Johann Eck's Textbooks as a Continuation of the Oxford Calculators. A Case Study into Sixteenth-Century German Scholasticism

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Abstract: Johann Eck (1486–1543) has been introduced to modern scholarship as a prominent figure of the pre-Tridentine Counter-Reformation. As part of the curricular transformations of the University of Ingolstadt, he wrote commentaries on logical and scientific works by Aristotle and Peter of Spain. Utilising a variety of sources, the two volumes dedicated to physics and natural philosophy published in 1518 and 1519 were self-contained textbooks including annotated translations of the texts and *quaestio*-commentaries. These developed the doctrines of the Oxford Calculators mediated through Continental sources, reproducing their conceptual and mathematical apparatus, including the famous middle degree theorem and Bradwardine's law.

Keywords: Johann Eck; Oxford Calculators; Aristotle commentaries; Scholastic physics; Bradwardine's law; middle degree theorem.

1. Introduction

Johann Eck (1486–1543) is best known for his theological positions and his anti-Protestant polemics, including debates with Karlstadt and Luther in 1519.[1]

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1 See Iserloh 1981, 22–48. Heiko A. Obermann introduces Eck as "[l]ater professor at Ingolstadt and Luther's principal opponent from the moment of the publication of his *Obelisci* (1518) and his participation in the Leipzig Debate (1519)," Obermann 1983, 18. For Eck's biography, see Wiedermann 1865; Greving 1906; Iserloh 1972, 34–51; Leinsle 2010, 269–272; Trüter 2016, 59–77.

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Significant attention has also been paid to his logic textbooks.[2] In contrast, his natural philosophy has been mostly disregarded, with the exception of the facts that Eck's *Physics* commentary refers to Luther as "D. Martinus Luder Heremita amicus noster," uses his own biography as an example of *fortuna*, and contains an introduction documenting the humanist tendencies of German universities.[3] To the best of my knowledge, the only exception appears to be Josef Schaff's 1912 dissertation, containing a basic and selective overview of 'Cursus Eckianus', discussed as a part of the history of physics at the University of Ingolstadt.[4]

Scholastic intellectuals in the early sixteenth century were no longer free from competition and were forced to react and, ultimately, transform or fade away. There were, of course, the three notorious issues: geocentric astronomy, in which celestial bodies were fundamentally different from earthly bodies, an approach to be replaced by heliocentric cosmology combined with the view that the universe is homogenous; Aristotelian hylomorphism (in its many variations) which was to be replaced by an ontology of particles and fields; and the view that the fundamental parameters of mechanics were force, resistance, and velocity, to be replaced by Newtonian mechanics based on force, weight and acceleration. Furthermore, around the middle of the sixteenth century, scholasticism underwent an internal transformation accompanied by curricular changes in which certain genres and debates were dropped. The relevant part of this transformation affected the *quaestio* com-

2 See Prantl 1855–1870, volume 4, 284–290; Seifert 1978 (criticised in Spade 1979); and Read 1991.

3 For the first observation, see Iserloh 1981, 23; for the second observation, see Trüter 2016, 70–74; for the third observation, see Seifert 1984, 140–44; Overfield 1984, 308–313.

4 See Schaff 1912. Schaff maps the institutional context of Eck's writings and gives their overview (paying significant attention to his astronomical views and theories of magnetism), but disregards the connections to the Oxford Calculators which the present paper will address.

mentaries on *Physics* and the later *disputationes Physicae*: Wallace's survey uncovered a significant drop in interest in calculatorial topics, which followed one of its peaks in the early sixteenth century. Apparently, the calculatorial spirit was inherited by Galileo and his followers, rather than being continued in the scholastic tradition.

To summarise Wallace's and Clagett's surveys of sixteenth-century scholastic physics (addressing primarily the theories of gravity and free fall and the quantification of qualities and motion), the tradition of the fourteenth-century British and Parisian physicists and their fifteenth-century Italian commentators (available in printed form) was developed in John Mair's circle. This circle of scholars included several teacher-pupil relations (although the lines of influence could have been more complicated), connecting (among others) John Mair, Jan Dullert of Ghent, Juan de Celaya, and Domingo de Soto. Domingo de Soto would later become the major influence for the further dissemination of calculatorial physics, since he was acceptable in a non-partisan way to Dominicans, such as Cosme de Lerma, who published *Physics* commentaries, *ex doctrina sapientissimi M. P. Fr. Dominici de Soto*, to Jesuits of the Collegio Romano, and to the Augustinian Alonso de la Vera Cruz, whose *Phisica speculatio* was published in Mexico in the 1550s.[5]

The present paper aims to supplement this body of knowledge with a detailed analysis of Johann Eck's physics as preserved in his textbooks. This effectively includes three important and hitherto under-researched areas: the tradition of Oxford physics as developed in John Mair's circle, sixteenth-cen-

5 The physics of John Mair's circle was researched as early as DUHEM 1913, 263–583; for more recent research, see WALLACE 1981; WALLACE 2004; DI LISO 2006, 39–108. For an overview of sixteenth-century scholastic physics, see CLAGETT 1959, 653–671 and DI LISCIA 1997, 143–76. For an overview of natural philosophy in Baroque scholasticism, see GELLERA 2022, 201–27. For late-medieval physics in general (other than Wallace and Clagett), see MAIER 1956; WEISHEIPL 1956; SYLLA 1991; VERBOON 2010; JUNG, PODKOŃSKI 2020; HANKE 2023.

tury German scholasticism, and Johann Eck's intellectual biography. Firstly, through discussing Eck's sources, lesser known aspects of physics in John Mair's circle will be addressed. As a line of dissemination of the ideas shared within the circle of John Mair, Eck is a (geographically separated and slightly younger) contemporary of Soto; in a way, they pertain to the same 'generation' of John Mair's pupils. As for the second area, Eck's logic commentaries on Peter of Spain and his scientific commentaries on Aristotle became standard textbooks according to the 1519/1520 statutes of the Ingolstadt Faculty of Arts; this situation appears to have changed by the time new statutes were issued in the 1530s.[6] These institutional facts made Eck's works a significant chapter in late-medieval German scholasticism. Lastly, Johann Eck was one the most significant sixteenth-century Western intellectuals, albeit for reasons other than his philosophical career. The present study will address the neglected aspect of Eck's intellectual biography.

To understand Eck's position in the Latin intellectual tradition, note that the dates of publication of his textbooks locate him after the discovery of the New World by the Old World, in the era of Renaissance humanism and at the brink of the scientific revolution. These points will now be briefly developed.

First, citing Paul of Burgos and Thomas Bricot, Eck copies the figure indicating the mutual positions of the sphere of earth **bdge**, of the sphere of water in the primeval phase of creation **mno** and the sphere of water after the water had been assembled **CDE**:

6 For the text of the statutes, see PRANTL 1872, volume 2, 160–161 and 183–186. As an example of the change, Eck's logic textbook was replaced with the humanistically oriented John Caesarius' *Dialectica* and Aristotle's scientific works were mentioned instead of Eck's commentaries. That period, including the curricular transformation at the University of Ingolstadt and the role of Johann Eck, is analysed in PRANTL 1872, volume 1, 141–216; LIESS 1980, 26–30.

