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THE CONCEPT AND ROLE OF *EXPERIMENTUM* IN JOHN BURIDAN'S *PHYSICS* COMMENTARY

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Budapest, 25 May 2010

Tóth Zita

Signature

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ABSTRACT

The Concept and Role of *Experimentum* in John Buridan's *Physics* Commentary

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John Buridan was one of the most influential natural philosophers of the Middle Ages, who has often been regarded as an important forerunner of modern physics. This thesis examines Buridan's natural philosophy from a methodological point of view, presenting his methodology both as it is explicitly elaborated in his theoretical writings and as practiced in his *Physics* commentary. By analyzing five questions on void of the latter work, I argue that experience has a twofold role in Buridan's argumentation: it provides the basis of certain premises, but has little part in the scientific explanations and demonstrations. I argue that this, in some respects restricted role, instead of contradicting, follows directly from Buridan's philosophy of science; the latter, although being based on an empiricist epistemology in the broad sense, assuming that experience is necessary for the acquisition of some scientific principles, also admits that there can be no necessary and universal knowledge without the active intellect.

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LIST OF ABBREVIATIONS

1. Buridan's works

QAnPo = *Questiones in libros Aristotelis Posteriorum Analyticorum*

QDA = *Questiones in libros Aristotelis De Anima secundum tertiam lecturam*

QNE = *Questiones super decem libros Ethicorum Aristotelis ad Nicomachum*

QP = *Questiones super octo libros Physicorum libros Aristotelis*

SD = *Summulae de Dialectica*

2. Others

AL = *Aristoteles Latinus*, editioni curandae praesidet L. Minio-Paluello.

AQP = *Aristotelis de Physico auditu libri octo, cum Averrois Cordubensis Variis in eosdem Commentariis.*

BQP = Roger Bacon, *Questiones supra Libros Octo Physicorum Aristotelis.*

GQP = Robertus Grosseteste, *Commentarius in VIII Libros Physicorum Aristotelis.*

JQP = *Ioannis de Ianduno philosophi acutissimi super octo libros Aristotelis de Physico auditu subtilissimae quaestiones.*

INTRODUCTION

"The *experientiae* or *experimenta* of mediaeval science are completely unlike the experiments of modern science," argues Peter King in one of his articles.[1] To judge properly whether he was right in this strong statement is not the aim of this thesis. First of all, I will not examine the rather unclear and complex role that experiment has played in early modern and modern natural science; nor am I going to discuss the concept as is found in some sixteenth- and seventeenth-century treatises. Second, my inquiry will not present a complete picture of the medieval concept either, which – as I have argued elsewhere[2] – changed quite remarkably between the twelfth and the fourteenth century. The sole aim of this thesis is to examine the concept and role of experiment in the writings of John Buridan, who was undoubtedly "the most distinguished,"[3] albeit far not the only, natural philosopher of the later Middle Ages.

What a philosopher says about his use of experiences does not necessarily coincide with how he in fact uses them in his practice. Consequently, any study of this concept and role has to consist of two parts, which – following David Lindberg[4] – can be labelled "methodological theory" and "methodological practice." Accordingly, I have also divided this thesis into two main parts, the first dealing with Buridan's methodological theory as found in his methodological writings, mainly in the commentary on Aristotle's *Posterior Analytics,* and the second examining, by means of a case study, the concept and role of experiment as it appears in his more practical work of natural philosophy, the *Physics* commentary.

[1] Peter King, "Medieval Thought-experiments: The Metamethodoloogy of Medieval Science," in G. Massey and T. Horowitz ed., *Thought-Experiments in Science and Philosophy* (Lanham, MD: Rowman & Littlefield, 1991), 43-64: 48.
[2] Zita Toth, "Empirizmus a középkorban" ["Empiricism in the Middle Ages"], MA Thesis, Eotvos Lorand University, 2009.
[3] Edward Grant, "Buridan, Jean", in *Dictionary of the Middle Ages*, ed. Joseph Strayer, (NY: Charles Scribner's Sons, 1989), 430-432: 430.
[4] David C. Lindberg, *The Beginnings of Western Science: The European Scientific Tradition in Philosophical, Religious, and Institutional Context, Prehistory to A.D. 1450* (Chicago: The University of Chicago Press, 2007), 362.

