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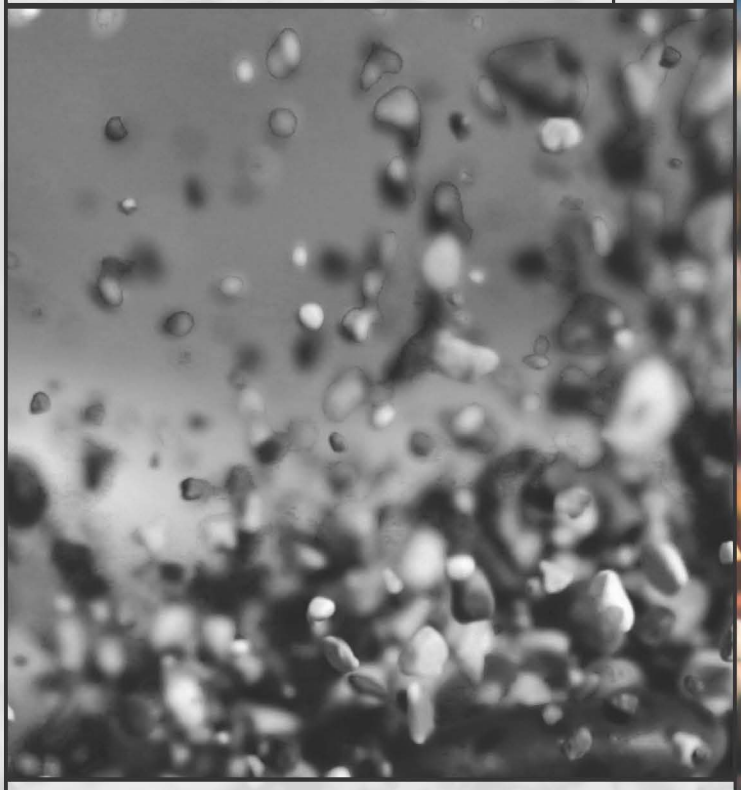

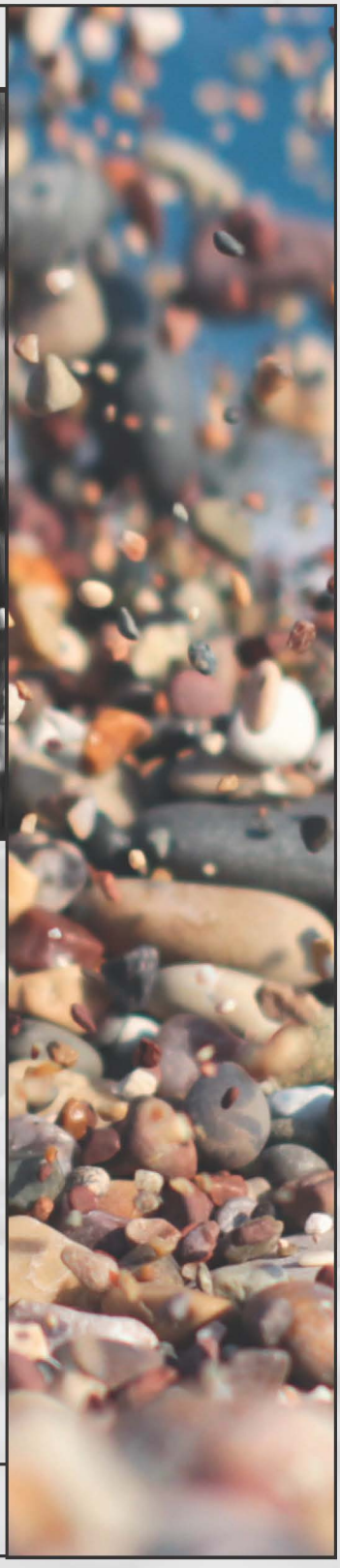

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TOWARDS THE MODERN THEORY OF MOTION

Oxford Calculators and the new interpretation of Aristotle

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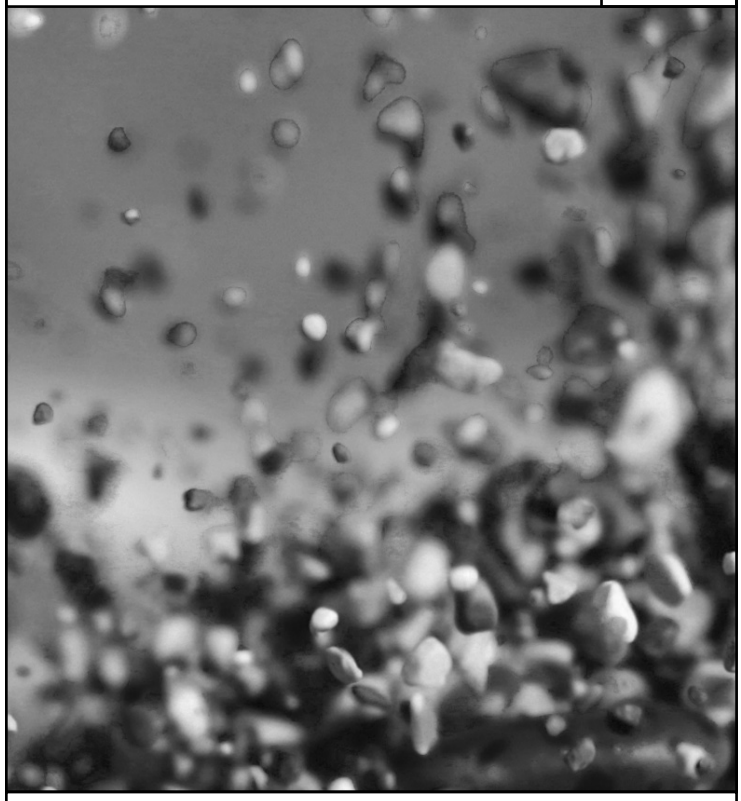