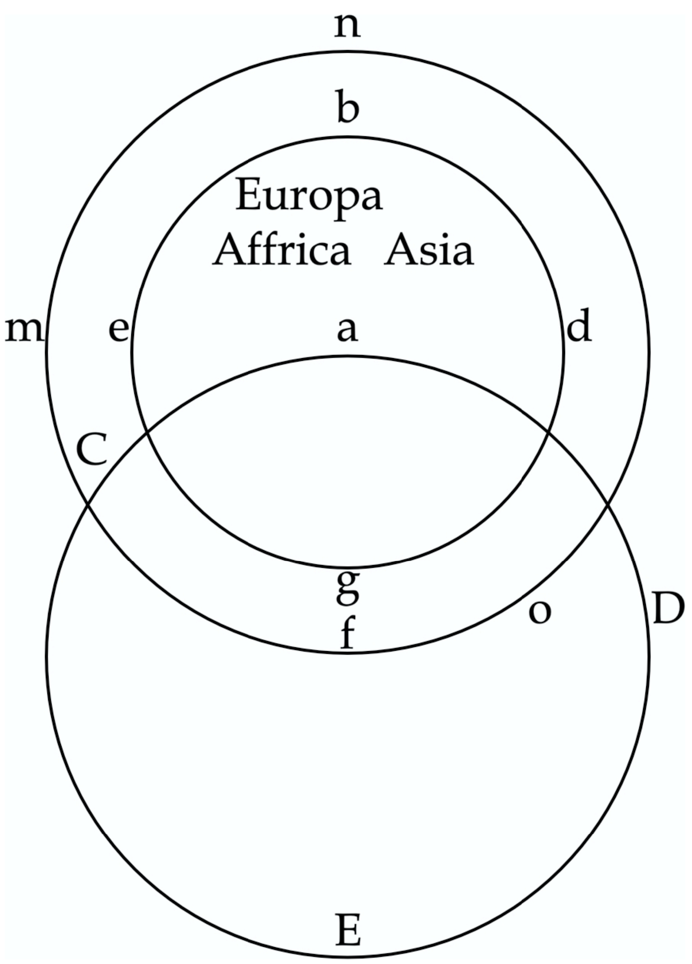

Figure 1, Eck 1518(1), fol. 56ra (adaptation)

The underlying view of the universe attempts to harmonise the biblical creation narrative with the Aristotelian account of the elements. One problem with that theory was that the sphere of earth was supposed to be surrounded by the sphere of water, which in turn is surrounded by the sphere of air etc., visualised by concentric circles.[7] This implies an obvious problem: the earth is actually *not* entirely surrounded by water. To solve it, an eccentric model was suggested.[8] However, Eck ultimately abandoned the eccentric model owing to empirical evidence, which in this case was the discovery of the New World.[9]

7 See ANONYMOUS 1510, h4v.

8 See SACROBOSCO 1501, b1r; for a modern edition see SACROBOSCO 2019.

9 "Ista est pulchra imaginatio, ac nulla autoritate vel philosophica vel theologica approbata, ideo eadem facilitate contemnitur qua asseritur, et potissimum quod iam experientia

Second, Eck wrote in an era when new translations of Ancient sources became available and some previously available sources were retranslated. To give just a few examples, Eck's commentary uses Argyropoulos' translation of *Physics*, cites Nipho's commentaries, and even occasionally cites Aristotle in Greek.[10]

Third, Eck was Copernicus' contemporary (1473–1543): his intellectual career straddles Copernicus' 1510s *Commentariolus* and his late-1530s or early-1540s *De revolutionibus*.[11] However, as Copernican astronomy only became publicly known outside a narrow circle of readers after his death and *Cursus Eckianus* was published prior to 1520, it seems safe to assume that he was not influenced by Copernicus. Eck predates Galileo (1564–1642), Kepler (1571–1630), Brahe (1546–1601) and Newton (1642–1727).[12] As a (partially confirmed) working hypothesis, the questions Eck asks about the universe, the contexts in which he does so, and the answers he suggests, are scholastic.[13] Lastly, it is a well-known feature of scholastic physics that it was rooted in conceptual analysis, rather than observations and carefully designed experiments.[14] While much of Eck's mechanics simply develops sources produced in this way, his works display interesting hints of empiricism. To give one illustrative (albeit rather comical) example, Eck discusses a theory of magnetic force that can be tested with a pair of scales and two magnets, and, possibly

est in oppositum, inuentis terris ea parte qua ipse arbitratur terram adhuc aquis occupatam, vt America […]," ECK 1518(1), fol. 55rb.

10 ECK 1519, fol. 70va. See also SEIFERT 1984, 141.

11 See RABIN 2023, citing GODDU 2010 as a source for Copernicus' intellectual path.

12 For the biographical data, see HOCKEY ET AL. 2014, *ad indicem*.

13 As an example, in his *De coelo* commentary, Eck asks *An sint vel possint esse plures mundi* (ECK 1519, fols. 15ra–16va), *Quot sunt numero sphaere coelestes* (ECK 1519, fols. 29va–31ra), *An necesse sit ponere circulos ecetricos et epicyclos, vt saluentur apparentia in motu planetarum* (ECK 1519, fol. 31ra–rb) and *An terra rotunda in medio mundi quiescat*? (ECK 1519, fols. 35vb–36rb).

14 See (among others) MURDOCH 1982(1); KRETZMANN 1982(1); KING 1991; ROUX 2011; GRELLARD 2011; KNUUTTILA, KUKKONEN 2011.

with some regret, notes that he is not able to replicate the crucial experiment, as he only owns a single piece of magnet.[15]

The present paper addresses Eck's fundamental mechanics as preserved in his commentaries on *Physics* which continue the tradition of the Oxford Calculators, written between 1517 and 1518 and published 1518, and in his commentaries upon *On the Heavens*, *On Generation and Corruption* and *Meteorology*, written in 1518 and published in 1519.[16] The commentaries share a common structure. First, a Latin translation of Aristotle's text is reproduced. Second, the text is summarised in *explanatio textus* and supplemented with *annotatio in textum*, often introducing material from Greek, Arabic, scholastic, and humanist commentaries. Third, selected problems are addressed in *explicatio scholastica*, which has the form of a *quaestio*-commentary; the disputed questions usually consist of the terminological introduction (*nota*), the conclusion (*responsiuus*), related issues (*dubia* or *dubitatiuus*), and objections with replies (*rationes* or *argumentatiuus*). To outline the content of the relevant commentaries, the lists of disputed questions will be included in the appendices.

The core of the present survey (presented in Sections 2.1 and 2.2 respectively) is the reconstruction of Johann Eck's kinematics (analytical tools for describing different forms of local motion) and dynamics (mathematical tools for establishing a correlation between the acting force and the velocity of the generated motion); as these are part of a common debate in Eck's era, his approach will be linked to his sources, which are explicitly acknowledged

15 "Dico tertio, quod quia ferrum sic mouetur ad motum magnetis, ideo ferrum cum magnete non est grauius quam magnes per se, quia ferrum mouetur ex se cum magnete, ideo si duo magnetes aequales ponantur ad duas stateras, unus cum ferro, alius sine ferro, illi aequaliter ponderabunt, hoc tamen vltimum non sum expertus, quia non habeo, nisi vnum magnetem […]," Eck 1518(1), fol. 91rb, related to Nicolas of Cusa by Schaff 1912, 38. There are several topics which deserve attention for the same reason, such as Eck's accounts of gravity, free fall, and inclined planes.

