarium*]. (*The Online Liddel-Scott-Jones Greek-English Lexicon*, henceforth *LSJ*; emph. according to the *LSJ*.)

These dictionary entries based on ancient usage of the word document that the term was attested in Antiquity in the sense of 'the science of dioptrics', exactly as used by Kepler.

### 2.1.6 Optics and Dioptrics

Why Dioptrics and not Optics? Two reasons: (1) Kepler already had used the latter term as the key word in the title of his 1604 book, *Ad Vitellionem Paralipomena quibus Astronomiae pars Optica traditur*, and (2) there is a difference between optics and dioptrics, as we can recognize from the [LSJ](#) entry above and the following:

**ὀπτ-ικός**, ἢ, ὅν, *of or for sight*: τὰ ὀπτικά *the theory of the laws of sight, optics*, Arist. *Metaph.* 1077a5 [Aristotle, *Metaphysica*], etc.; so ἡ ὀπτική (sc. θεωρία) *ib.* 997b20 [*ibidem*]; [ὀπτι]καὶ ἀποδείξεις *Id.* APo. 76a24 [Aristotle, *Analytica posteriora*]; [ὀπτι]κοὶ λόγοι *Gal.* 17(2).214 [Galenus, *In Hippocratis librum vi epidemiarum commentarii V*]; [ὀπτι]κή δύναμις *Id.* 8.20 [*idem*]. [...] (Emph. according to the [LSJ](#).)

Optics is therefore primarily a theory of sight. Kepler explains this himself, as well as the relationship of his two books ([Kepler, 1611: 2, dedicatory letter](#)). *Dioptricē* is a term used by ancient geometers when speaking of refracted rays. Simply put, the main topic of Kepler's *Dioptricē* are telescopes (Kepler uses the term *conspicillum*), not vision.

## 2.2 Harmonice

We shall now turn to the most frequently mistaken of Kepler's book titles, which even the (not entirely) omniscient Wikipedia lists as "*Harmonices Mundi*" ([Kepler, 1619](#)). Kepler's title reads, *Ioannis Kepleri Harmonices Mundi libri quinque*. Leaving aside the perplexing proliferation of 'p's in Kepler's surname, let us focus on the word *harmonices*.

### 2.2.1 Meaning

This is not one of Kepler's neologisms, nor is it an entirely obscure term, as can be readily seen consulting any reputable Latin dictionary:

**harmonicē** -ēs, f. [Gk. ἁρμονική] The theory of music. *Vitr.* 5.3.7 [Vitruvius Pollio, *De architectura*]; [harmoni]ce autem musica litteratura obscura et difficilis 5.4.1. ([Oxford Latin Dictionary](#), henceforth *OLD*, p. 786; emph. according to the *OLD*.) **harmonica**, -ae *sive* (sec. gr. ἁρμονική): [harmonic]ē, -ēs (v. 1.22 sqq.: *VITR.* 5, 3, 8. 5, 4, 1 [Vitruvius Pollio, *De architectura*]) f., sc. *ars vel ratio*: *VITR.* 5, 3, 8 theatrorum per [harmonic]en ad augendam vocem ratiocinationes ab antiquis sunt constitutae. 5, 4, 1 [harmonic]e (*sic Marini, editores. harmonia codd.*) autem est musica litteratura obscura et difficilis. *FRG. Cens.* 11, 1 p. 64, 12 [*Fragmentum Censorini*] musicae partes: [harmonic]a, organica, rhythmica eqs. (sim. *ISID. orig.* 3, 19, 1. 3, 20, 1 [Isidore, *Origines*]). p. 64, 14 [harmonic]a (har-

monia *Hultsch*). *MART. CAP.* 9, 936 [Martianus Capella, *De nuptiis Philologiae et Mercurii*] quae ... ad melos pertinent, [harmonic]a dicuntur, quae ad numeros, rhythmica, quae ad verba, metrica (*ISID. orig.* 3, 18, 1. *al.*). 937. 938 [harmonic]a habet partes disputationis septem eqs. *BOETH. mus.* 5, 2p. 352, 1 ([Boethius, *De institutione musica*] cf. 5, 3 p. 354, 27. 355, 6). p. 352, 4 [harmonic]a est facultas differentias ... sonorum ... perpendens. *ISID. orig.* 3, 20, 2. *et al.* (*Thesaurus linguae Latinae*, henceforth *TLL*, 6,3: 2538; emph. according to the *TLL*.)

And the [Oxford English Dictionary](#) (henceforth *OED*) adds:

*Harmonics*, **B.** n. 1. In plural. A theory or system of musical sounds or intervals; that part of acoustics which relates to music (rarely in singular). *Obsolete* except in reference to ancient systems. (Emph. according to the *OED*.)

### 2.2.2 Genitive vs. Nominative

Clearly, the Greek word for harmonics (theory of harmony) is ἡ ἁρμονική, and its genitive case is τῆς ἁρμονικῆς. Aristotle mentions ἡ ἐν τοῖς μαθημασιν ἁρμονική (sc. ἐπιστήμη), the mathematical theory of music ([Metaphysics: 997b21; LSJ](#): entry ἁρμονικός). The word *harmonicēs* in Kepler's title is therefore a transliterated Greek genitive singular. The book's title may be translated as *Johannes Kepler's Five Books of World's Harmonics*.

The variant with the preposition 'on', viz., *Johannes Kepler's Five Books on the Harmonics of the World*, would be less accurate. The preposition 'on' would have been appropriate had Kepler's title been *J. Kepleri de Harmonice Mundi Libri V*. He chose not to use the preposition *de*. By using a simple genitive case he indicates that his work is not just about this new science; the book is this new science of 'cosmic harmonics' or 'world's harmonics'.

Matters have been straightforward so far. Confusion often arises when abbreviating Kepler's title, writers search for its core. The book's title proper in the nominative case (and using the Roman transliteration of Greek as Kepler did) is *Harmonice Mundi* pronounced *Harmōnikē Mundī* with a hard *kappa*, and without the *sigma* which belongs to the genitive. No argument can justify using the genitive case in the abbreviated title.