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Preface

Chris Schabel in his excellent book: "Theology at Paris 1316–1345. Peter Auriol and the problem of divine foreknowledge and future contingents" opens his Preface with a statement which suitably reflects the context of our research into the Oxford Calculators' 14th-century philosophy of nature. We repeat after Schabel: "The path that this present study has taken has been as roundabout as the historiographical path […] that led to the serious lacuna that this book attempts to fill."

Studies into the Oxford Calculators tradition had their beginnings with Pierre Duhem's research published at the start of the 20th century. The discovery of mathematical physics, which, in accordance to the common opinion of historians of medieval science, was "introduced" by Thomas Bradwardine, initiated intensive research in the field. Konstanty Michalski, Marshall Clagett, Annelise Maier, Lamar Crosby, Curtis Wilson, John Murdoch, Ernest Moody, George Molland, John Longway, Stephen Read, Fabienne Pironet, Sabine Rommevaux, and Edith Sylla, to mention only a few names, devoted their studies either to preparing critical editions of the Oxford Calculators' texts or to presenting the main ideas of the Calculators themselves. The primary and secondary literature, as our Bibliography shows, is extensive.

The predominant belief, expressed by Edith Sylla, and commonly accepted, is that: "The Calculators carried their analyses and calculations a bit too far for it to be plausible that their main goal was discoveries in natural philosophy". In her opinion the works of such personalities of fourteenth-century Oxford philosophy as Richard Kilvington, Thomas Bradwardine, William Heytesbury, John Dumbleton and Richard Swineshead, albeit full of discussion of problems from natural philosophy, were intended from the outset to be first of all, more or less advanced, logical exercises, meant primarily for advanced undergraduates. We, however, made an afford to prove that the Oxford Calculators works were aimed not at formulating increasingly complicated logical

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riddles, but rather at developing the natural science, with a specially attention put on "science of motion' within the typically Aristotelian scheme of theoretical science.

Taking into account how much has been discovered, edited and written on the Oxford Calculators, we decided to revise and compare the results of our and other historians' studies on the intellectual heritage of these fourteenth-century English thinkers in order to provide those interested with an updated and well supplemented account on the Oxford Calculators natural philosophy in perhaps its most fundamental aspect – at least from the point of view of Aristotelian philosophy – namely on the "science of local motion". The first conclusion that must be form here, at the very beginning, is that the term "the Oxford Calculators' school" is perfectly adequate and well-grounded as a general notion with respect to the thinkers we refer to below. As will be shown, the concepts and solutions these thinkers included in their philosophical works were developed within the context of the ideas presented by the other group members – sometimes as simply borrowed ideas, sometimes as ones deemed dubious, and sometimes as mere impulses for further discussions and solutions. The other conclusion, perhaps far more subversive, is that it was not Thomas Bradwardine who introduced mathematics in the form of the new 'calculus of ratios' to the Aristotelian "science of local motion", but his contemporary, one of the most ingenious and unorthodox personalities of those times – Richard Kilvington. Only because there remained so few manuscript copies of Kilvington's works on natural philosophy, ones hitherto poorly scrutinized, did historians of medieval philosophy and science better know Thomas Bradwardine and his handbook "On the proportions of speeds in motions".

To achieve our main goal, i.e., to answer questions about continuity or discontinuity in the development of science from the Medieval period up to the Scientific Revolution we offer detailed analyses based on the first published critical editions of Latin-manuscript texts by Richard Kilvington, William Heytesbury, the anonymous author of the treatise *De sex inconevnientibus* and a part of Dumbleton's *Summa logiacae and philosophia narturalis* (Part III: *De motu locali*).

Our research confirms our belief that scientific truths in general, and even historical facts in particular, are never established once and forever, thus, through the present book we intend to revise the story of the Oxford Calculators' school.

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In the course of the research and preparing critical editions, we have greatly benefited from the financial support provided by National Science Centre, Poland (UMO-2015/17/B/HS1/02376).

We would like to express our gratitude to Edith Sylla, André Goddu, Daniel Di Liscia and Chris Schabel, who have helped us in our work, both through constructive criticism and support. We thank Barbara Bartocci, Rodney Thompson and David Rundle for their help with the manuscripts of Dumbleton's *Summa*. Research for this book has been based mainly on manuscripts. The following libraries provided us with direct access to manuscripts: the Biblioteca Apostolica Vaticana, Gonville & Caius College Library, Cambridge, Peterhouse College Library, Cambridge, the Biblioteca Malatestiana in Cesena, the Wellcome Historical Medical Library, London, Lambeth Palace Library, London, the Biblioteca Nazionale Marciana in Venezia. Elżbieta Jung expresses special thanks to Verity Parkinson – the Resource Service and Support Librarian at Merton College Library Archive, University of Oxford and Anne Chaster – Deputy Librarian at Magdalen College Library and Archives, University of Oxford, for their kind assistance and help.