16 The editions used are: Eck 1518(1); Eck 1519.

by him. This will be supplemented by three brief surveys into the minor context in which the tradition of the Oxford Calculators is typically developed, namely the *On Generation and Corruption* commentaries (exploring the notion of physical agency), logical treatises (exploring inferential roles of 'to begin' and 'to cease'), and *Sentences* commentaries (exploring the quantification of qualities).

2. Scholastic Mechanics in the *Physics* Commentary

Eck's commentary on Book VII of *Physics* addresses two basic problems of late-medieval mechanics, namely the dynamic question of how local motion should be approached from the point of view of its cause (*penes causam*) and the kinematic question of how local motion should be approached from the point of view of its effect (*penes effectum*), discussed as the second and third *dubium* of the second question. The sources Eck mentions in this context are mainly from two periods, namely the fourteenth century, including Richard Swineshead, William Heytesbury, Thomas Bradwardine and *alii calculatores*, and Albert of Saxony, and the sixteenth century, including Augustino Nifo and some authors pertaining to John Mair's circle (John Mair, Jan Dullaert, Luis Coronel).[17]

The aforementioned *dubia* spread over a mere three columns in the *folio* format,[18] which is far too short to reproduce the contemporary debates in their entirety. Thus, it seems symptomatic of Eck's approach that while he views Dullaert's account as the most extensive and notes that the contempor-

17 For the literature on the physics of John Mair's circle see above.

18 For physical descriptions of the codex, see https://opacplus.bsb-muenchen.de/permalink/49BVB_BSB/1mrtm42/alma991091846189707356 and https://www.manuscriptorium.com/apps/index.php?direct=record&pid=NKCR__-NKCR__5_B_000036__3LZ3NEE-cs (accessed 20 October 2023).

ary kinematics branches into the followers and opponents of Heytesbury, he labels himself and his readership as those "who favour brevity" and praises Mair's *Sentences* commentary.[19]

2.1 Kinematics or **motus penes effectum**

Oxford-style kinematics typically introduces velocity and acceleration together with their division based on uniformity and difformity. Eck only discusses velocity while disregarding acceleration.

Velocity of local motion is defined in steps. First, velocity in general is defined in terms of space traversed related to time.[20] The other two steps introduce circular and rectilinear motion, which are two elementary forms of (natural) motion in Aristotelian physics. Every natural motion is either the rectilinear motion upward and downward of sublunar bodies, or the motion

19 The relevant passages are as follows: "Hanc quaestionem cum sequenti Suisset, Hentisber, Bravardinus et alii calculatores latissimi pertractant. L. Coronel idem fecit, sed copiosissime M. Ioan. Dullaert, qui revera cerebrum aperuit in hac materia, verum nos breuitati studentes, amoeni ingenii doctorem Ioan. Maioris suo secundo imitabimur," ECK 1518(1), fol. 94va; "Et quamuis sint pugnanter magistrorum sententiae, vt facile leges Suessam et Alb. Saxonem in vi. Ioan. Dullaert in iii. Phys. at nos vt pridem Ioan. Maioris imitabimur, nescio enim quo pacto viri illius ingenium vbique mirifice me obiectat," ECK 1518(1), fol. 94vb; "Alia reperies in locis praeallegatis, parum enim confert haec subtiliatio, Dullaert sequitur Hentisber, Nyphus soluit rationes Hentisberi etc.," ECK 1518(1), fol. 95ra. This is not an isolated statement in Eck, who claims that a certain problem in the theory of degrees and intensity has been discussed ad nauseam: "Hanc materiam fuse esse disputatam vsque ad nauseam per G. Ocham, G. Arimiñ., Alphonsum, Gabriel et alios dist. 17. primi. Cameraceñ., q. 9 Saxo. in 5. physi. as si Bruxeleñ. et alios communiter in 3. physi. Nos auream breuitatem secuti, exameni ingenii doctore Ioan. Maioris selectiora decerpemus," ECK 1519, fol. 72ra.

20 "Velocitas motus localis attenditur penes spacium pertransitum, non absolute, sed in ordine ad tempus […]," ECK 1518(1), fol. 95ra. As suggested particularly by the view of rotation, 'velocitas' might be more accurately translated with 'speed', rather than 'velocity'; as noted by Clagett and Grant, 'velocitas' meant "speed or velocity without vectorial implications" (see CLAGETT 1959, 210; GRANT 1966, 18) and Peter King favoured 'speed' over 'velocity' as the correct translation of 'velocitas' (see KING 1991, 58). With this caveat, the term 'velocity', which appears more common in the recent scholarship, will be used.

of celestial bodies, which ultimately reduces to circular motion.[21]

The velocity of circular motion is measured by "the line drawn by the point in the middle of the semidiameter of a moving body."[22] That might sound strange to a modern reader, who would probably perceive the motion of a celestial body as the motion of the orbiting body itself. If, for the sake of example, such an orbit were circular, the key parameter would be the circumference of such a circle, i.e., the trajectory of the orbiting body. Eck's paradigmatic example, on the other hand, is the motion of a wheel or of a celestial sphere. In other words, the hypothetical motion of the orbiting body would be perceived as the motion of the (imaginary) wheel that is part of a celestial sphere, at whose circumference that body is located. The reason why it is the *centre* of the circumference of the sphere is explained in terms of the famous Merton 'middle degree' or 'mean speed' theorem: a uniformly difform quality is equivalent to its middle degree. As an example, if a certain body is unevenly white such that the lowest degree of its whiteness is equal to zero, the highest degree of its whiteness is equal to eight and all intermediate degrees are regularly distributed, the degree of whiteness of the body equals four, which is the middle degree. To relate the same theorem to local motion, if a certain body starts moving from rest and uniformly accelerates until its degree of velocity is equal to eight, at which point it stops moving, its motion is equivalent to the motion with a degree of velocity equal to four over the same distance.[23] Since a uniformly difform quality is measured by its middle degree, Eck argues, the same approach should apply to circular motion, where

21 See ECK 1519, fol. 5va–vb. The dichotomy appears crucial prior to Kepler's revolutionary idea that elliptical, rather than circular, trajectories play the key role in celestial kinematics (see KRAFFT 1991).

22 "Velocitas motus circularis attenditur non penes spacium corporale aut superficiei, sed lineale, ita quod cognoscitur penes lineam descriptam a puncto medio semidiametro rei motae […]," ECK 1518(1), fol. 95ra.

23 See SYLLA 2010 for various formulations and proofs of the theorem.

one should focus on the middle point of the circumference, rather than the points which are the slowest or the fastest moving.[24]

The velocity of rectilinear motion is measured by the amount of space traversed by the middle point of a moving body; incidentally, the justification is different from circular motion.[25] As Eck is well aware, this statement had been a matter of detailed debate since the fourteenth century; he notes the opposition between Heytesbury followed by Dullaert and Nifo (who followed Albert of Saxony).[26]

Eck introduces three definitions of uniform motion and suggests that difformity be defined accordingly. The first and the third of these are straightforward: a motion is uniform if equal space is traversed in equal time or if the intensity of the motion is equal in its every part. The second definition claims that uniform motion "proceeds from a single proportion," without elaborating further.[27] The statement is quite likely copied from Dullaert's *Physics* commentary, where the uniformity of motion translates to a constant proportion between force and resistance, uniformity of motion being defined in terms of dynamics.[28]

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24 "Probatur illa conclusio, quia qualitas vniformiter difformis mensuratur gradu medio, ergo et motus localis circuli non mensurabitur tardissimo nec velocissimo, sed medio puncto […]," ECK 1518(1), fol. 95ra. Eck appears to follow the reasoning of Dullaert (see DULLAERT 1506, g3rb) and Mair (see MAIR 1510(2), fol. 4ra–rb).