### 2.2.3 Latinization Level

The fully Latinized form of the Greek word ἁρμονική (Roman transliteration *harmonice*, less ambiguous transliteration *harmōnikē*) is *harmonica*, attested in some late ancient writings, namely, Martianus Capella, *Ps.-Censor-*

inus, Boethius or Isidore of Seville, as listed in [TLL](#) (vol. 6.3: 2538, see the entry above). Sadly, *harmonica* can be easily confused in modern English with a homonym designating a mouth organ. Undaunted, some contemporary scholars (let them remain unnamed) elect to employ *Harmonica Mundi*. We have seen that in the case of *Dioptricē* Kepler had little choice but to use the Greek ending. Here, however, his options were perhaps more open, and he could have chosen the Latinized form, *Ioannis Kepleri Harmonicae Mundi libri V*. He did not do so, and we must respect his choice. Allow us to remark, however, that the illustrious Imperial Mathematician thus contributed to the confusion of an unworthy posterity sadly lacking in classical culture.

### 2.3 *Astronomia nova* αἰτιολόγητος

The work generally referred to as *Astronomia nova*, is arguably Kepler's greatest single achievement. Analyzing Tycho's observations of Mars, Kepler breaks with millennia of tradition, rejecting the heavenly perfection of circles and concluding that planetary orbits are ellipses: Kepler's First Law of Planetary Motion. *Astronomia nova* also contains Kepler's Second Law specifying the rate of orbital motion. The book was published in 1609, just months before Galileo's report on his first astronomical observations with a telescope, *Sidereus nuncius*.

#### 2.3.1 The Title Page

The text on the title page is a single sentence:

Astronomia Nova Αἰτιολόγητος seu Physica Coelestis, tradita commentariis de motibus stellae Martis ex observationibus G[entilis] V[iri] Tychonis Brahe: Jussu & sumptibus Rudolphi II. Romanorum Imperatoris &c: Plurimum annorum pertinaci studio elaborata Pragae, a S[u]ae C[aesare]ae M[ajesta]tis S[acr]ae Mathematico Joanne Keplero, cum ejusdem C[aesare]ae M[ajesta]tis privilegio speciali Anno aerae Dionysianae MDCIX.

This text contains a number of delightful points, most of which would distract us from the task at hand. Kepler refers to his *studium pertinax plurimum annorum*: "... a tenacious study lasting many years ..." according to [Donahue \(1992: 27\)](#). While *pertinax* and *tenax* and their English versions 'pertinacious' and 'tenacious' are basically synonyms, the former conveys more than a hint of stubbornness. As [Voelkel \(2001: 252\)](#) has shown, the presence of this seemingly autobiographical element in the book title is a part of Kepler's design, "... taking the readers with [the Astronomer] during his metaphorical 'battle with Mars'."

#### 2.3.2 A New Word for a New Science

Apart from numerous other difficulties, one of the reasons behind Kepler's *studium pertinax* was that he was navigating new waters. And not just a new pond or even a new sea, but rather an entirely new ocean. He strove to express a new kind of insight into celestial motions: a new kind of causality, a new kind of relationship between the celestial motions and mathematics, between the material world and astronomical phenomena, and, ultimately, a new kind of causal relationship between a mathematical model and a physical system, indeed, a new kind of physical science. It was so new that he resorted to coining new words to express its novelty. The title of this work is not just *Astronomia nova*, but rather *Astronomia nova αἰτιολόγητος*. Kepler's neologism opens a host of questions, which we shall address in the following section.

### 3 KEPLER'S ETIOLOGICAL NEOLOGISM

#### 3.1 The Neglected *Hapax Legomenon*

In order to describe the way in which his *astronomia* was *nova*, Kepler resorted to Greek, coining the word αἰτιολόγητος. Let us first say that Kepler himself only uses the word on the title page and nowhere else (as far as we can rely on a quick digital search of [KGW](#), and the detailed index in [KGW, Volume 22, 2017: 535](#)), and most literature (with some notable and worthy exceptions: [Voelkel, 2001](#)) does not pay any attention to it whatsoever. Doing our best to avoid the opposite extreme, we think the word is sufficiently prominent to merit some attention.

#### 3.2 Kepler's Own Word

We suggested that the word was coined by Kepler. Let us justify this claim. The [Thesaurus linguae Graecae®](#) (henceforth [TLG](#)) contains altogether 43 entries ending in -λογία, including two opposites of the word αἰτιολόγητος: δυσαιτιολόγητος and ἀναιτιολόγητος. Of course, ancient sources are not fully preserved, and, therefore, lexicographical statistics are valid only in terms of extant texts and there is always a possibility that new findings will change them. However, there is no entry for Kepler's αἰτιολόγητος (his own occurrence in *Astronomia nova* is not listed in [TLG](#) since it excerpts only Greek sources). Compound words may take on a wide range of meanings. Let us illustrate this with a few examples taken from [LSJ](#): ἀναιτιολόγητος, -ον, 'for which no cause can be assigned'; δύσαιοιολόγητος, -ον, 'hard to account for'; ἀφύσιοιολόγητος, -ον, 'not to be explained by science', or 'without knowledge of natural laws'; ἀναστρολόγητος, -ον,



'ignorant of astronomy'; εὐλογητός, -ή, -όν, 'blessed'; ἀναπολόγητος, -ον, 'inexcusable'; 'undefended', or 'without making a defence'; εὐαπολόγητος, -ον, 'easy to excuse'. In view of the word's absence in the classical corpus mapped by the *LSJ* and *TLG* we claim that the neologism αἰτιολόγητος was created by Kepler himself.

Kepler's αἰτιολόγητος was possibly inspired by one of the opposites, ἀναπολόγητος. This form is attested sporadically, employed in Greek scholarly, esp. medical texts and fragments (there are only 15 occurrences in *TLG*). Kepler may have encountered it in Ptolemy's *Apotelesmatica*, better known as the *Tetrabiblos* or *Quadripartitum*, as we shall discuss below.