After clarifying the requirements of scientific knowledge as presented by Buridan, the first part of the thesis addresses the question how such knowledge is attainable. Since knowledge in the strict sense has to be necessary, universal, and causally demonstrated, its possibility raises several difficulties, especially in an empiricist and nominalist framework. Buridan's solution, as will be shown, rests on certain presuppositions about the capacity of the intellect, which, by its natural inclination towards truth, is able to judge the disposition of the senses, to cognize the objects essentially, as well as to arrive at universal, necessary knowledge of them. Accordingly, although experience plays a crucial role in the acquisition of scientific principles that form the basis of scientific reasoning, the final criterion of the validity of these principles has to be set up by the intellect.

The second part of this thesis argues that this twofold role of experience can be observed well in Buridan's scientific practice. To analyze the latter, I selected the questions on the void in his *Physics* commentary. A close reading of these *questiones* with a special attention to the kinds of arguments Buridan uses throughout will illuminate, on the one hand, some important characteristics of experiments, and, on the other hand, will demonstrate how this methodological practice corresponds to the theory outlined in the first part. As my analysis rests primarily on a text that still lacks a modern edition, I provide a working edition of these five *questiones* in the appendix. In the text, unless otherwise indicated, all the translations are mine.

Although a remarkable amount of literature has been written both on the physics and on the more abstract philosophy of Buridan, his methodology has remained relatively unstudied. His natural philosophy was first discovered by Pierre Duhem,[5] who regarded his impetus theory as being an important step towards the physics of the seventeenth century, most importantly towards Newton's law of inertia. It would be futile now to recapitulate the

[5] Pierre Duhem, *Le Système du Monde. Histoire des Doctrines Cosmologiques de Platon à Copernic*, 10 vols. (Paris: A. Hermann, 1913—1959), mainly in vol. 8.

whole continuity-debate that Duhem's statement caused; by the studies of Annaliese Maier,[6] Marshall Clagett,[7] Ernst A. Moody,[8] and Edward Grant,[9] Buridan's mechanics and his place in the history of science has received special attention throughout the twentieth century. This attention is preserved, although in a slightly different form, in the more recent articles and books by Johannes Thijssen[10] and Jack Zupko,[11] and – especially concerning Buridan's semantics and ontology – by Gyula Klima's monograph,[12] published last year. The only two articles that deal with Buridan's theory of science are that of T. K. Scott,[13] and Peter King;[14] these, however, only discuss his methodological theory, without any reference to his scientific practice.

The lack of literature on Buridan's methodology is all the more surprising as medieval scientific methodology in general has been studied extensively by a number of authors, such as Alastair C. Crombie,[15] John Murdoch,[16] and Edward Grant.[17] While Crombie argued that experimental means for establishing a theory in natural philosophy can be well found already