25 "Velocitas motus localis recti attenditur penes spacium lineale descriptum a puncto medio totius corporis moti," ECK 1518(1), fol. 95ra.

26 See ECK 1518(1), fol. 95ra (quoted above). For Dullaert, see DULLAERT 1506, g3rb–vb; for Heytesbury's position, see HEYTESBURY 1494, fols. 37vb–39ra; for Albert's position, see ALBERT OF SAXONY 1971, 68; ALBERT OF SAXONY 1999, volume 3, 891–903; for Nifo's position (referencing "Albertulus") see NIFO 1508, fols. 159va–161ra.

27 "Premitto II, quod motus alius est vniformis, alius difformis. Vniformis localis est quo in aequalibus partibus temporis aeqalia spatia pertranseuntur […] vel motus uniformis est motus proueniens ab vnica proportione, vel est motus secundum omnes suas partes aeque intensus, difformem ab opposito explica," ECK 1518(1), fol. 94va.

28 "Motus localis vniformis est quo in equalibus partibus equalia spacia nata sunt pertransiri […] motus localis vniformis est motus proueniens ab vnica proportione […] Prima diffinitio explicat effectum motus localis vniformis, ista secunda causam. Vel iterum sic

Furthermore, the uniformity of motion is threefold, namely uniform with respect to time (*quoad tempus*), uniform with respect to the subject, i.e., the moving body (*quoad subiectum*) and uniform with respect to both. The motion is uniform with respect to the subject if all parts of the moving body are moving with equal velocity; the motion is uniform with respect to time if it is not accelerated (as the example goes).[29] After defining uniformity and difformity, the difference between the uniform difformity and difform difformity of the motion is introduced. The motion of a body is uniformly difform if the velocity of its middle part exceeds the velocity of its slowest part by the same amount by which it is exceeded by the velocity of the fastest part.[30] This seems surprising, since the definition focuses on difformity *quoad subiectum*, rather than *quoad tempus*, which is how uniformity was defined in an earlier passage and how the notion was typically introduced.[31]

2.2 *Dynamics or* **motus penes causam**

The fundamental problem of scholastic dynamics was the relation between velocity, force, and resistance. Since the 1320s, two things appear to have been taken for granted, namely that these are the only relevant factors and

potest diffiniri: motus localis vniformis est qui secundum omnes suas partes est eque intensus," DULLAERT 1506, g3rb.

29 "Adde quod motus potest esse trifariam vniformis, scilicet quoad subiectum, quoad tempus et quoad vtrumque. Quoad subiectum, vt quando graue descendit per medium vniforme, tunc totum et partes eius aeque velociter mouentur, sed quia motus est velocior in fine, quam in principio, non mouetur vniformiter quoad tempus. Quoad tempus, vt coelum quod in aequali tempore aequales portiones circuli describit, sed partes difformiter mouentur, nam propinquiores polo tardius mouentur […]," ECK 1518(1), fol. 94va. There is a parallel passage in Eck's *On the Heavens* commentary with the examples relevant to astronomy; see ECK 1519, fol 26ra–rb.

30 "Praemitti III, quod motuum difformium alius est vniformiter difformis, alius est difformiter difformis. Vniformiter difformis […] quia medium partis subiecti tantum exceditur in velocitate ab extremo citius moto, quantum ipsum excedit tardius […] Opposito modo diffinit motus difformiter difformis […]," ECK 1518(1), fol. 94va.

31 See CLAGETT 1959, 199–219.

that the problem is solvable in terms of proportional relations. Such a framing requires further debate on three issues. First, the nature of proportions.[32]

The theory of proportion is included in Bradwardine's *De proportionibus velocitatum in motibus* and Albert of Saxony's *Tractatus proportionum*, but Eck refers directly to Book V of Euclid's *Elements of Geometry* and a "book of arithmetic" used in the quadrivial course of the University of Ingolstadt.[33] The nature of force is discussed in Eck's commentaries upon *On Generation and Corruption* and *On the Heavens* (see below). Resistance, which turns out to be an umbrella concept for a variety of factors, is discussed in the commentary on Book IV of *Physics*.

The physics problem is to formulate a satisfactory formula describing the relation between these parameters. Eck introduces four different theories. As he is explicit regarding his sources, it is possible to compare the relevant formulations. The lists from the works of Bradwardine, Albert of Saxony and Dullaert, who are mentioned by Eck in this context, and Eck, are as follows:[34]

32 For *proportiones*, see Livesey 1986, 283–310; Sylla 2008, 67–119.

33 "Praemitto I quid sit proportio, quid proportionalis et quot species eius maioris vel minoris inaequalitatis, quid proportio rationalis, quid irrationalis et quomodo cognoscatur proportio proportionum et excessus vnius proportionis super aliam, quae omnia require in nostro elementario quadruuii libro Arithmeticae. […] vt patet ex Arithmetica et V. Elementorum Euclydis, nam sine illis principiis frustra aliquid tentabis in hac materia," Eck 1518(1), fol. 94va.

34 For Mair's position referenced by Eck, see John Mair, *In secundum Sententiarum*, fol. 6ra–rb (the same views are discussed); Mair's *Physics* commentary, issued in print in 1526 contains a longer discussion of the problem: see Mair 1526, i5va–k2va. Furthermore, see Coronel 1511, fols. 79va–80rb, referencing Heytesbury, Swineshead and Albert of Saxony's *Tractatus proportionum*.

Thomas Bradwardine *De proportionibus velocitatum in motibus*[35]	Albert of Saxony *Tractatus proportionum*[36]	Jan Dullaert *Questiones phisicales*[37]	Johann Eck *Adnotationes ac commentarii super Acroases Physicae*[38]
[B_1] *Opiniones erroneae proposito pertinentes sunt quattuor, quarum prima ponit proportionem velocitatum in motibus sequi excessum potentiae motoris ad potentiam rei motae.*	**[O_1]** *De primo sit prima conclusio: proporcio velocitatum in motibus non attenditur penes proporcionem potenciarum inter se.*	**[O_1]** *Prima tenet quod proportio velocitatum in motibus attenditur penes proportionem potentiarum motiuarum inter se.*	**[O_1]** *Prima. Proportio velocitatum non est sumenda penes proportionem potentiarum motiuarum inter se.*
[B_2] *Sequitur de secunda opinione erronea ponente proportionem velocitatum in motibus sequi proportionem excessus potentiae motoris super potentiam rei motae.*	**[O_2]** *Secunda conclusio: proporcio velocitatum in motibus non attenditur penes proporcionem resistenciarum inter se.*	**[O_2]** *Secunda opinio tenet quod proportio velocitatum in motibus debet attendi penes proportionem resistentiarum inter se.*	**[O_2]** *Secunda. Proportio velocitatum non attenditur penes proportionem resistentiarum inter se.*
[B_3] *Sequitur de tertia opinione er-*	**[O_3]** *Tercia conclusio: proporcio velo-*	**[O_3]** *Tertia opinio fuit quod proportio*	**[O_3]** *Tertia. Proportio velocita-*

35 See BRADWARDINE 1955, 86, 92, 94, 104 and 112.

36 See ALBERT OF SAXONY 1971, 62–63. There is a parallel passage in Albert's Physics commentary: "[…] prima conclusio: proportio velocitatum non est sicut proportio potentiarum moventium inter se. […] Secunda conclusio: proportio velocitatum non est sicut proportio resistentiarum. […] Tertia conclusio: proportio velocitatum non est sicut proportio excessuum […] Quarta conclusio: proportio velocitatum in motibus est sicut proportio proportionum moventium ad suas resistencias," ALBERT OF SAXONY 1999, volume 3, 981–983. The sixteenth-century editions of this text preface this passage with a reference to the treatise on proportions; see, for instance, ALBERT OF SAXONY 1504, fol. 74va. While Eck is referencing Albert's *Physics* commentary in this context, *Tractatus proportionum* seems to be a closer fit, which suggests that Albert's influence on Eck was indirect.