### 3.3 The Semantic Components

The word is composed of two roots: αἰτί- and λόγ-. Their meanings are deeply related to each other and to the notion of causality but each has its own semantic individuality.

*LSJ* entries supplemented with *TLG* show that the root αἰτί- is the foundation of the adjective αἴτιος, -α -ον ('responsible for', figuratively, 'being the cause of a thing / to a person') attested already in Homer (since the fifth century BCE esp. in rhetorical and philosophical texts). The substantivized forms τὸ αἴτιον and ἡ αἰτία differ mainly by their usage; the neuter appears in prose (esp. philosophical) and it is linked to the figurative meaning of the adjective, while the feminine is more common and has a wider range of meanings, similarly to the original adjective.

The second root is the foundation of one of the most common and richest verbal nouns ὁ λόγος (masc., derived from the verb λέγω, λέγειν in its figurative meanings of 'to count' and 'to say'). The semantic breadth of this noun is unique, ranging from 'account', 'measure', 'value' through 'relation/proportion', 'rule', 'law', 'ground', 'reason', 'thinking', 'assertion', 'argumentation', all the way to 'speech', 'language', 'debate', and even the divinity behind the order of the world. Its occurrences in *TLG* are in the hundreds of thousands.

In the postclassical period, after the fourth century BCE, the two roots were combined into compound expressions. The compounds relevant for Kepler's term are the contracted verb αἰτιολογῶ, -εῖν and the noun αἰτιολογία:

**αἰτιολογέω**, *inquire into causes, reason, account for*, ὑπὲρ τῶν μετεώρων Epicur. Ep. 1 p. 31U. [Epicurus, *Epistula ad Herodotum*], cf. Diocl. Fr. 112 [Diocles, *Fragmenta*], Plot. 6.7.3 [Plotinus, *Enneades*], Plu. 2.689b [Plutarchus, *Quaestiones con-*

*vivales*]; τὸ ζητούμενον Aenesid. ap. S.E.P. 1.181 [Sextus Empiricus, *Pyrrhonicae hypotheses*], cf. Demetr.Lac. 1012.68 [Demetrius Lacon, *Opus incertum* (P. Herc. 1021)] [...] **αἰτιολογία**, ἡ, *a giving the cause of a thing [...]* (*LSJ*: entry αἰτιο-λογέω and αἰτιο-λογία; emph. according to the *LSJ*.)

The closest to Kepler's term is the negative verbal adjective of two endings ἀναπολόγητος, -ον, the positive version of which appears in Kepler's book title.

### 3.4 A Verbal Adjective

Generally speaking (Tronci, 2014), the Greek verbal adjectives formed with the suffix -τό- express various meanings derived from the verb. Depending on the type of the verb (transitive/intransitive) and the context, they can be roughly equivalent to the English past participle or to the English adjectives in '-able/-ible'. We can only say that Kepler's αἰτιολόγητος is formed in line with the rules of morphology, and any Greek speaker would readily understand it. In the phrase *astronomia nova αἰτιολόγητος*, its meaning is unmistakable as similar to an English past participle.

It may be of significance that Ptolemy, introducing astrological divination based on various accidents of birth, uses a negative form of the adjective (equivalent to an English adjective in '-able, i.e., 'unetiologizable', 'causally unexplainable'):

τὰ δὲ ἐνδεχομένην ἔχοντα τὴν κατάληψιν, οὐ διὰ κλήρων καὶ ἀριθμῶν ἀναπολογίτων (Ptol. *Tetr.* 3.4.4, lines 6–8).

What, however, admits of prediction we shall investigate, not by means of lots and numbers of which no reasonable explanation can be given ... (Robbins, 1940: 234–235).

It is highly probable that this is a text Kepler knew in Greek. In a letter to Nikolaus Vicke (letter nr. 607 of 8 February 1611), Kepler remarks on Cardano's commentary on this work of Ptolemy, which contained only the Latin translation of *Tetrabiblos*, referring to Ptolemy's Greek text (*KGW*, Volume 16, 1954: 360–367; cf. also the notes on p. 463). Similarly, Herwart von Hohenburg, corresponding with Kepler (letter nr. 121 of 16 May 1599, *KGW*, Volume 13, 1945: 332–337, see esp. p. 334), quotes the *Tetrabiblos* in Greek, asking Kepler's advice (given in letter nr. 123 of 31 May, *KGW*, Volume 13, 1945: 339–356). Considering the sixteenth century editions of the *Tetrabiblos*, the Greek text was readily available to Kepler (Joachim Camerarius' 1535 edition was Greek only, republished in 1553 as a bilingual Greek–Latin edition; Gerolamo Cardano's 1554 commentary contains, as we noted above, only the Latin

translation).

We suggest that Kepler may have coined his term by removing the *alpha privativum* (corresponding to English 'un-/il-/ir-') from Ptolemy's adjective.

### 3.5 Etiological Astronomy?

In our search for a suitable English equivalent let us turn to the [OED](#), entry *aetiology*:

aetiology|etiology, n. Etymology: < classical Latin *aetiologia* inquiry into, or explanation of, causes, in post-classical Latin also in medical context (1602 or earlier) < ancient Greek αἰτιολογία < αἴτια responsibility, guilt, blame, accusation, cause, reason (< αἴτιος culpable, responsible < an unattested noun (compare ἔξαιτος choice, excellent) < the stem of αἰνυσθαι to take hold of, seize (< the same Indo-European base as Tocharian B ai- to give) + -τος, suffix forming adjectives) + -λογία -LOGY *comb. form*. Compare Middle French *aitiologie*, French *étiologie*, †*aetiologie* (1550 in an apparently isolated attestation, and subsequently from 1694, in medical context; 1611 in philosophical context), Spanish *etiología* (1580), Italian *eziologia* (1631 as †*etiologia*; earliest in medical context).