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Chapter I

Lives and Works of Oxford Calculators

The fourteenth-century English thinkers active in Oxford formed the School, these being the so-called Oxford Calculators, a gathering previously known as the Merton School, since – as the precedent historians of science thought – its members were affiliated with Merton College.[1] Twentieth century scholars were sure that the founder of the School of Oxford Calculators was Thomas Bradwardine, who in 1328 had composed his famous *Treatise on Ratios of Speeds in Motions* (*Tractatus de proportionibus velocitatum in motibus*). In this work he offered the so-called New Rule of Motion, later known and discussed by the next generation of Oxford Calculators as well as by continental thinkers right up to the sixteenth century.[2] Elżbieta Jung's long lasting research, however, has revealed that already before 1328 there were intense, fruitful discussions on this issue between the members of Baliol College, Oxford. The anonymous author of *De sex inconvenientibus* written after 1335 mentions two names: Thomas Bradwardine and Adam of Pipewelle.[3] Bradwardine was already famous during his lifetime, while the second thinker is almost unknown – we only know that he was the member of Baliol College in 1326.[4] But yet we have a perfect witness of those discussions,

1 See for example J.A. Weisheiple, *Ockham and some Mertonians*, "Medieval Studies" 30 (1968), pp. 163–213; Idem, *Ockham and the Mertonians*, [in:] "The History of the University of Oxford", T.H. Aston (ed.), Oxford 1984, pp. 608–658; M. Clagett, "The Science of Mechanics in the Middle Ages", Wisconsin 1959.

2 The secondary literature on this subject is so extensive that it is difficult to mention even the most important works. In the footnotes below there are references to relevant works.

3 See infra, Anonimus, *De sex inconvenientibus*, q. *Utrum in omni motu sit certa servanda velocitas*, (Editions), §. 95, p. 334.

4 See, G.C. Brodrick, "Memorials of Merton College with biographical notices of the wardens and fellows", Oxford 1884, p. 195; A.B. Emden, "A Biographical Register of the University of Oxford to A.D. 1500", vol. III, P to Z, Oxford 1959, p. 1484; S. Rommevaux-Tani, *The study of local motion in the "Tracta-*

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that is Richard Kilvington's commentaries on Aristotle's *On generation and corruption* and on the *Physics*. Kilvington's works were written in 1326 at the latest, and – as it appears – they were the source for the new theory of motion presented by Bradwardine in 1328.[5] Thus, the founders of the School, about whom we can be sure, are Richard Kilvington and Thomas Bradwardine. The next generation of Oxford Calculators are formed by William Heytesbury, John Dumbleton, with the last, well-known Calculator who "gave the name to this group of thinkers", being Richard Swineshead. It seems that to this group also belongs the anonymous author of the treatise *De sex inconvenientibus*, written after Hetesbury's *Regulae solvendi sophismata* (1335) and before Nicolas of Autreourt's question *Utrum visio craturae rationalis beatificalis per verbum possit intendi naturaliter* (1339).[6]

This chapter briefly presents the biographies and works of the *dramatis personae* of this book as well as short descriptions of their works devoted to local motion, which is the main subject of the book itself.[7]

tus de sex inconvenientibus": an example of inheritance form the Oxford Calculators, [in:] "Quantifying Aristotle. The Rise and Decline of the Oxford Calculators", D. Di Liscia, E. Sylla (eds), (forthcoming); E. Jung, "Zmiany ilościowe i ich miara w traktacie *O sześciu niedorzecznościach*, (Research on Science & Natural Philosophy, vol. III), Łódź 2020, pp. 15, 19; Eadem, *The New Interpretation of Aristotle. Richard Kilvington, Thomas Bradwardine and the New Rule of Motion*, [in:] "Quantifying Aristotle…", (forthcoming).

5 See, E. Jung, *The New Interpretation of Aristotle*…, (forthcoming); Ricardus Kilvington, *Quaestiones super libros Physicorum*, q. *Utrum in omni motu potentia motoris excedit potentiam rei motae*, (Eiditons), pp. 215–266.

6 See below, p. 22–28.

7 With the Oxford Calculators was associated also Roger Swineshead (fl. 1330, d. ca. 1365) a Master of Sacred Theology and a Benedict monk of Glastonbury. His work, variously entitled as *Descriptiones motuum*, *De Primo Motore* or, *De motibus naturalibus* was written after Bradwardine's *Tractatus de proportionibus velocitatum in motibus*, i.e., after 1328 but before 1337, when it was copied in Erfurt Amplonian Ms F 135, the only complete extant copy. Roger Swyneshead is also the author of the logical works: *Obligationes* and *Insolubilia* edited and commented by Paul Spade ("Roger Swineshead's *Obligationes*: Edition and Comments", "Archives d'histoire doctrinale et littéraire du moyen âge" (AHDLMA), 44 (1977), pp. 243–85; "Roger Swineshead's *Insolubilia*: Edition and Comments", AHDLMA 46 (1979), pp. 177–220). Since Edith Sylla described this work *On natural motion* in detail and, in fact, there is nothing specially interesting with regard to the theory of local motion we shall pass over this work here. See, E. Sylla, "The Oxford Calculators and the Mathematics of Motion 1320–1350. Physics and Measurement