37 See DULLAERT 1506, q5vb–q6ra.

38 See ECK 1518(1), fol. 94vb.

ronea, quae ponit proportionem velocitatum in motibus (manente eodem motore vel aequali) sequi proportionem passorum, et (manente eodem passo vel aequali) sequi proportionem motoris.	*citatum <in motibus> non attenditur penes proporcionem excessum duorum <seu differenciarum> inter se ipsarum potenciarum movencium super suas resistencias.*	*velocitatum in motibus debet attendi penes proportionem excessuum pontentiarum ad suas resistentias.*	*tum non debet attendi penes proportionem excessuum pontentiarum ad suas resistentias.*
[B4] *Quarta vero opinio ponit quod nulla est proportio nec aliquis excessus potentiae motivae ad potentiam resistivam.*	–	–	–
[B5] *Proportio velocitatum in motibus sequitur proportionem potentiarum moventium ad potentias resistentivas.*	**[O4]** *Quarta conclusio: proporcio velocitatum in motibus attenditur penes proporcionem proporcionum potenciarum <movencium> super suas resistencias. Et hoc est quod sotet dici: proporcionem velocitatum sequi proporcionem geometricam.*	**[O4]** *Istis opinionibus relictis, sola hec opinio tenenda est quod velocitas in motibus debet attendi penes proportionem proportionum potentiarum ad suas resistentias […]*	**[O4]** *Quarta. Proportio velocitatum attenditur penes proportionem proportionum (hoc est proportionem Geometricam) potentiarum ad suas resistentias.*

The texts split into two groups with Bradwardine on one side and the remaining texts on the other.[39]

39 For the reconstruction, see the next footnote, together with Lindberg 2007, 309–313.

The ultimately accepted positions are the same, i.e., **[B_5]** is the same as **[O_4]**, called 'Bradwardine's law': the proportion of velocities follows the proportion (of proportions) of forces above resistances. Furthermore, **[B_1]** appears identical to **[O_3]**. **[B_2]**, **[B_3]**, and **[B_4]** have no counterpart in Eck's group and **[O_1]** and **[O_2]** have no counterparts in Bradwardine's text. The second observation suggests that Bradwardine disregarded positions which omit some of the relevant factors, in these cases resistance and force respectively. It is not clear what to make of the absence of **[B_2]** (which is held to emphasise the proportion of the difference between force and resistance to the resistance, thereby developing [**B_1**]), but the absence of **[B_4]** (saying that force and resistance cannot be analysed in terms of proportion or excess) suggests that the quantifiability of mechanics is taken for granted.

The absence of **[B_3]** appears to be the most surprising feature of Eck's group. In modern terms, **[B_3]** is typically reconstructed as being equivalent to saying that the proportion of velocities simply follows the proportion of proportions of forces to resistances:

$$[B_3]\ \frac{V_1}{V_2} = \frac{\frac{F_1}{R_1}}{\frac{F_2}{R_2}}$$

which reduces to saying that velocity is directly proportional to force and inversely proportional to resistance:

$$V \propto \frac{F}{R}$$

or:

$$kV = \frac{F}{R}$$

Its absence is surprising, as it appears to be a more natural starting point than the relatively complicated Bradwardine's law.

To reconstruct Eck's group, note that **[O_1]–[O_4]** are primarily formulated in terms of proportional relations, where the typical problem is a mutual comparison between two motions defined in terms of velocity, force and resistance, rather than any calculation of velocity based on force and resistance.[40] For the same reason, it makes no sense to ask, for example, what the relevant units of physical quantities are: historically speaking, Eck (apparently in agreement with his sources) only speaks about 'degrees' (*gradus*) of a certain quantity. **[O_1]** appears to claim that the proportion of velocities follows the proportion of the respective forces:

$$[O_1]\frac{V_1}{V_2}=\frac{F_1}{F_2}$$

[O_2] appears to claim (assuming charitably that velocity is *inversely* proportional to resistance) that the proportion of velocities follows the proportion of the respective resistances:

$$[O_2]\frac{V_1}{V_2}=\frac{R_2}{R_1}$$

and **[O_3]** appears to claim that the proportion of velocities follows the proportion of the excesses of forces over resistances:

$$[B_1/O_3]\frac{V_1}{V_2}=\frac{F_1-R_1}{F_2-R_2}$$

After dismissing these three views, Eck presents the theory that "a proportion of velocities is measured by the proportion of proportions (i.e., the geometrical proportions) of moving forces to their resistances,"[41] elucidated by two ex-

40 Note that Crosby's reconstruction of Bradwardine followed the alternative path in his introduction to Bradwardine's treatise; se e BRADWARDINE 1955, 32–38. This paper is closer to the reconstructions offered by MAIER 1946, 147–166, GRANT 1966, 14–24; GRACIA 1970, 175–195 (that contains a confrontation of these formulations).

41 See ECK 1518(1), fol. 94vb.

amples: If F_1/R_1 equals four and F_2/R_2 equals two, then the velocity of the motion produced by F_1 is twice the velocity of the motion produced by F_2; and if F_3/R_3 equals eight and F_4/R_4 equals two, then the velocity produced by F_3 is thrice the velocity produced by F_4.[42]

In agreement with the traditional reconstruction of Bradwardine's law, this translates to:

$$[B_5/O_4]\,\frac{F_1}{R_1}=\left(\frac{F_2}{R_2}\right)^{\frac{v_1}{v_2}}$$

meaning that (anachronistically):

$$\frac{v_1}{v_2}=\log_{\left(\frac{F_2}{R_2}\right)}\frac{F_1}{R_1}$$

As implied by the definition of logarithmic functions, the domain of the base is the set of all positive real numbers other than 1 and the domain of the function is the set of all real numbers greater than 0;[43] moreover, no value in the denominators can be equal to zero. While these restrictions are not discussed as mathematical problems by Eck, some of them are validated by further debate on **[B_5/O_4]**.

The first restriction is based on the principle that motion and action only proceed from "the proportion of greater inequality" between force and resistance, which means that the degree of a moving force must be greater than the degree of the respective resistance, whence $F_n/R_n>1$ (as otherwise, the resulting velocity would presumably be equal to zero); that alone guaran-

42 "Vt si **a** ad **b** est proportio quadrupla et **c** ad **d** est proportio dupla, tunc **a** movet **b** in duplo velocius quam **c d**, quia proportio quadrupla est dupla duplae. Similiter si **a** esset in proportione octupla ad **b** et **c** duplum ad **d**, tunc **a** in triplo citius moveret, quoniam octupla est tripla duplae, vt pater ex Arithmetica et V. Elementorum Euclydis, nam sine illis principiis frustra aliquid tentabis in hac materia," ECK 1518(1), fol. 94vb.