There are three meanings, which we shall summarize (the full [OED](#) entry is 3 pages long) as: (1) Substantive forms of: assign a cause, provide a reason. Cause or reason assigned. May also be negative: assign responsibility, blame ("his story... has a distinct savour of aetiology" 1893). (2) Study of causation, etc. 'Now rare'. (3) *Medicine*. Medical English makes frequent use of this word, spelled 'etiology' or, less commonly but more correctly, 'aetiology'.

Kepler wanted to qualify his 'new astronomy' with a new adjective in order to separate it from previous approaches. Let us consider translating αἰτιολόγητος as 'etiological' although we are aware that this is an adjective derived directly from the noun, rather than a verbal adjective (a form derived directly from the verb, e.g., 'etiologized', 'etiologizing'). The exact equivalent of 'etiological' is αἰτιολογική (feminine). The verbal adjective is more dynamic, emphasizing action.

Nonetheless, we believe the translator's primary preoccupation must be to keep the attribute in the short title. This calls for a simple and recognizable adjective.

Turning to German for inspiration, we were disappointed that the admirable Max Caspar (one of the chief editors of [KGW](#), who himself edited 11 out of 22 volumes, and translated various works and letters by Kepler), in his excellent German 1929 edition of the work, used the circumlocution *ursächlich begründet*,

i.e., a past participle *begründet* qualified by an adverb *ursächlich*. Thus, unfortunately, not even Caspar was able to find a one-word equivalent for αἰτιολόγητος.

Translating the single word αἰτιολόγητος by several words, Kepler's intention inevitably dissipates. The phrase becomes cumbersome, and a multi-word attribute is invariably omitted from the short title. If the title is abbreviated as *Astronomia Nova*, a claim to this astronomy's novelty is expressed but not specified: What makes it new? It is Kepler's 'etiological' approach, hence our preference for a *New Etiological Astronomy*.

### 3.6 The Medical Connection

It is obvious that Kepler did not associate the word with the negative connotations it sometimes has (etiology as blame-casting or finger-pointing) but he may have, consciously or otherwise, drawn on the word's medical currency. In his introduction to *Astronomia nova αἰτιολόγητος*, Kepler himself mentions medicine as a model for his new type of inference and influence, i.e., between a new epistemology and a new ontology of causes (often called etiology in philosophy textbooks). Indeed, Kepler appears to think of medicine as a model 'natural science' ([KGW, Volume 3, 1990: p. 19, line 22;](#)<sup>2</sup> [p. 22, line 32](#)), using it to justify his incomplete reasoning (medicine is based on conjectures derived from physics, i.e., natural philosophy).

[Helander \(2014\)](#) explains the medical profession's adoption of Greek terms:

The role of Greek became especially important in medicine. Renaissance scholars translated Greek medical authors into Latin. Anatomical names were to be Latin, the names of pathology were to be Greek; this holds true for old terms as well as for the numerous neologisms. This is why the brain is called cerebrum, but inflammation of the brain encephalitis.

On the epistemological plane, Kepler views medical etiology, as well as his new physics, as somewhat inferior to a mathematical proof but still quite compelling. As for the ontology of causes, medicine attributes a condition or malady to a set of underlying factors, seeing causal links between them (if 'causal link' is the right modern counterpart to Kepler's way of thinking). Kepler searches for a similar kind of relationship between astronomical phenomena and physical realities.

The topological and editorial proximity of the title page and Kepler's introduction, where these points are made, is also an argument in favor of the medical connection.

We believe (see also Voelkel, 2001: 217) that the best English translation of αἰτιολόγητος is 'etiological'. The current connection of 'etiological' to the field of medicine should not be held against this solution; if anything, it may be considered as an argument in its favor.

## 4 KEPLER AND GREEK

### 4.1 Kepler's Proficiency in Greek

Kepler's knowledge of Greek was considerable. Dissatisfied with Xylander's Latin translation (1592), he translated into Latin Plutarch's dialog *Περὶ τοῦ ἐμφαινόμενου προσώπου τῷ κύκλῳ τῆς σελήνης* (*On the Face which Appears in the Orb of the Moon*, in *KGW, Volume 11.2, 1993: 380–409*). Improving Xylander's work, he proved not only that he was simply able to understand the Greek text, but mainly that he mastered the language profoundly, considering he proposed various emendations of and conjectures on the fragmentarily preserved original and also added his own marginal notes (identifying particular speakers of the dialogue and announcing different readings) and astronomical commentary on it (*KGW, Volume 11.2, 1993: 410–436*).

The editor of Kepler's commented translation, Helmuth Grössing, summarizes Kepler's achievement:

Seine Leistung als Übersetzer und Kommentator ist an jener der bedeutenden Humanisten wie Erasmus, Pirckheimer, Grynaeus, Stephanus, Amyot, Crusius oder Xylander u.a. zu messen. (*KGW, Volume 11.2, 1993: 487*; "His performance as a translator and commentator can be measured against those of the great humanists such as Erasmus, Pirckheimer, Grynaeus, Stephanus, Amyot, Crusius, Xylander, and others.")

As we have seen, Greek also appears in Kepler's book titles, where Greek words play an important role. We argue that Kepler's proficiency in Greek meant that his use of Greek terms was nuanced and that they carry layers of significance, which would have been much clearer to Kepler's contemporaries than it is to us today.

### 4.2 New Latin

Kepler used Latin as a live language. This was a Latin different from that of Cicero or Augustine (although striving to emulate the great classics) and likewise different from the Latin of St. Thomas Aquinas. This 'learned Neo-Latin' was very much a live language, nonetheless, and it had a certain current usage (Tunberg, 2000; Závorský, 2011). Unfortunately, we do not have a full lexicographical and grammatical mapping

of this humanist and baroque Latin (yet). We have seen the example of how Kepler's linguistic sense in Latin would have informed his choices of appropriate 'Latinization levels' when using Greek terms. For instance, he must have felt that the Greek word διοπτρική would not have sounded sufficiently familiar to the Latin-speakers of his day, which is why he chose to keep its Greek inflexion.