[6] Most importantly in Anneliese Maier, *An der Grenze von Scholastik und Naturwissenschaft* (Rome: Edizioni di Storia et Letteratura, 1952).
[7] Marshall Arthur Clagett, *The Science of Mechanics in the Middle Ages* (Madison: University of Wisconsin Press, 1959).
[8] Ernst Moody, "The Dynamics of the Leaning Tower Experiment (I-II)," *Journal of the History of Ideas* 12 (1951): 163-193, 375-422.
[9] Just a few of his relevant works are: Edward Grant, "John Buridan, a Fourteenth Century Cartesian." *Archives internationale d'histoire de Sciences* 16 (1963): 251-255; "Motion in the Void and the Principle of Inertia in the Middle Ages," *Isis* 55 (1964): 265-292; "Jean Buridan and Nicole Oresme on Natural Knowledge," *Vivarium* 31 (1993): 84–105; *A History of Natural Philosophy* (Cambridge: Cambridge University Press, 2007).
[10] J. M. M. H. Thijssen, "Buridan, Albert of Saxony and Oresme, and a Fourteenth-century Collection of *Questiones* on the *Physics* and on *De generatione et corruptione*," *Vivarium* 24 (1986), 70-82; "John Buridan and Nicholas of Autrecourt on Causality and Induction," *Traditio* 43 (1987): 237-255; "Prolegomena to a Study of John Buridan's Physics," *American Catholic Philosophical Quarterly* 79 (2005): 493-502.
[11] Jack Zupko, *John Buridan: Portrait of a Fourteenth-Century Arts Master* (Notre Dame: University of Notre Dame Press, 2003); Jack Zupko and J. M. M. H. Thijssen ed., *The Metaphysics and Natural Philosophy of John Buridan* (Leiden: E. J. Brill, 2001).
[12] Gyula Klima, *Jean Buridan* (Oxford: Oxford University Press, 2009).
[13] Thomas K. Scott, "John Buridan on the Objects of Demonstrative Science," *Speculum* 40 (1966): 654-673.
[14] Peter King, "Jean Buridan's Philosophy of Science," *Studies in the History and Philosophy of Science* 18 (1987): 109-132.
[15] Alastair Cameron Crombie, *Robert Grosseteste and the Origins of Experimental Science: 1100-1700* (Oxford: Clarendon Press, 1953).
[16] John Emery Murdoch, "The Analytic Character of Late Medieval Learning: Natural Philosophy without Nature," In *Approaches to Nature in the Middle Ages*, ed. L. D. Roberts (Binghamton: Medieval and Renaissance Texts and Studies, 1982), 171-213.
[17] Edward Grant, "Medieval Natural Philosophy: Empiricism without Observation," In *The Dynamics of Aristotelian Natural Philosophy from Antiquity to the Seventeenth Century*, ed. C. Leijenhorst, Ch. Lüthy, J. Thijssen (Leiden: E. J. Brill, 2002).

in the early thirteenth century, Murdoch and Grant share the view that medieval natural philosophy, despite its empiricism in epistemology, was based not on observation, but on imagination or thought experiments; consequently, they characterize it as "natural philosophy without nature" and "empiricism without observation." Which of these two methods, surprisingly differently described, applies to Buridan's natural philosophy or what the latter characterization exactly means, requires further inquiry.

The third issue this thesis touches on is the treatment of the void as found in Buridan. Although Edward Grant has written a whole book on the medieval and early modern history of the arguments,[18] he asserts that "a long discussion on the void in Buridan's *Questions on the Physics* is, however, quite disappointing. … Indeed, one gets the impression that for Buridan the topic was a frustrating and unprofitable one thrust upon him by events beyond his control,"[19] therefore dismisses him almost altogether. Other articles[20] that discuss the later history of the concept of the void also only touch on Buridan's vew, but do not examine it deeply.

All in all, as this very selective bibliography suggests, the secondary literature on the three central topics of this thesis – that is, on Buridan, on the medieval methodology of science, and the treatment of the vacuum – is quite extensive, although there has been little effort to unify them into an account of Buridan's methodology that includes both his methodological theory and practice. Such an account, although it might not enable one to answer Peter King's claim with any certainty, would lead to a better understanding of the methodology of fourteenth-century natural philosophy.

[18] Edward Grant, *Much Ado about Nothing: Theories of Space and Vacuum from the Middle Ages to the Scientific Revolution* (Cambridge: Cambridge University Press, 1981).
[19] "Motion in the Void and the Principle of Inertia in the Middle Ages," *Isis* 55 (1964): 265-292: 275.
[20] Charles B. Schmitt, "Experimental Evidence for and against a Void: The Sixteenth-Century Arguments," *Isis* 58 (1967): 352-366; Sylvia Manzo, "The Arguments on Void in the Seventeenth Century: The Case of Francis Bacon," *The British Journal for the History of Science* 36 (2003): 43-61.

PART ONE: EXPERIMENTUM IN BURIDAN'S METHODOLOGICAL THEORY

1. THE DEFINITION OF SCIENTIFIC KNOWLEDGE

In the sixth book of the *Nicomachean Ethics*, Aristotle characterizes scientific knowledge in the following way:

> Now what knowledge is, if we are to speak exactly and not follow mere similarities, is plain from what follows. We all suppose that what we know is not capable of being otherwise; of things capable of being otherwise we do not know, when they have passed outside our observation, whether they exist or not. Therefore the object of knowledge is of necessity. Therefore it is eternal; for things that are of necessity in the unqualified sense are all eternal; and things that are eternal are ungenerated and imperishable. Again, every science is thought to be capable of being taught …; it proceeds sometimes through induction and sometimes by deduction. Now induction is of first principles and of the universal, and deduction proceeds from universals. There are therefore principles from which deduction proceeds, which are not reached by deduction; it is therefore by induction that they are acquired. Knowledge, then, is a state of capacity to demonstrate. … Knowledge is belief about things that are universal and necessary, and there are principles of everything that is demonstrated and of all knowledge (for knowledge involves reasoning).[21]

There are several remarkable characteristics of knowledge which are enumerated in this passage. We are informed that knowledge is of the necessary, therefore of the eternal; that it is universal; that it is either acquired by induction or by deduction. Elsewhere Aristotle also makes clear that we know something scientifically if we know its causes.[22]

Buridan also grants these characteristics, which, however, raise several further questions. What can we know in this strict sense of scientific knowledge? How can we arrive at such knowledge? Are those processes by which we acquire this knowledge reliable?

[21] *Nicomachean Ethics* VI, 1039 b19-32; 1140 b31-33. Translation is from the revised Oxford translation in Jonathan Barnes ed., *The Complete Works of Aristotle* (Princeton: Princeton University Press, 1995). Cf. AL XXVI, 255-258: *Sciencia quidem igitur quid est, hinc manifestum, si oportet certificare et non sequi similitudines. Omnes enim suspicamur quod scimus non contingere aliter habere. Contingencia autem aliter cum extra speculari fiant, latent si sunt, vel non. Ex necessitate ergo, est scibile. Eternum ergo. Ex necessitate enim encia simpliciter, omnia eterna. Eterna autem, ingenita et incorruptibilia. Adhuc docibilis omnis sciencia videtur esse, et scibile discibile. ... Hec quidem enim per induccionem, hec autem sillogismo. Induccio quidem utique principium est et credulitas universalis. Sillogismus autem, ex universalibus. Sunt ergo principia ex quibus sillogismus, quorum non est sillogismus. Induccio ergo. Sciencia quidem ergo est habitus demonstrativus. ... Quia autem sciencia de universalibus est existimacio et e necessitate entibus, sunt autem principia demonstrabilium et omnis sciencie, cum racione enim sciencia.* See also his *Posterior Analytics* I, 2-6, 12.

[22] *Physics* 184 a1 ff.

Buridan addresses the question of the objects of scientific knowledge in several places. In the commentary on the *Nicomachean Ethics* he asks whether knowledge is of eternal things.[23] Knowledge, as he notes, can be understood in two ways: either as knowledge of a proposition (that is, a demonstrated conclusion) or as knowledge of the things themselves which the terms of the proposition stand for. So, for example, one can know the proposition *omnis homo est risibilis* as a demonstrable conclusion; but by knowing this proposition, one also has knowledge of every human being and of everything that is capable of laughing.[24]

1.1. Necessity and universality

Granting that – at least in one sense – the object of knowledge is a proposition inevitably leads to the next question: Is a proposition eternal and necessary, or can it be? ("Eternal" and "necessary" were synonyms in the Aristotelian tradition as well as for Buridan; as Buridan notes, "Properly speaking all that and only that is called necessary, which always is, was, and will be."[25]) In dealing with this issue, Buridan distinguishes two ways in which such a question might be understood. A proposition can either be treated according to its existence (*quantum ad suam realitatem*) or according to its truth (*quantum ad suam veritatem*). In the former sense, which thus concerns material existence – the uttered or the written form of a sentence or a sentence as it is being formed in the mind – a proposition is clearly not eternal, as no physical or quasi-physical entity is.[26]

[23] QNE VI, q. 6: *Sexto queritur utrum omnes scibile sit eternus.*
[24] QNE VI, q. 6.: *Sciendum est quod scibile potest capi dupliciter. Uno modo pro conclusione demonstrabili; alio modo pro re significata vel rebus significatis per terminus conclusionis sive pro qua vel pro quibus termini conclusionis supponunt. Hoc enim cocnlusio omnis homo est risibilis est scibilis quia demonstrabilis et sciendo eam nos habemus scientiam de omnibus hominibus et de omnibus risibilibus.*
[25] QAnPo I, q. 15: *Proprie loquendo omne illud et solum illud dicitur necessarium quod simper est, fuit et erit.*
[26] Ibid.: *Proprie loquendo nulla propositio est necessaria. Quia omnis propositio fit a nobis et potest corrumpi si cessemus ab eius intellectione aut si obliviscemur eam, aut etiam si moriemur; ideo omnis propositio potest non esse.*