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1. Richard Kilvington

Richard Kilvington (we know almost seventy different spellings of his name) was born at the beginning of the fourteenth century in the village of Kilvington, Yorkshire in 1302/03. He was the son of a priest of the diocese of York. During his study at arts, he could have been first in Baliol, where he most likely met Bradwardine.[8] In Oxford he became Master of Arts (1325/26) then a Doctor of Theology (ca. 1335). Most likely, Kilvington was a fellow of Oriel College, Oxford.[9] Richard Kilvington's activities after Oxford are better known than his academic career. Having finished his studies, he joined the household of Richard of Bury, whose patronage helped some bachelors and doctors in their ecclesiastical careers and royal service. Between 1334–1345 Bury's household included Thomas Bradwardine, Walter Burley, Richard Bentworth, Richard FitzRalph, Robert Holcot, Richard Kilvington, Walter Segrave, John Maudith and John Acton.[10] Even after Bury's death, in 1345, Kilv-

by Latitudes", New York 1991, pp. 111–128; Eadem, *Mathematical physics in the work of the Oxford Calculators Roger Swineshead's On Natural Motion*, [in:] "Mathematics and Its Applications to Science and Natural Philosophy in the Middle Ages. Essays in Honor of Marchall Clagett" E. Grant, J.E. Murdoch (eds), Cambridge 1987, pp. 69–102; Spade, Paul Vincent and Read, Stephen, "Insolubles", *The Stanford Encyclopedia of Philosophy* (Fall 2018 Edition), Edward N. Zalta (ed.), URL = <https://plato.stanford.edu/archives/fall2018/entries/insolubles/>.

8 See, N. Kretzmann, B.E. Kretzmann, "The 'Sophismata' of Richard Kilvington. Introduction, Translation and Commentary", p. XXIV. Annelise Maier described Kilvington as Bradwardine's student. She, however, did not offer any specific evidence for this claim, and hence the Kretzmanns see this as unlikely (see, N. Kretzmann, B.E. Kretzmann, "The 'Sophismata'…", p. XX, n. 9).

9 There is documentary evidence that Kilvington was a fellow of Oriel College, Oxford University. In 1333 he was mentioned as a "provisor" of Oriel; in 1331 he donated a substantial number of books to Oriel's library (see N. Kretzmann, B.E. Kretzmann., "The 'Sophismata'…", p. XXV, n. 28–29).

10 W. Chambre, "Continuatio Historiae Dunelmensis", Newcastle 1839, p. 128: "Multum <enim> delectabatur de <comitiva> clericorum; et plures semper clericos habuit in sua familia. De quibus fuit Thomas Bradwardyn, postea Cantuariensis Archiepiscopus, et Ricardus Fyzt Rauf, postmodum Archiepiscopus Arnmanachae, Walter Burley, Johannes Maudit, Robert Holcot, Ricardus de Kylwyngton, omnes doctores in theologia: Ricardus Benworth, postea Episcopus Londoniensis et Walterus Segraffe, postea Episcopus Cicestrensis".

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ington was still a "king's clerk" going abroad "on necessary business" with royal "protection and safe conduct". In 1350 Kilvington was the Archdeacon of London. In 1354 he was appointed Dean of Saint Paul's cathedral in London. Along with Richard FitzRalph, Kilvington was involved in the battle against mendicant friars. The struggle began in London and in 1357 it moved to Avignon, where FitzRalph appeared to defend his views before Innocent VI. Kilvington was active in the support of FitzRalph in his treatise: *In causa domini Armachani allegationes magistri Ricardi devoti viri contra Fratres*. It seems certain that FitzRalph's and Kilvington's argument with the mendicants continued almost until the ends of their lives. Kilvington was probably a victim of the Black Death and died in 1361, two years after the papal bull reconfirmed the mendicant privileges. Richard Kilvington was buried in Saint Paul's cathedral in London.[11]

We do not know any of Kilvington's philosophical or theological works, which might have been written after his transition from the university to a public career. His diplomatic and ecclesiastical career did not stimulate his further scholarship, nor did his being a member in Richard of Bury's household. Apart from a few sermons, all of Kilvington's known works stem from his teaching at Oxford, and they often reflect the lively class discussions.[12] None of his works is written in the usual commentary format, following the order of books in the respective works of Aristotle. In accordance with the fourteenth-century Oxford practice, Kilvington reduced the number of topics discussed to certain central issues, which were fully developed with no more than ten questions constituting a commentary.[13] The reduction in the range of

11 For more details see E. Jung, "Works by Richard Kilvington", AHDLMA 67 (2000), pp. 184–225; Eadem, "Między filozofią przyrody a nowożytnym przyrodoznawstwem. Ryszard Kilvington i fizyka matematyczna w średniowieczu", Łódź 2002; Eadem, "Arystoteles na nowo odczytany. Kwestie o ruchu Ryszarda Kilvingtona", Łódź 2014; Jung, Elzbieta, "Richard Kilvington", *The Stanford Encyclopedia of Philosophy* (Winter 2016 Edition), Edward N. Zalta (ed.), URL = <https://plato.stanford.edu/archives/win2016/entries/kilvington/>. In these works there is also an extensive bibliography.

12 See Ryszard Kilvington "Kwestie o ruchu" (Ricardus Kilvington, *Quaestiones de motu*), Polish translation by E. Jung, [in:] "Arystoteles na nowo odczytany…", Łódź 2014, pp. 107–316.

13 See, for example, Richard Kilvington, *Quaestiones super libros Ethicorum*", [in:] "Richard Kilvington's *Quaestiones super libros Ethicorum*. A Critical Edition with an Introduction" by Monika Michałowska, Leiden 2016, pp. 63–336.