In order to see more clearly how Greek terms functioned in Kepler's Latin texts, we must make a brief excursion into Neo-Latin studies. New Latin or Modern Latin is distinct from Old, Classical, Vulgar and Medieval Latin. Neo-Latin Studies (a more appropriate Latin term is *Litterae Latinae Recentiores*) examine Latin-language literary production from the fifteenth century up to the present day. Contrary to the popular idea of a discontinuity between the Middle Ages and Renaissance, many medieval features continued, including the heterogeneity of methods and of usage in language, as well as ample application of Medieval manuals and dictionaries (e.g., Balbi's universal dictionary of 1286 known as the *Catholicon*). The Latin of Humanism, building on Medieval usage, introduced a great lexicographical flowering, with new topics and new approaches requiring a new vocabulary.

The first attempt to process this new vocabulary globally occurred at the end of the twentieth century in the form of René Hoven's (1993) *Lexique de la Prose Latine de la Renaissance* (*Dictionary of Renaissance Latin from Prose Sources*; the second, revised and significantly expanded edition was published in 2006). Hoven's remarkable selection of texts is not entirely systematic nor representative (see the list of authors and works surveyed in Hoven, 2006: xiv–xxviii).

Recent work on Neo-Latin neologisms was carried out by Hans Helander (especially the specialized chapter in Brill's *Encyclopedia of the Neo-Latin World*; Helander, 2014). His analyses show that the importance of Latin word formation in Renaissance and modern times is still insufficiently recognized even though, as Helander points out, Latin was the main vector of all new knowledge. A new worldview created and understood with new tools required new terms derived from Latin and Greek lexical units. These new needs ran into purist trends at first, with some authors desiring a return to the vocabulary and sociolinguistic register of Cicero, but practical considerations won the day in technical texts where new terms were indispensable. While historiography, theology and the humanities demonstrated a certain linguistic inertia and a closer link to the



Medieval lexical and social reality (cf. [IJsewijn-Sacré, 1998: 386ff.](#)), natural sciences expanded their terminology naturally and organically. According to Helander, Greek was an especially productive source because the theoretical sciences of antiquity were developed in the Greek environment and language while the Roman cultural milieu employed them mainly in school manuals, and in late antiquity at that. It is only natural that Johannes Kepler draws upon both Greek established vocabulary and neologisms.

### 4.3 Greek Terms: Inevitable or Superior?

Durissima est hodie conditio scribendi libros Mathematicos, praecipue Astronomicos. Nisi enim servaveris genuinam subtilitatem propositionum, instructionum, demonstrationum, conclusionum; liber non erit Mathematicus: sin autem servaveris; lectio efficitur morosissima, praesertim in Latina lingua, quae caret articulis, et illa gratia quam habet graeca, cum per signa literaria loquitur. ([Kepler, 1609: \\*1](#))

At the very beginning of his *Introduction to this Work*, viz., to the *Astronomia nova αἰτιολόγητος* of 1609, Johannes Kepler complains that reading mathematical and astronomical texts is dreary and painstaking to the highest degree (*lectio morosissima*), and that Latin exacerbates the challenge, lacking the "... articles and grace ..." of Greek. (How profound would have Kepler's despair and distress been if faced with the ultimate horror: a mathematical text written in a degenerate, vulgar vernacular tongue that had abandoned inflexion centuries ago? One shudders at the thought.)

Perhaps lamenting the inadequacies of Latin while extolling the virtues of Greek simply went with the affectations of the humanist erudite? After all, the movement itself owed much to the regaining and reclaiming of ancient Greek texts. This elitist attitude surely did play a role in part. An early instance of this phenomenon was the Second Sophistic (fl. in the second century CE). These authors cultivated the ideal of a 'proper' Attic Greek and Ciceronian Latin to distinguish themselves from other authors of the day whom they regarded as pseudo-scholars.

In ancient times, scholarly writing was conducted in Greek. In the earlier times of the Roman Republic, Romans were not very interested in theoretical knowledge and even later, when the Greek and Roman cultures mingled more, the latter had only a limited intention to develop some of the so-called 'arts'. There was no 'inferiority complex', as it is frequently supposed: they were genuinely disinterested (cf. [Cicero, Tusculanae disputationes](#)

[1,1,2–3](#)). Their relationship to mathematical knowledge is very well demonstrated by Quintilian who recommends the study of geometry mainly to train the brain of future orators ([Quintilianus, Institutio oratoria 1,10,34–48](#)). Similarly, [Vitruvius \(De architectura 1,4\)](#) recommends the introductory acquaintance of mathematical disciplines in order to become a better architect. By the time of the Second Sophistic, the Greeks and Romans had truly merged, and bilingualism became the ideal. Certain fields, including astronomy, were cultivated in Greek and others in Latin.

Humanists regarded it as crucial to convince their peers of their mastery of the classical sources. This erudite elitism contributed to Kepler's practice but we do not believe it was the decisive factor adequately and fully explaining his choices. Early modern Latin writers very often had no choice but to borrow Greek words and insert them into their Latin text. In many cases, Kepler simply had no genuine Latin alternative. And neither do we. After all, do we not use Greek terms, too? These Greek terms are present in all European languages, and few have tried to replace them with domestic equivalents. Where would modern scholars be without 'problems', 'axioms', 'hypotheses', 'theories', 'diameters', 'polygons', 'logic', 'mathematics', and all the other terms coined by ancient Greek speakers? And do we not coin new quasi-Greek terms all the time? As for scholarly texts in applied mathematics, Kepler saw that they were all in Greek (Boëthius' translation of Euclid's *Elements* notwithstanding), and advanced mathematical and astronomical terminology was Greek ([Lo Bello, 2013: ix–x](#)).

## 5 KEPLER'S NEW CELESTIAL PHYSICS

We have seen two aspects of Kepler's adoption of Greek terms: style and necessity, both playing their roles, the former's role being less important than the latter's. In the case of *αἰτιολόγητος*, however, we shall argue that Kepler introduces a Greek term to draw the reader's attention to the novelty of his approach, viz., his new, non-Aristotelian, kind of causal explanation of astronomical phenomena.