On the other hand, concerning the truth of a sentence, one has to make another distinction. That the truth of a sentence is eternal can either mean categorically and absolutely speaking that the proposition is always true; or hypothetically that it is true whenever it is formed. As Buridan shows, there is no such sentence that would be eternal in the first sense without any restriction; not even the sentence "God exists" is such, because – given that the signification of names is *ad placitum* – it could happen that the names "God" and "chimera" simply switch their supposition. In this case, however, the sentence "chimera exists" would be necessarily true and the sentence "God exists" false.[27] Moreover, if a proposition does not exist – and all propositions are able not to exist – it cannot be true or false.[28]

Therefore, the eternity of scientific propositions should be understood in a hypothetical way; they are true whenever they are formed. Their necessity means that as long as they are scientific propositions it is impossible for the things to be otherwise than the propositions signify.[29]

The next question arising from these considerations is how propositions can be necessarily true if the things they signify are not eternal. According to Buridan, there are two characteristics of a scientific proposition which guarantee this necessity and eternity: Its subject needs to have a special kind of supposition (*suppositio naturales*), while its predicate has to be predicated essentially.[30] Essential predications are necessarily true with the

[27] Ibid. *Et illam appositionem addo quia haec propositio vocalis 'deus est', vel sibi consimilis, posset esse falsa, eo quod significationes nomminum sunt ad placitum. Quia iste terminus vocalis 'deus' posset imponi ad significandum tantum quantum 'chimaera', vel converse, et tunc illa esset falsa 'deus est' et haec necessaria 'chimaera est'.*

[28] Ibid.: *Nulla propositio est necessaria, scilicet in essendo, ut dictum est, ita etiam nulla propositio est necessaria in essendo veram. Quia sicut potest non esse, ita potest non esse vera, quia quando ipsa non est, ipsa nec est vera nec falsa.*

[29] Ibid.: *Dicitur enim 'perpetua' quia simper si formetur est vera, vel simper si formetur est ita sicut ipsa significant. Et dicitur 'incorruptibilis' quia non potest falsificari, quia non potest non esse ita; unde in proposito idem est propositionem esse falsificatam et esse corruptam.*

[30] Unfortunately, Buridan nowhere elaborates the relation of these two requirements; this seems to be, however, the only logical conclusion drawn from his explicit remarks. I have to thank Gyula Klima for elucidating this issue for me.

presumption of the existence of the *supposita* of their subject, which is precisely the pre-condition guaranteed by their subject having natural supposition.

Buridan recapitulates the notion of *suppositio naturales* as it is held by some ancient logicians. As he notes,

> That is called natural supposition, according to which a common term indifferently stands for present, past, and future things.[31]

For example, the sentences "a man will be white," or "a man is sitting," do not have natural supposition, for they can be true at one time and false at another. On the contrary, the sentence "the three angles of a triangle are equal to two right angles" is not restricted to any time; it is true whenever the sentence is formed, even if in that instance no triangle exists. If the proposition were true only of present and past triangles, the absurd consequence would follow that if a new triangle were formed, one would no longer have knowledge of triangles unless the proposition is demonstrated again, and so on each time a new triangle is drawn.[32] Another example also shows that supposition cannot always be restricted to the present: The sentence "every mother loves her son" is false, because there was a mother (s.c. Medea), who did not.[33] But a past-tense sentence could not falsify a present-tense proposition did this latter not stand equally for the past, present, and future. Similarly, therefore, in demonstrative science, all propositions are true regardless of time; the sentence "every human is an animal" or "the angles of a triangle are equal to two right angles" are true even if no human beings or no triangles exist, their subjects encompassing all past, present, and future humans or

[31] QAnPo I, q. 16: *Vocauerunt tamen suppositionem 'naturalem' secundum quam terminus communis indifferenter supponit <pro> praesentibus, praeteritis et futuris.*