43 These, of course, are textbook points; see (e.g.) MUNEM, YIZZE 1997, 250.

tees that the logarithmic formulation of **[B_5/O_4]** is meaningful.[44]

Furthermore, several scenarios are addressed in which some of the values are extreme. One of them is infinite velocity or, in scholastic terms, instantaneous motion, discussed in the commentary on Book VI of *Physics*. The examples of instantaneous change include both supernatural agency, such as the creation of the universe and transubstantiation, and natural agency, such as the propagation of light, meaning that the speed of light is infinite.[45] Other than the propagation of light, every physical change is assumed to be successive, as infinite velocity would require an infinite moving force, which natural agents do not have.[46] The other side of the same coin appears to be that an infinite moving force produces infinite velocity of motion.

Finally, as a traditional problem of Aristotelian physics, motion in a vacuum is discussed.[47] Eck solves the ontological part of the problem in a fairly common way by saying that a vacuum is physically impossible but can be produced by God.[48] The mathematical and physics part of the problem is how to calculate velocities in a medium with zero resistance.[49] To be more specific,

44 This principle is a presupposition (*nullus motus potest provenire a proporcione equalitatis nec minoris inequalitatis*) of Albert of Saxony dynamics; see ALBERT OF SAXONY 1971, 62 (with the notion of the proportion of greater inequality discussed at page 59). Eck formulates the principle for activity: "a proportione maioris aequalitatis fit actio, id est quando virtus agentis forties agit, quam virtus passi resistit," ECK 1519, fol. 65va.

45 See ECK 1518(1), fol. 85va–vb; for a parallel passage, see ECK 1520, fol. 26ra. Eck's view on the propagation of light appears to follow the Aristotelian mainstream; see LINDBERG 1978, 45–72.

46 "[…] omnis mutatio est successiva. Confirmatur quia producere posse effectum precise in hora est aliquantae virtutis et in medio horae est maioris virtutis, ergo in instanti producere erit infinitae virtutis, sed nulla virtus creata est infinita, ergo nulla virtus creata producet aliquid in instanti. […] Porro omnis virtus agentis creatis est finita, ergo solum aget actione temporario," ECK 1518(1), fol. 85vb.

47 See GRANT 1981, 5–66, which offers a general overview of the debate on resistance and motion in a vacuum.

48 ECK 1518(1), fol. 60vb–61ra.

49 Traditionally, this related to the principle that there is no proportion between a finite quantity and an infinite quantity. In the translation of Aristotle's *Physics* used by Eck, the relevant passage is: "vacui ad plenum nulla prorsus esse ratio potest," ECK 1518(1),

the problem is the motion in a vacuum of a 'simple' body, which is only composed of a single element. The reason is that resistance was held to have an 'internal' and an 'external' component. For local motion, the internal resistance of a body results from the proportion of elements of which it is composed, where every element has its own natural motive tendency, and these weaken or cancel each other out. As a result, a body composed of a single element has internal resistance equal to zero. The external resistance is typically assumed to include the density of the medium, which for a vacuum is equal to zero. As a consequence, if resistance only included these two components, the resistance of a simple body moving through a vacuum would equal zero. In this controversial issue, Eck sides with "Vuesalia"[50] who develops Avempace's position that external resistance includes the "incompossibility of the *termini*": a body cannot traverse a distance instantaneously, as that would entail being in different parts of the trajectory at the same time. This alone guarantees that the total resistance of a moving body is *never* equal to zero, which solves the problem with extreme input-values in the denominators in both formulations of **[B_5/O_4]**.[51]

fol. 58v, which is interpreted in the subsequent *explanatio* as) follows: "[…] omnis motus habet proportionem ad alium motum, sed motus in vacuo non potest habere, proportionem in pleno, ergo non est motus in vacuo. Medii enim vacui ad medium plenum nulla est proportio in raritate et densitate," ECK 1518(1), fol. 60v. Incidentally, the same problem might occur for infinite values if Eck were to cite the principle "proportio nulla est inter finitum et infinitum"; see SIGNORIELLO 1872, 283–284.

50 This is possibly Johannes Rucherat de Wesalia, an Erfurt proponent of *via moderna*, whose *Physics* commentary is mentioned in the 1492 catalogue of the Ingolstadt Faculty of Arts; see LOHR 1971, 276–277; WÖHLER 2004, 525–526.

51 See ECK 1518(1), fol. 61ra–va for the entire debate. External resistance is defined as follows: "Praemitto IIII duplicem esse resistentiam, vna est intrinseca, quando mobile habet quid per essentiam, per quid resistit motui. Alia est extrinseca, quando ratione alterius retardatur a motu, quod potest multipliciter fieri. 1. propter aequilibrium, sic mensurando carnes in pondere carnes et pondus resistunt, quod neutrum descendit; 2. propter coniunctum, vt si leui coniungitur graue, citius enim currit equus liber, quam sub ponderosa sarcina; 3. propter figuram, et sic quadratum tardius descendit per aerem quam sphericum eiusdem grauitatis, spericitas est aptior motui; 4. propter virtutem trahentem in oppositum, sic ferrum tardius descendit sub magnete quam sine magnete,

3. Further Contexts

3.1 Spatial Limits of Physical Agency

The range of natural agency is assumed to be spatially limited. This topic, connected to both the Aristotelian and modern traditions, is discussed in (at least) three interesting contexts by Eck.

First, Eck introduced "the sphere of activity" to capture the spatial limitation of physical agency and its consequences in his *On Generation and Corruption* commentary. He asks whether every action entails a reaction (*an omne agens in agendo repatitur*), such as in the scenario where cold water cools a hot piece of iron while being warmed as a result, a possible counterexample being the activity of the Sun which does not appear to be reactively influenced by sublunary objects.[52] When listing conditions under which action entails reaction, he requires that the agent and re-agent must be in each other's sphere of activity, whose size appears to be a function of the respective force, whence finite physical agency is spatially restricted.[53]

Second, in his *On the Heavens* commentary, Eck introduces the classification of forces (*potentia*) and their limitations in terms of *maxima* and *minima*.[54]

Third, while discussing instantaneous change in the *Physics* comment-

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quia magnes habet virtutem attractiuam ferri, sic succinus palee; 5. propter medium, citius enim cadit lapis per aerem, quam per aquam; 6. propter mouens, possum enim lapidem velociter et impetuose proiicere possum et lente; 7. incompossibilitas terminorum, scilicet termini a quo et termini ad quem. Vuesalia," Eck 1518(1), fol. 61rb. Note how difficult it would be to capture these various factors in a single number.

52 See Eck 1519, fols. 65va–66rb. Late-medieval debates on action and reaction are discussed in Caroti 1995; Caroti 1997.

53 "Tertia quod agens sit infra sphaeram actiuitatis passi, vnde secundum Aristo. omnis actio physica non impedita et medio aeque disposito et agente aliunde non directo, fit sphaerice quare si agentis sphaere diameter esset vt decem passi vt quinque, tunc possent sic approximari, quod agens non reperaretur, hic enim **a** agit in **b**, sed **b** non reagit, quoniam **a** est extra sphaeram suae actiuitatis," Eck 1519, fol. 65vb.