Kepler expresses the same novel approach in the work's second title, *Celestial Physics*. In Kepler's time *physica* was a Greek-based synonym for the Latin (or rather, somewhat less Greek) term *philosophia naturalis* (natural philosophy). The major text read in a typical natural-philosophy course was Aristotle's work known as *Physica*. This has very little to do with our post-Newtonian understanding of the term and the discipline (e.g., [Schuster, 2012](#)). The

predominant view in Kepler's time differed most importantly from ours by regarding mathematical models of planetary motion as below the lofty realm of 'physics', i.e., natural philosophy. The latter's task was to provide explanations, based on causes, and ultimately, based on appeals to the 'nature' of things. Mathematical models were mere descriptions, offering no deeper understanding of the phenomena's 'nature'. Thus, Kepler's second title *Physica coelestis* carries essentially the same meaning as the first one, *Astronomia aἰτιολόγητος*.

In many instances Kepler follows a long tradition of a confusion between cause and reason consecrated by Aristotle (Bunge, 1979: 226–227). A classic example is Kepler's cause/reason for the four then-known satellites of Jupiter. His supposition is that the Creator gave the Jovians four beautiful orbs for their pleasure to compensate for virtually hiding the four inner planets from the Jovians' view due to the angular closeness of the Sun (Kepler, *Dissertatio cum Nuncio Sidereo*, in *KGW, Volume 4, 1941: 309, lines 25–33*). This, in fact, is a reason; not a cause. The central argument of *Astronomia nova aἰτιολόγητος*, however, concerns causes in the proper sense of the term.

Kepler's emphasis on explaining planetary motion by 'physical causes' is clear and explicit from his *Introduction*. Voelkel (2001: 128) summarizes Kepler's project:

In the *Astronomia nova*, Kepler went to some lengths to present his argument in all three major cosmological forms: Ptolemaic (geocentric), Copernican (heliocentric), and Tychonic (geo-heliocentric). And he acknowledged that these hypotheses "are for all practical purposes equivalent to a hair's breadth, and produce the same results." (20: 2–3) [*KGW, Volume 3, 1990: 20, lines 2–3; trans. Donahue, 1992: 48*]. Establishing the truth of Copernicanism therefore hinged on celestial physics and what Kepler could establish about the causes of the motions.

What kind of physical causes did Kepler have in mind? To us, with the benefit of 400 years of hindsight, it may seem trivial but Kepler was entering uncharted territory. Indeed, his 'true theory of gravity' applies something 'like magnetism' but based on bonds of 'kindred' (*corpora cognata*) to the Earth–Moon system and to other 'corporeal substances':

If two stones were set near one another in some place in the world outside the sphere of influence of a third kindred body, these stones, like two magnetic bodies, would come together in an intermediate place, each approaching the other by an interval proportional to the bulk (*moles*) of the other.

If the moon and the earth were not each held back in its own circuit by an animate force or something else equivalent to it, the earth would ascend towards the moon by one fifty-fourth part of the interval, and the moon would descend towards the earth about fifty-three parts of the interval, and there they would be joined together; provided, that is, that the substance of each is of one and the same density [because the calculation is based on volumes but they ought to be based on *moles*]. (Donahue, 1992: 55).

In his *Astronomia nova aἰτιολόγητος*, Kepler's 'gravity' is effectively limited to the Aristotelian sublunary world, but it is already a most inspiring step toward Newton's gravitational *actio in distans*, including the linear dependence on what will Newton call *massa*, but short of the inverse square law. Already in *Dioptricē* 1611, Kepler extends the concept to Jupiter and its four satellites, which form a celestial family of their own, bound by the same type of ties of kindred as the Earth–Moon pair; the latter is bonded by the bodies' earthiness, while the Jovian family has its own bond, a 'Jupiteriness'; and in 1611 none of this has anything to do with the planets orbiting the Sun. Kepler develops his theory further in the *Epitome* of 1618–1621. The Sun is finally included in Kepler's concept of gravity at that point. The notions of kindred are less important and Kepler focuses on quasi-magnetic emanations, decreasing with distance as  $1/r$  or  $1/r^2$  (Hecht, 2017; 2019; although Kepler discovered the Second Law which we, thanks to Newton, see as a consequence of the conservation of angular momentum, Kepler remained unaware of the significance of angular momentum and of its conservation).

These considerations make Kepler look like an early Newton. We must add several important points, making Kepler look less Newtonian. The types of causes/reasons present in Kepler's cultural milieu included mostly-bad theology (see the Jovian example above), many different varieties of magic, (quasi)Platonist mathematical realism, medical etiologies based on observations of correlations, etc. Each of them merits a full study in its own right, and we cannot devote appropriate space to any of them in this paper. We have already touched upon some. Let us conclude by opening a few additional lines of inquiry.

Themes popular in the day, conspicuous by their absence in Kepler, were alchemy, astrology, and magic in general and *magia naturalis* in particular, which was in the mainstream of science as understood around 1600 (Capeocchi, 2018:118–125). One line of inquiry had to do with the search for the Divine language or pos-

sibly for the Adamic language. This was often identified with Hebrew, which may have also signaled a connection to the kabbalah, incl. gematria. Kepler, however, does not mention magic, and we believe he refrains from any overt or covert signals identifiable by various practitioners, because he wants to present his “etiological” approach as different and new.

Kepler's classical confusion between causes and reasons also concerns mathematical models. In his *Mysterium cosmographicum* Platonic solids dictate the proportions of planetary orbs: mathematics is a ‘cause’ of the physical world. This approach reverses the traditional attitudes where mathematical models are mere tools tracing relationships between quantities or where they describe quantitative aspects of the physical world. In the former sub-case mathematical models are instruments distinct from but somewhat parallel with the physical reality. In the latter sub-case, mathematical models are more directly linked to physical reality being derived from it. In both cases, mathematics is secondary, the physical world is primary. *Mysterium* reverses this outright. *Astronomia nova αἰτιολόγητος* is less one-sided. The assumption is that the physical world has a mathematical structure, and that this structure is the ‘inmost form of the nature’ of the physical things (‘naturae penitissima forma’, *Apologia Tychonis contra Ursum scripta*, in *KGW, Volume 20.1, 24, line 2*). What does this mean in practice?