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topics is counterbalanced by deeper analysis of the questions chosen for treatment. Some of Kilvington's questions cover twenty folios, which in a modern edition yield about 180 pages. Only his logical treatise was not written as a commentary, but rather as "a guide" for students showing how to solve sophisms. In the preface to his *Sophismata* Kilvington says:

> When we are able to call both sides into question, we will readily discern what is true and what is false, as Aristotle says in Book One of his *Topics*. Therefore, in order that we may more readily discern what is true and what is false, in the present work, which consists of *sophismata* to be thoroughly investigated, I intend, to the best of my ability, both to demolish the two sides of the contradiction and also to support them by means of clear reasoning. I am led to do this by the request of certain young men who have been pressing their case very hard. And so, wishing to give them something I have often heard them ask for, I have undertaken an attempt in that direction.[14]

Richard Kilvington's philosophical works, the *Sophismata* and *Quaestiones super De generatione et corruptione*, composed before 1324, came from his lectures as a bachelor of arts; the *Quaestiones super Physicam* composed at the latest in 1326 and *Quaestiones super Libros Ethicorum* (before 1333) date from his time as an arts master; after he advanced to the Faculty of Theology, he produced eight questions on Peter Lombard's *Sentences (*1333 or 1334).[15] Most of Kilvington's works are still to be found in manuscripts, only his commentary to the *Ethics*, which consists of eight questions,[16] and 48 sophisms, which form his *Sophismata*, are critically edited, *Sophismata* have also been translated into English by Kretzmanns. His commentary on the *On generation and corruption* form a set of

14 N. Kretzmann, B.E. Kretzmann, "The ‚*Sophismata*'…, (*Introduction*), p. 1.

15 See E. Jung, *The New Interpretation of Aristotle*…., (forthcoming).

16 See M. Michałowska, "Richard Kilvington's *Quaestiones super libros Ethicorum*…", (Introduction, pp. 11–26).

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nine questions,[17] his commentary on the *Sentences* is formed in a set of eight questions.[18]

From the perspective of the present book the most important is a set of eight questions which belong to his commentary on Aristotle's *Physics*. Recently Jung has proven that Kilvington's questions on the *Physics* perfectly testify to the dispersed tradition of this commentary. The whole set consists of eight questions: one question with an exposition of the *Physics*, to be found in a Vatican manuscript (Vat. Lat. 4353),[19] a set of

17 The questions are as follows: *Utrum augmentatio sit motus ad quantitatem*; *Utrum numerus elementorum sit aequalis numero qualitatum primarium*; *Utrum ex omnibus duobus elementis possit tertium generari*; *Utrum continuum sit divisibile in infinitum*; *Utrum omnis actio sit ratione contrarietatis*; *Utrum omnia elementa sint adinvicem transmutabilia*; *Utrum mixtio sit miscibilium alteratorum unio*; *Utrum omnia contraria sint activa et passiva adinvicem*; *Utrum generatio sit transmutatio distincta ab alteratione*. They are to be found, as a complete or incomplete set, in the following mss.: Brugia, Stedelijke Openbare Bibl. 503; Cambridge, Peterhouse 195; Erfurt, Wissenschaftliche Allgemeinbibliothek, Amploniana Cms 8º 74; Kraków, BJ 648; Paris, BnF lat. 6559; Sevilla, Bibl. Colombina 7–7–13.

18 The commentary on the *Sentences* is to be found in the following libraries: Bologna, Bibl. Comunale dell'Archiginnasio A. 985; Brugge, Stedelijke Openbare Bibliotheek, Hs. 188, Hs 503; Erfurt, CA. 2° 105; London Harley, British Library, 3243; Paris, BnF lat. 14576, 15561; Praha, Národní Knihovna České Republiky, Cod. III B. 10; Wrocław, Bibl. Uniw., IV F 198; Vatican, Vat. lat. 4353; Firenze, Bibl. Nationale Centrale Cod. II. II 281 ; Tortosa, Bibl. de la Catedral y del Cabildo de la Sanctísima Iglesia Catedral, Cod. 186. The eight questions, from ms. Bologna are titled as follows : 1) *Utrum Deus sit super omnia diligendus*; 2) *Utrum per opera meritoria augeatur habitus caritatis quo Deus est super omnia diligendus* ; 3) *Utrum omnis creatura sit suae naturae certis limitibus circumscripta* ; 4) *Utrum quilibet actus voluntatis per se malus sit per se aliquid* ; 5) *Utrum peccans mortaliter per instans solum mereatur puniri per infinita instantia interpolata*; 6) *Utrum aliquis nisi forte in poena peccati possit esse perplexus in his quae pertinent ad salutem*; 7) *Utrum omnis actus factus extra gratiam sit peccatum*; 8) *Utrum aliquis possit simul peccare venialiter et mereri vitam aeternam*. For a description of the manuscripts see M. Michałowska, "Richard Kilvington on the capacity of created beings, infinity, and being simultaneously in Rome and Paris. Critical edition of question 3 *Utrum omnis creatura sit suae naturae certis limitibus circumscripta* from *Quaestiones super libros Sententiarum* with an Introduction" (forthcoming).

19 In my paper *Works by Richard Kilvington* (p. 203, n. 102) I claimed that only four questions on motion from the Marciana library form Kilvington's commentary to the *Physics*. Detailed study, however, revealed that *expositio* of the *Physics* as well as one question not two, as I had claimed before, were also composed by Richard Kilvington.