54 See Eck 1519, fols. 19va–20vb. For medieval debate, see Wilson 1960, 57–114; Heytesbury 1984; Di Liscia 2014.

ary, Eck commented on the fact that the intensity of light produced by a finite source decreases with the distance from the source. While the presentation of the problem is rather sketchy, his take appears to be that such a decrease is linear, as the intensity of light is held to reach zero at a certain distance.[55] To summarise, action propagates itself in a spherical way, the sphere of activity is limited, and the intensity of some effects decreases linearly with distance from the agent.[56]

3.2 Physics in Logical Treatises

Various branches of logical analysis provide further traditional contexts for late-medieval physics. First, there is a genre of sophisms that played a significant role in fourteenth-century university curricula.[57] However, Eck's logic textbooks, i.e., his *Bursa pavonis*, *Elementarius dialecticae*, and commentary on Peter of Spain, do not contain a separate treatise on sophisms. That said, the quantification of qualities and motion is briefly mentioned in the treatises on categories.[58] Furthermore, both *Bursa pavonis* and the commentary on Peter of Spain contain *tractatus probationum* citing Paul of Venice as an inspiration and

55 "Si illuminatio fuerit in instanti, tunc posset illuminare in infinitum, si medium esset infinitum, contrarium huius patet, quia semper remissius illuminat, si negat respondens, legat post formacem scripturam remote a lumine. […] Ad IIII negatur sequela quia est virtus finita, ideo aget solum in finitam distantiam, nam si producat lumen ut quattuor, tunc in puncto quod in duplo magis distat a luminoso quam punctum in quo lumen est vt 4 est non gradus luminis, lumen in puncto ad bonum sensum," Eck 1518(1), fols. 85vb–86ra.

56 The generally acknowledged sources for this account of physical agency are Averroes 1953, 247–249 and Grosseteste 1912, 64, cited in the fourteenth century by (e.g.) Oresme 1996, 100, and Marsilius of Inghen 1500, k2va, who in turn is referenced by Eck. For another two significant sources cited by Eck in the relevant contexts, see Nifo 1508, fol. 167vb and 1506, fol. 42ra–va; Mair 1510(1), fols. 69vb–72va. For the development of the concept of the sphere see Krafft 1991, 195–210.

57 For the genre of 'physical sophisms', see Pironet, Spruyt 2023, § 2.3.2 or the less recent but more detailed Sylla 1982, 546–553.

58 See Eck 1516, fols. 41va and 46ra; Eck 1517(1), fols. 49va–vb and 65ra–va; Eck 1517(2), a6v–b1r; Eck 1518(2), a6v–b1r.

discussing the inferential roles of 'to begin' and 'to cease' (*de incipit et desinit*), including the terminology of the instances of change (*de primo et ultimo instanti*).[59] Also, the incorporation of beginning and ceasing into 'proofs' stands in opposition to those fourteenth-century authors who included the analysis of beginning and ceasing in their treatises on consequences.[60] As such, they are a continuation of the logical tradition of the Oxford Calculators, which in turn was a continuation of the debate on *syncategoremata* and *exponibilia*.[61]

3.3 Physics in Commentaries on the Book of Sentences

A significant context for debates on physics topics in Eck's era were commentaries on *Sentences*. To mention but three relevant examples, Eck cites Gregory of Rimini's, Pierre d'Ailly's and John Mair's commentaries on the seventeenth distinction of the *First Book of Sentences*.[62] Eck lectured on *Sentences* during his stay in Freiburg in 1506 and 1509, including lecturing on Ockham's and Biel's commentaries, and Biel's commentary references Gregory of Rimini and Pierre d'Ailly's commentaries on *Sentences*.[63] However, it is not clear whether there is a written record of these lectures. Eck is also known to have commented on the *First Book of Sentences* in the 1540s, but

59 See ECK 1507, h3r–h4r and ECK 1516, fol. 104rb–va. For Paul of Venice's position in the debate, PAUL OF VENICE 2002, 95–97.

60 See John of Holland's *Consequentie magistri Johnnis de Holandria bone et vtiles*, Kraków, Biblioteka Jagiellońska, ms. 2660, fols. 33v–36r; FERRYBRIDGE 1507, q1va–q3vb; BERTAGNA 2008, 668 (which sits on the borderline between consequences and proofs). Incidentally, the genre of proofs can be traced back to another author from the Calculators' circle, Richard Billingham; see BILLINGHAM 1970; DE RIJK 1982. For an overview of the genre, see (e.g.) BOS 2007.

61 For an overview of the genre, see WILSON 1960, 29–56; MURDOCH 1979, 117–146; MURDOCH 1982, 586–587; KRETZMANN 1982, 212–214; KANN 2008, 89–110. The issue has come to the fore in the recent scholarship, including the critical editions of Walter Burley (see BURLEY 1955; SHAPIRO, SHAPIRO 1965); Thomas Bradwardine (see NIELSEN 1982), Marsilius of Inghen (see CIOLA 2017) and others.

62 See (e.g.) ECK 1518(1), fol. 93rb–vb; ECK 1519, fol. 65va.

63 See GREGORY OF RIMINI 1982, 215 and ff.; PIERRE D'AILLY 1490, o4vb–p5ra; BIEL 1973, 441.

the text does not comment on the seventeenth distinction.[64]

4. Closing Remarks

For a general characterisation of Johann Eck's role in scholastic physics note that, first, despite the notable influences of the humanist movement, the doctrinally most significant parts of Eck's mechanics are a continuation of the Oxford calculatorial tradition.[65] While Eck is familiar with the fourteenth-century Calculators, whom he mentions by name, he appears predominately to follow the sixteenth-century sources. Typically, he neither reproduces nor elaborates on the majority of the debates included in his sources. He avoids discussing multiple artificial scenarios in order to fine-tune conceptual analysis, probably as that pertained to the genre sophisms which he openly criticised.[66] In his own words, a person interested in the details of the calculatorial tradition should go read Dullaert. While Eck relies significantly on earlier sources, it should not be overlooked that he made some decisions: to take one example, he follows Dullaert in dynamics, but he sides with Nifo against Heytesbury and Dullaert in his kinematics, interestingly following Albert of Saxony in both cases.

Second, despite the frequent use of pictorial material, there are no traces of Nicole Oresme's influence in Eck's commentaries, i.e., no signs of the application of geometry to physics. In other words, the mathematical apparatus of his physics is based on *proportiones*, rather than *latitudines*.

Finally, as Eck's logic and scientific commentaries became standard

64 See ECK 1976.

65 Incidentally, the doctrinally significant Nifo's influences on Eck can typically be traced back to scholastic debates.

66 See SEIFERT 1984, 140, who pointed out Eck's use of phrases such as "reiectis sophismatum quisquiliis" and "eliminate barbarie, expulses sophismatum quisquiliis" in his Peter of Spain and *Physics* commentaries.

textbooks for the University of Ingolstadt, further exploration into the network of scholars associated with this university seems to be a promising step in future research on Johann Eck's influence.