The Aristotelian distinction between the physical and purely mathematical aspects of astronomy was ‘eroding’ (Voelkel, 2001: 217; cf. Jardine, 1988: 225–257) and Kepler's approach was among the most radical. In the Introduction to *Astronomia nova αἰτιολόγητος* he writes: *Physicam coelestem Astronomiae permiscui* (“I have mingled celestial physics with astronomy”; *KGW, Volume 3, 1990: 19, lines 20f.*; Donahue, 1992: 47). Voelkel argues that Kepler is understating the radical novelty of his proposal

... for his approach subordinated astronomical theory to physics. In this sense, his etiological astronomy was truly new. (Voelkel, 2001: 217, section ‘Front Matter’).

The mathematical model being the ‘inmost form of nature’, one may and must judge the merits of mathematical hypotheses by their ability to explain a greater range of phenomena, resonating with nature.

## 6 CONCLUSION

We have shown that Kepler's use of Greek terms in the titles of three of his principal works resulted from a combination of three factors: necessity, style, and personal choice. Mastery of Greek was an important mark of a humanist erudite, and Kepler, without a doubt, was proud of his own proficiency. We do not think that the three cases under consideration, however, were just a point of style. In the more theoretical academic fields, including advanced astronomy, Greek terminology had (and still has) no Latin equivalent. We discussed the ancient origins of this linguistic phenomenon, which left Neo-Latin writers with few alternatives to adopting Greek terms.

We devoted special attention to the case of *Astronomia nova αἰτιολόγητος*, where we argued that Kepler coined a new term (αἰτιολόγητος), and that he did so in order to underline the novelty of his approach. We proposed the hypothesis that Kepler was inspired by Ptolemy's use of the negative form of the word ἀναιτιολόγητος, as well as the medical and scientific use of the lexical family derived from the verb αἰτιολογῶ, -εῖν. These considerations led us to support ‘etiological’ (Voelkel 2001) as a valid English translation of Kepler's term. Listing the factors leading Kepler to the adoption of these Greek terms would be incomplete without mentioning factors that did *not* play a role in his choices. In particular, we argue that Kepler's prominently displayed Greek terms were not a secret flag rallying like-minded scholars (a ‘dog-whistle’ signal). Similarly, the term *harmonice* also merits closer examination but it is beyond the scope of this paper.

As our secondary goal we hope that this paper contributes to an understanding and well-founded pronunciation of Kepler's book titles: (1) the letter ‘c’ is a transliterated *kappa*, and hence should be pronounced as the hard ‘k’ sound (*dioptrikē, harmonikē*); (2) the abbreviated title of the 1619 book is *Harmonice mundi* (not *Harmonices*); and (3) we advocate that Kepler's neologism be kept in the abbreviated title of his 1609 work *Astronomia nova αἰτιολόγητος* (aitiologetos) or *New Etiological Astronomy*.

## 7 ACKNOWLEDGMENTS

We are indebted to Fr. Justin Whittington, S.J., for his kind and thoughtful review of our excursions into classical philology and to Dr Kateřina Bočková Loudová for her invaluable advice on Greek lexicographic references.