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three questions in a Seville manuscript (Biblioteca Colombina 7–7–13), a set of four questions on motion, to be found in Venice library (Venezia, Bibl. Naz. Marciana, lat. VI, 72), single questions are also to be found in other manuscripts.

The questions are as follows:

Expositio super primum librum Physicorum (Ms. Vatican, Vat. lat. 4353).

1. *Utrum omne scitum sciatur per causam* (Ms. Vatican, Vat. lat. 4353).
2. *Utrum omne quod generetur ex contrariis generetur* (Ms. Vatican, Vat. lat. 4353; Seville Colomb. 7–7–13).
3. *Utrum in omni generatione tria principia requirantur* (Ms. Seville Colomb. 7–7–13; Paris BnF lat. 6559; Bruges, Stedelijke Openbare Bibliotheek 503).
4. *Utrum omnis natura sit principium motus et quietis* (Ms. Seville Colomb. 7–7–13).
5. *Utrum potentia motoris excedit potentiam rei mote* (Ms. Venezia, Bibl. Naz. Marciana lat. VI, 72 (2810); Vat. lat. 2148).
6. *Utrum qualitas suscipit magis et minus* (Ms Venezia, Bibl. Naz. Marciana, lat. VI, 72 (2810); Paris, BnF lat. 16401; Vatican, Vat. lat. 2148; Vat. lat. 4429; Paris, BnF lat. 6559; Oxford, Bodl., Canon Misc. 226; Praha, Narodni Knihovna III. B; Cambridge, Peterhouse 195).
7. *Utrum aliquod motus simplex possit moveri aeque velociter in vacuo et in pleno* (Venezia, Bibl. Naz. Marciana, lat. VI, 72 (2810)).
8. *Utrum omne transmutatum in transmutationis initio sit in eo ad quod primitus transmutatur* (Venezia, Bibl. Naz. Marciana, lat. VI, 72 (2810)).[20]

From the point of view of the main problem of this book, the fifth question devoted to the problem of local motion is the most interesting. This question is – as Kilvington says – divided into four articles, where he firstly presents and discusses different opinions describing the way of "measuring" the primary conditions necessary for motion to occur, such as an excess of an acting power over the passive one; the possible limit of an acting power causing the motion; the possible limit of a passive power to be overtaken; and the result of their actions i.e., the speed of motion as well as possible rule describing it. The issues raised here will be discussed in Chapter III.

20 On details see E. Jung, *The New Interpretation of Aristotle.…*, (forthcoming).

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2. Thomas Bradwardine

Thomas Bradwardine (ca 1295–1349) in 1321 was a Bachelor of Arts at Balliol College, in 1323 he became a fellow of Merton College, Oxford where he probably remained for the next twelve years. In the same year he became Master of Arts, in 1333 a bachelor and in 1340 a Doctor in theology. Like Kilvington, Bradwardine belonged to the circle of friends and courtiers of Richard de Bury who introduced him to the royal court of Edward III. Bradwardine actively participated in the life of the Church and the royal court. His career as an ecclesiastic began in 1333 when he was made Canon at Lincoln Cathedral and was to be crowned with his election in 1349 as Archbishop of Canterbury. As the chancellor of St. Paul's Cathedral in London, Bradwardine was appointed royal chaplain in 1337 and, probably, the king's confessor. He accompanied Edward in his travels to Flanders and France during the campaign of 1346. Immediately after his episcopal consecration, which was held in Avignon, Bradwardine returned to England to assume his position, yet he died a month later, on the 26th of August 1349, as a victim of the first wave of the Black Death.[21]

Thomas Bradwardine authored many significant works, which cover a number of scholarly domains. His insight and intellectual inquisitiveness earned him the title of *Doctor profundus* and a mention in Chaucer's *Canterbury Tales*. The philosophical works of his that have been preserved to our time are the following: two treatises in mathematics: *Speculative Arithmetic* (*Arithmetica speculativa*) and *Speculative Geometry* (*Geometria speculativa*),[22] a number of logical treatises (all written before 1328), a famous work on the theory of motion *Treatise on Ratios of Velocities in Motions* (*Tractatus de proportionibus velocitatum in motibus*), written in 1328,[23]

21 On Bradwardine see, for example, http://www-history.mcs.st-andrews.ac.uk/Biographies/Bradwardine.html, the article by J.J. O'Connor and E.F. Robertson.

22 A critical edition in G. Molland, "*Geometria speculativa* of Thomas Bradwardine. Text with critical Discussion" (unpublished Ph.D. dissertation), Cambridge 1967.

23 A critical edition in: "Thomas of Bradwardine. His *Tractatus de Proportionibus*. Its Significance for the Development of Mathematical Physics". Edited and translated by H. Lamar Crosby, Jr., Madison 1955, pp. 64–140. In the colophon of Bradwardine's treatise one reads: "Explicit tractatus de proportionibus editus a magistro Thoma de Bradelbardin. Anno Domini MCCC28."