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Appendix 1. The Structure of Johann Eck's *Physics commentary* (1518)

Book I	**Q. 1** Whether physics as a science discussing natural beings is distinct from other sciences. *An Physica sit scientia rerum naturalium consideratiua ab aliis distincta* (fols. 1ra–3rb) **Q. 2** Whether scientific knowledge results from the cognition of principles, causes and elements. *An scientia fiat ex cognitione principiorum, causarum et elementorum* (fols. 3vb–5vb) **Q. 3** whether there is only one immobile being, as claimed by Parmenides and Melissus. *An tantum sit vnum ens immobile, sicut posuerunt Parmenides et Melissus* (fols. 6vb–12rb) **Q. 4** Whether a part of a whole which is in rest can be in a motion. *An toto quiescente possit illius pars moueri* (fol.13rb–13vb) **Q. 5** Whether everything is in everything, as Anaxagoras thinks. *An quodlibet sit in quolibet, vt Anaxagoras autumauit* (fols. 14vb–16rb) **Q. 6** Whether the principles of natural beings are mutually contrary. *An principia rerum naturalium sint contraria* (fols. 16vb–18rb) **Q. 7** Whether there are only three principles of natural beings. *An tantum tria sint rerum naturalium principia* (fols. 19rb–21rb) **Q. 8** Whether matter is an actual or potential being distinct from

	form and privation. *An materia sit ens in actu vel potentia a forma et priuatione distinctum* (fols. 22rb–25rb)
Book II	**Q. 1** Whether nature is correctly defined by the Philosopher. *An natura recte diffiniatur a philosopho* (fols. 27ra–29vb) **Q. 2** Whether the analysis of causes pertains to physics. *An ad physicum pertineat tractatus causae* (fols. 30vb–33rb) **Q. 3** Whether fortune and chance are correctly explained by the Stagirite. *An fortuna et casus sane per Stagyritam explicentur* (fols. 34vb–36rb) **Q. 4** Whether nature acts towards an end, which generates necessity. *An natura agat propter finem, a quo necessitas oriatur* (fols. 37vb–39rb)
Book III	**Q. 1** Whether motion is defined correctly. *An motus recte diffiniatur* (fols. 40vb–42ra) **Q. 2** Whether motion is distinct from a moving object. *An motus distinguatur a mobili* (fols. 42ra–45rb) **Q. 3** Whether there is an actually infinite sensible body. *An sit corpus sensibile actu infinitum* (fols. 49rb–50vb)
Book IV	**Q. 1** Whether the definition of the place is correct. *An diffinitio loci sit bona* (fols. 54ra–57vb) **Q. 2** Whether the existence of vacuum is possible. *An possibile sit esse vacuum* (fols. 60va–62vb)

	Q. 4 [sic!] Whether the definition of time is correct. *An diffinitio temporis sit bona* (fols. 66va–68rb)
Book V	**Q. 1** Whether motion as such only exists in three categories. *An solum ad tria praedicamenta sit per se motus* (fols. 70rb–72rb)
	Q. 2 What is required for the unity of motion. *Quae requiruntur ad vnitatem motus* (fols. 73va–74vb)
	Q. 3 Whether a motion is contrary to another motion and to a state of rest. *An motus contrarietur motui et quieti* (fols. 76rb–77rb)
Book VI	**Q. 1** Whether there are indivisible points in a line. *An in linea sint puncta indiuisibilia* (fols. 79rb–81rb)
	Q. 2 Whether there is a 'now' or an indivisible instant. *An sit aliquod nunc seu instans indiuisibile* (fols. 84va–86rb)
	Q. 3 Whether an indivisible object can move *per se.* *An indiuisibile possit per se moueri* (fols. 87vb–88rb)
Book VII	**Q. 1** Whether everything that is in motion is set in motion by something else. *An omne quod moueatur ab alio moueatur* (fols. 90rb–91vb)
	Q. 2 Whether motions are mutually comparable *An motus sint adinuicem comparabiles* (fols. 93va–95vb)
Book VIII	**Q. <1>** Whether motion is eternal. *An motus sit eternus* (fols. 97va–98vb)
	Q. <2> Whether animals move themselves while heavy or light inanimate objects do not. *An animal moueaur ex se et non graue vel leue inanimatum* (fols.

	103ra–104rb) **Q. <3>** Whether local motion is the primary motion. *An motus localis sit primus motuum* (fols. 107vb–108vb) **Q. <4>** Whether the prime mover has infinite power. *An primus motor sit infinitae virtutis* (fols. 110ra–111rb)

Appendix 2. The Structure of Johann Eck's commentary upon *On the Heavens* (1519)

Book I	**Q. 1** Whether there is a fifth simple body moving in a simple motion different from the four elements. *An praeter quattuor elementa sit quintum corpus simplex simplici motu motum* (fols. 6rb–6(bis)vb) **Q. 2** Whether the heavens have matter. *An coelum habeat materiam* (fols. 10va–12vb) **Q. 3** Whether there are or can be multiple worlds. *An sint vel possint esse plures mundi* (fols. 15ra–15vb) **Q. 4** Whether the world is uncreated and eternal. *An mundus sit ingenitus et aeternus* (fols. 19ra–20vb)
Book II	**Q. 5** Whether the six differences of position exist in the heavens. *An sex differentiae positionum reperiantur in coeli natura* (fols. 22va–23vb) **Q. 6** Whether the heavens in regular motion are spherically shaped. *An coelum regulariter motum sit sphaericae figurae* (fols. 26ra–26vb) **Q. 7** What is the number of celestial spheres. *Quot sunt numero sphaere coelestes* (fols. 29va–32rb) **Q. 8** Whether the round Earth rests in the centre of the world. *An terra rotunda in medio mundi quiescat* (fols. 35vb–36rb)
Book III	–

Book IV	**Dubitatiuncula** How is the heaviness of objects experienced without scales. *Quomodo sine pondere experiamur grauitatem rerum* (fol. 44va–vb) **Q. 9** Whether similar to no element being heavy when in its own place, there is something heavy or light absolutely speaking and something heavy or light relatively speaking. *An sicut nullum elementum est graue in suo loco, ita sit aliquod simpliciter graue, aliquod leue, aliquod graue et leue in respectu* (fols. 47ra–48rb)

Appendix 3. The Structure of Johann Eck's commentary upon *On Generation and Corruption* (1519)

Book I	**Q. 1** What is the primary subject-matter of this part of physics. *Quod est huius partis physicae subiectum primarium* (fol. 48va–vb) **Q. 2** Whether something comes to be absolutely speaking. *An aliquid simpliciter generetur* (fols. 52vb–54rb) **Q. 2(bis)** Whether alteration is generation. *An alteratio sit generatio* (fols. 54va–57rb) **Q. 2(ter)** Whether growth is generation. *An auctio sit generatio* (fols. 59ra–61rb) **Q. 4** Whether every agent acts through contact. *An omne agens agat per contactum* (fols. 64va–66rb) **Q. 5** Whether elements are truly preserved in a possible mixture. *An in mixtione quae est possibilis elementa vere maneant* (fols. 67va–68vb)
Book II	**Q. 6** Whether there are only four elements, equally as there are only four tangible primary qualities. *An sicut quatuor sunt qualitates primae tangibiles, ita tantum quatuor sunt elementa* (fols. 70vb–73rb) **Q. 7** Whether every element can come to be out of any other element. *An quodlibet elementum ex quolibet generari possit* (fol. 76ra–rb)

	Q. 8 Whether there is a mixture out of four elements. *An mixtum sit ex quatuor elementis* (fols. 77va–78vb) **Q. 9** Whether every living being has a determinate period of its life. *An omne viuens habeat determinatam periodum suae vitae* (fol. 81ra–81vb)

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