## 8 REFERENCES

- Bunge, M., 1979. *Causality and Modern Science. Third Revised Edition*. New York, Dover Publications.
- Capeocchi, D., 2018. *The Path to Post-Galilean Epistemology. Reinterpreting the Birth of Modern Science*. Cham (Switzerland), Springer.
- Caspar, M. (transl.), 1929. *Astronomia Nova: Neue, ursächlich begründete Astronomie*. München, Berlin, R. Olden-Bourg (in German).
- Donahue, W.H. (transl.), 1992. *Astronomia nova*. Cambridge, Cambridge University Press.
- Helander, H., 2014. On Neologisms in Neo-Latin. In Kallendorf, C. (ed.), *Brill's Encyclopaedia of the Neo-Latin World* ([http://dx.doi.org/10.1163/9789004271296\\_enlo\\_B9789004271012\\_0003](http://dx.doi.org/10.1163/9789004271296_enlo_B9789004271012_0003); accessed 20 July 2021).
- Hecht, E., 2017. Kepler and the origins of pre-Newtonian mass. *American Journal of Physics*, 85, 115–123.
- Hecht, E., 2019. Kepler and the origins of the theory of gravity. *American Journal of Physics*, 87, 176–185.
- Hoven, R. 2006. *Lexique de la Prose Latine de la Renaissance. Deuxième Édition Revue et Considérablement Augmentée*. Leiden, Brill (in French).
- IJsewijn, J., and Sacré, D. 1998. *Companion to Neo-Latin Studies, Part II. Literary, Linguistic, Philological and Editorial Questions. Second Edition*. Leuven, Leuven University Press.
- Jardine, N., 1988. *The Birth of History and Philosophy of Science: Kepler's Defence of Tycho against Ursus with Essays on its Provenance and Significance*. Cambridge, Cambridge University Press.
- Kepler, J., 1609. *Astronomia nova aīpiológētos*. [Heidelberg, Vögelin].
- Kepler, J., 1611. *Dioptrice*. Augustae Vindelicorum, typis Davidis Franci [Augsburg, David Franz].
- Kepler, J., 1619. *Harmonice mundi*. Lincii Austriae, sumptibus Godofredi Tampachii, Bibl. Francof., excudebat Ioannes Plancus [Linz, Gottfried Tambach and Johann Planck].
- KGW**: Kepler, J., Dyck, W. von, Caspar, M. (founding eds.), Bialas, V., Grössing, H. et al. (vol. eds.), 1937–2017. *Johannes Kepler Gesammelte Werke*. München, Bayerische Akademie der Wissenschaften (in German).
- LSJ**: The Online Liddel–Scott–Jones Greek–English Lexicon. In *Thesaurus Linguae Graecae® Digital Library* (<http://stephanus.tlg.uci.edu/lj/#eid=1>; accessed 20 July 2021).
- Lo Bello, A., 2013. *Origins of Mathematical Words: A Comprehensive Dictionary of Latin, Greek, and Arabic Roots*. Baltimore, Johns Hopkins University Press.
- OLD**: *Oxford Latin Dictionary*. 1968. Oxford, Clarendon Press.
- OED**: *Oxford English Dictionary*. 1989. *Second Edition*. Oxford, Oxford University Press.
- Robbins, F.E. (transl.), 1940. *Tetrabiblos*. Cambridge (Mass.), Harvard University Press.
- Schuster, J., 2012. Conceptual and historiographical foundations—Natural Philosophy, Mixed Mathematics, Physico-mathematics, Method. In *Descartes–Agonistes. Physico–Mathematics, Method & Corpuscular Mechanism 1618–33 (Studies in History and Philosophy of Science, Volume 27.)*. Dordrecht, Springer. Pp. 31–98.
- TLG**: *Thesaurus Linguae Graecae® Digital Library*. Ed. Maria C. Pantelia. University of California, Irvine (<http://www.tlg.uci.edu>; accessed 20 July 2021).
- TLL**: *Thesaurus Linguae Latinae*. Bayerische Akademie der Wissenschaften (<https://thesaurus.badw.de/tll-digital/tll-open-access.html>; accessed 20 July 2021).
- Tronci, L., 2014. Verbal adjectives. In Giannakis, G.K. (ed.), *Encyclopedia of Ancient Greek Language and Linguistics. Volume 3*. Leiden, Brill. Pp. 471–477.
- Tunberg, T., 2000. Neo-Latin literature and language. In Grendler, P F. (ed.), *Encyclopedia of the Renaissance*. Gale (<https://www.gale.com/intl/databases/gale-in-context>; accessed 20 July 2021).
- Voelkel, J.R., 2001. *The Composition of Kepler's Astronomia Nova*. Princeton, Princeton University Press.
- Sentiváni, M., and Zavorský, S. (transl., comm.), 2011. *Dissertatio cosmographica seu De mundi systemate. Slavica Slovaca*, 46 (3 suppl.), 1–154.



**Fr. Paul Gabor, S.J.**, Ph.D., was born in 1969 in Košice, Slovakia. He studied Particle Physics at Charles University Prague, Czech Republic (1988–1995). His work focused on instrumentation, participating in the development of the ATLAS detector for the Large Hadron Collider at CERN, the European Laboratory for Particle Physics in Geneva, Switzerland.

He entered the Society of Jesus in 1995, did his 2-year novitiate in Kolin, Czech Republic, followed by philosophy studies in Cracow, Poland. After this, he taught philosophy for a year in Olomouc, Czech Republic. He studied theology in Paris, France. He was ordained to the priesthood in 2004. After ordination, he earned a PhD in astrophysics in 2009 in Paris, where he again opted for instrumentation, working with Alain Léger, the author of the proposed Darwin space observatory. Gabor's work under Alain Léger was carried out at the Institut

d'Astrophysique Spatiale, University of Paris South, focusing on two optical test beds, SYNAPSE and NULLTIMATE.

Fr. Gabor joined the Vatican Observatory in September 2010 and was assigned to the Vatican Observatory Research Group in Tucson. He became its Vice Director in September 2012. One of his chief responsibilities is the 1.8-meter Vatican Advanced Technology Telescope on Mt Graham. He is preparing its roboticization, providing new research opportunities in the upcoming era of time-domain astronomy. He is currently engaged in two exoplanet-related observing programs, (1) EDEN (a collaboration with the University of Arizona, MPIA Heidelberg, and NCU Taiwan) focused on nearby M-dwarf exo-Earth transits and TESS follow-up, and (2) the TESS-VATT-

PEPSI Spectroscopic Survey of potential TESS exoplanet host <8.5mag FGK stars in the North Ecliptic Pole region. In his capacity as an observatory director he is also active in astronomy-site protection efforts, mainly in the preservation of dark skies.

Since 2012, he has taught history and philosophy of astronomy at the University of Arizona.



**Associate Professor Katarina Petrovičová** was born in 1976 in Hradec Králové, Czech Republic. She studied Philosophy and Latin language and literature for an M.A. at the Faculty of Arts at Masaryk University in Brno, Czech Republic and completed postgraduate studies for a PhD in Classical philology at the same university.

Already during her studies, she showed a special interest in scholarly and philosophical literature from their beginnings to the transition of the Ancient to the Medieval scholarship. She has since published two monographs on the topic: *Docere ac delectare: Metamorphoses of Roman Scholarly Literature* in 2008, and *Martianus Capella: The Arts on Their Way from Antiquity to Middle Ages* in 2010 (both in Czech, Host publishers), and a series of papers analyzing various aspects and peculiarities of both types of literature.

Katarina works in the Department of Classical Studies at Masaryk University (since 2014 as an Associate Professor of Classical Philology). From 2017 to 2019, she was involved in the interdisciplinary project "The sources of Early Modern Science", which translated and published key seventeenth century scientific writings and made them accessible to experts and the lay public, contributing to the quest for the roots of modern scientific thought. Translations of texts by Johannes Kepler (*Astronomia nova αἰτιολόγητος*, selected chapters), Galileo Galilei (*The Assayer*), Isaac Newton (*Mathematical Principles of Natural Philosophy*, Selections), Jacob Bernoulli (*The Art of Conjecturing*, Part Four), and Bernard de Fontenelle (*Conversations on the Plurality of Worlds*) were accompanied by thorough commentaries on their philosophical and scientific backgrounds. Katarina Petrovičová translated Kepler's text for this project.