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Treatise on the Continuum (*Tractatus de continuo*).[24] The theological works are the commentary to the *Sentences*, some questions of which are edited by Kathrine Tachau and Jean-Francois Jenest;[25] to this commentary also belongs a question on future contingents, which is edited as a separate work: *On Future Contingents* (*Utrum Deus habeat praescientiam futurorum contingentium ad utrumlibet*).[26] The most famous of Bradwradine's theological works, printed in 1618, is: *In Defense of God Against the Pelagians and On the Power of Causes, to his Fellow Mertonians* (*De causa Dei contra Pelagium et de virtute causarum ad suos Mertonenses*).[27] He – as he says – started to elaborate this work when he was a philosophy student,[28] but the final version was composed in 1344. Bradwardine is also an author of the treatise *De memoria artificiali adquirenda* (*On Acquiring a Trained Memory*).[29]

It seems that most of Bradwardine's philosophical treatises were composed as "a guide" or a textbook for students. Beyond any doubts

24 A critical edition in: J.E. Murdoch, "Geometry and the Continuum in the Fourteenth Century: A Philosophical Analyses of Thomas Bradwardine's *Tractatus de continuo*" (unpublished Ph.D. dissertation), Microfilm Ann Harbor, Harvard University, 1957.

25 See J.-F. Genest and K. Tachau, *La lecture de Thomas Bradwardine sur les Sentences*, AHDLMA, 57 (1990), 301–306.

26 A critical edition by Jean-Francois Genest, *Le De futuris contingentibus de Thomas Bradwardine*, "Recherches Augustiniennes et Patristiques", 14 (1979), pp. 249–336.

27 "Thomae Bradwardini Archiepiscopi Olim Cantuariensis De causa Dei contra Pelagium et de virtute causarum ad suos Mertonenses, libri tres", Opera et studio Henrici Savilli (...) Londini 1618.

28 Thomas Bradwardine, *De causa Dei…* [in:] E. Jung, *Determinism and Freedom in Thomas Bradwardine's View*, [in:] "If God exists… Human freedom and theistic thesis", A. Stefańczyk, R. Majeran (eds), Lublin 2019, p. 247: " Later, yet before I had begun my study of theology, provided with these words as with a ray of grace and in possession of some representation of truth, it appeared to me that I saw from afar God's grace preceding as to timing and nature all good meritorious works, namely the desired will of God who, prior as to time and nature, wills the salvation of a deserving human being and produces his deserts in himself before that man does it himself. Just as God is Prime Mover with respect to all motions, so I was provided with God's grace before any effort of mine, for which I render Him my thanks."

29 For *De memoria* see M. Carruthers (ed.), "Journal of Medieval Latin" 2, (1992), 25–43; translation in M. Carruthers, "The Book of Memory: A Study of Memory in Medieval Culture", New York 1990, pp. 228–281; see also M. Carruthers, J. Ziolkowski, *The Medieval Craft of Memory*, [in:] "An Antology of Texts and Pictures", M. Carruthers, J. Ziolkowski (eds), Philadelphia 2002, pp. 205–214.

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such a role was played by his famous *Tractatus de proportionibus*, in which he made an extensive use of Kilvington's question on local motion. Bradwardine's treatise is divided into four chapters. The first one recapitulates the knowledge about proportionality to be found in Boethius' *Arithmetic* and Campanus de Novara's *Commentarium super quantum librum "Elementorum" Euclidis*; in the second chapter, Bradwardine criticizes four theories interpreting Aristotle's statement that speed is proportional to the acting and passive powers involved; in Chapter III Bradwardine introduces his own solution of the problem and "he commences his exegesis by quoting Aristotle and Averroes in general support of his view, after which he launches directly into his twelve theorems concerning velocity";[30] chapter IV deals with circular motions. Bradwardine's theory is a subject of detailed study in Chapter III below.

3. William Heytesbury

William Heytesbury was born sometime before 1313 in Wiltshire in the Salisbury Diocese. He is first mentioned as a fellow at Merton College in Oxford in 1330. He held the administrative position of a bursar (i.e., the recipient of a scholarship) of Merton in 1338–1339, responsible for determining dues, auditing accounts, and collecting revenues. By 1340 he had completed his regency in arts at Merton and, together with John Dumbleton, had been named a foundation fellow at the new Queen's College in 1340, but soon he returned to Merton College. He was a Doctor of Theology by July 1348, chancellor of the University in 1371–72, and may have been chancellor also in 1353–1354. He died between December 1372 and January 1373.

Heytesbury obtained his fame thanks to his logical works, none of his theological works is known. Heytesbury's extant writings, which are tentatively dated to the period 1331–1339 are (with one exception) concerned with the analysis of fallacies and sophisms. *Sophismata* is a collection of sophisms for advanced students working on natural philosophy ("sophisms – as Paul Spade describes it – are problematic sentences about which one can give plausible arguments both that they are true

30 L. Crosby Jr, Thomas of Bradwardine His *Tractatus de proportionibus*…., p. 38.

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and also that they are false").[31] *Sophismata asinina* is a collection of sophistical proofs that the reader is a donkey. *Iuxta hunc textum*, also known as *Consequentiae Heytesbury*, is a collection of sophisms designed for testing formal inference rules. *Casus obligationis* is a collection of epistemic sophisms. *De sensu composito et diviso* is a manual on the logical analysis of the *de re/de dicto* ambiguity. *Termini naturales* is a vocabulary of basic physical concepts. Most of these have not been critically edited, but early prints, recent editions, and several modern translations are available.[32]

His most important and influential work, written in 1335, is, beyond any doubt, *Rules for Solving Sophisms* (*Regulae solvendi sophismata* or *Logica*).[33] The *Rules* are divided into six chapters. The first three chapters are principally logical in character and they respectively discuss: 1) the rules for

31 William Heytesbury, "On *Insoluble* Sentences. Chapter One of His *Rules for Solving Sophisms*", translated with an Introduction and Study by Paul Vincent Spade, Toronto 1979, p. 2.

32 For details see Hanke, Miroslav and Jung, Elzbieta, "William Heytesbury", *The Stanford Encyclopedia of Philosophy* (Spring 2018 Edition), Edward N. Zalta (ed.), URL = <https://plato.stanford.edu/archives/spr2018/entries/heytesbury/>.

33 This work (complete or incomplete) is to be found in the following mss: Bergamo, Bibl. Civica "Angelo Mai", MA 481; Brugge, Hoofdbibliotheek Biekorf (Stadsbibliotheek), 497; Brugge, Hoofdbibliotheek Biekorf (Stadsbibliotheek), 500; Cesena (Forlì-Cesena), Bibl. Comunale Malatestiana, S.X.5; Vatican, Chig. E.V.161; Vatican Chig. E.VI.193; Vatican, Ottob. lat. 662; Vatican, lat. 2136; Vatican, lat. 2138; Vatican, lat. 3144; Crema (Cremona), Bibl. Comunale, 190; Erfurt, Amplon. 2° 135; Erfurt, Amplon. 2° 313; Erfurt, Amplon. 4° 270; Firenze, Biblioteca Riccardiana, 790; Firenze, Bibl. Riccardiana, 821; Kraków, BJ 621; Kraków, BJ 704; Leipzig, Universitätsbibliothek, 529; Leipzig, Universitätsbibliothek, 1360; Leipzig, Universitätsbibliothek, 1370; London, Wellcome Library 350; München, Bayerische Staatsbibliothek, Clm 23530; Oxford, Bodl., Canon. misc. 221; Oxford, Bodl., Canon. misc. 409; Oxford, Bodl. Canon. misc. 456; Padova, Bibl. Antoniana, Manoscritti 407; Padova, Bibl. Universitaria, 1123; Padova, Bibl. Universitaria, 1434; Padova, Bibl. Universitaria, 1570; Praha, Národní Knihovna Ceské Republiky, III.A.11 (396); San Gimignano (Siena), Bibl. e Archivio Comunale, 25; Sarnano (Macerata), Biblioteca Comunale, E. 15; Venezia, Bibl. Naz. Marciana, lat. VIII. 38(3383); Verona, Bibl. Civica, 2881; Warszawa, BN III. 8058. For a detailed description on codices see. P.V. Spade, *The Manuscripts of William Heytersbury's* Regulae solvendi sophismata. *Conclusions, Notes and Descritptions*, "Philosophical Quarterly" 31 (1981), pp. 271–313; see also http://www.mirabilweb.it/title/regulae-solvendi-sophismata-guillelmus-hentisberus-title/3600.

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handling so-called "insoluble" sentences in disputations, i.e., paradoxes; 2) the sophisms involving the words "know" and "doubt"; 3) the logical problems arising from the use of "relative" terms. The next three chapters are concerned with the philosophy of nature and they respectively deal with: 4) the problem of the beginning and ceasing of continuous processes; 5) the limit decision problem on maxima and minima of the physical factors of the different type of changes. In the sixth chapter – *On the three categories*, Heytesbury sets out rules for speed: in accelerated local motion, with regard to place; in quantitative changes, with regard to acquired quantity; in qualitative changes with regard to intensity of quality.[34] Given the main topic of this book, we are interested in debates about local movement, which we write about in the Chapter III.

4. The Anonymus Author of the *De sex inconvenientibus*

A good testimony as to the very quick assimilation of the works of Richard Kilvington, Thomas Bradwardine and William Heytesbury is an anonymous treatise entitled *De sex inconevnientibus*. The question on local motion: *Utrum in motu locali sit certa servanda velocitas* is the fourth and the last question of the anonymous treatise *De sex inconvenientibus* written by a thinker who also was associated with the Oxford Calculators.[35] Al-

34 To date, the best and only such comprehensive study of the problems presented in *Regulae* is the book by C. Wilson, "William Heytesbury. Medieval Logic and the Rise of Mathematical Physics", Madison 1960.

35 On this text (in general or on its selected fragments) see P. Duhem, "Études sur Léonard de Vinci", vol. 3, Paris 1913, pp. 420–424, 471–474; Idem, *La dialectique du Oxford et la Scolastique italienne*, "Bulletin Italien", vol. 12 (1912), pp. 22–26, 101–103, 289–292; M. Clagett, "The Science of Mechanics in the Middle Ages", Madison 1959, pp. 263–265; S. Caroti, *Da Walter Burley al 'Tractatus de sex inconvenientibus'. La tradizione inglese della discussione medievale 'De reactione'*, "Medioevo. Rivista di Storia della Filosofia Medievale", vol. 21 (1995), pp. 257–374; G. Fernández Walker, *A New Source of Nicholas of Autrecourt's 'Quaestio': The Anonymous 'Tractatus de sex inconvenientibus'*, "Bulletin de Philosophie Médiévale", vol. 55 (2013), pp. 57–69; S. Rommevaux, *Six inconvénients découlant de la règle du mouvement de Thomas Bradwardine dans un texte anonyme du XIV*e *siècle*, [in:] "L'homme au risque de l'infini: Mélanges d'histoire et de philosophie des sciences offerts à Michel Blay", M. Malpangotto, V. Jullien, E. Nicolaïdis (eds), Turnhout, 2013, pp. 35–47; Eadem, *Un auteur anonyme du XIV*e *siècle,* à Oxford, lecteur de Pierre de Maricourt,

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