[32] Ibid.: *Item, ponamus quod modo tibi demonstratum est quod omnis riangulus habet tres angulos aequales duobus rectis , quaero utrum per talem demonstrationem tu habeas scientiam demonstratiuam de omnibus triangulis uel solum habeas de praeteritis et praesentibus. Si primo modo, habeo propositum. Si secundo, sequitur illud inconueniens quod si fieret unus nouus triangulus et tu dormias, tu non habebis scientiam demonstratiuam extendentem se ad illum triangulum, quia numquam fuit tibi illud demonstratum; ergo tu nullo modo habes scientiam demonstratiuam quod omnis triangulus habet tres angulos aequales duobus rectis, quia oporteret reiterare demonstrationes quotiens fierent noui trianguli.*

[33] Ibid.: *Et isto modo diceretur quod haec esset falsa 'omnis mater diligit filium suum', quamuis omnis quae modo est diligat, et esset falsa quia Medea non diligebat.*

triangles. This kind of supposition enables one to make a universal, necessary statement without knowing whether its subject is actually instantiated.

The other guarantor of the necessary truth of a sentence is that its predicate is predicated essentially of the subject. This criterion is needed because otherwise one could not distinguish between a definition of man as "biped white animal" or as a "rational animal," of which only the second statement catches the essence of being human.

Without going deeply into Buridan's philosophy of language, it must be noted first that an essential predicate is one that contrary to accidental predicates, signifies its *significata* absolutely, not in connection to anything else:

> We call the predication of a term of another 'essential' if neither of these two terms adds some extrinsic connotation to the things they supposit for. Therefore, although the term 'animal' signifies more [things] than the term 'man', nevertheless, it does not appellate over and above the signification of the term 'man' anything having to do with man, i.e., as something pertaining to man. A predication is called 'non-essential', or 'denominative', if one term of it adds some extrinsic connotation over the signification of the other, as for example 'white' supposits for a man and appellates whiteness as pertaining to him. Therefore the predication 'A man is an animal' is essential, whereas the predications 'A man is white' or 'A man is risible' are denominative.[34]

The crucial characteristic of an essential predicate is, therefore, that it can never become false of its subject unless that subject ceases to exist: e.g., the predicate "white" can be once true of Socrates, but in the moment he becomes black, the proposition "Socrates is white" becomes false; therefore, it is not an essential, but a denominative one. On the contrary, the predicate 'animal' or 'man' will be always true of him, and becomes false only when he dies. For the necessary universal propositions of science, we need exactly this kind of predication. (That does not mean, however, that essential predicates can belong only to the category of

[34] SD 2.5.2: *Vocamus autem essentialem praedicationem alicuius termini de aliquo alio termino cuius neuter terminus super significationem alterius addit aliquam connotationem extraneam circa ea pro quibus unus illorum terminorum supponit. Unde licet iste terminus 'animal' plura significet quam iste terminus 'homo', tamen ultra significationem istius termini 'homo' nihil appellat circa hominem, id est per modum adiacentis homini. Praedicatio autem non essentialis sed denominatiue uocatur cuius unus terminus super significationem alterius addit alienam connotationem, ut 'album' supponit pro homine et appellat albedinem sibi adiacentem. Ideo haec praedicatio est essentialis 'homo est animal'; et haec est denominatiue 'homo est albus'.* Translations are from John Buridan, *Summulae de Dialectica*, annotated tr. with a philosophical introduction by Gyula Klima (New Haven: Yale University Press, 2001), 127.

substance. A predicate, for example, which marks the differentia of a given species, is certainly essential; nevertheless, it is a quality.)

Secondly, Buridan makes a further distinction between absolute and relative terms and concepts.

> For the soul can think of things by two kinds of concepts. In one way, [it thinks of things] without comparing things to one another, and it is by the mediation of such concepts that the soul imposes the terms 'man', 'white', 'two cubits long', [etc.,] to signify; such concepts therefore are to be called 'absolute', properly and primarily, and consequently also the spoken terms subordinated to these concepts are called 'absolute terms'. In another way the soul thinks of things in relation to one another, comparing one to another, and such concepts are properly called 'relatives' and 'relations', for it is by these that the soul relates and compares things to one another. It is by the mediation of these concepts that those spoken terms are imposed to signify, which, accordingly, we call 'relative', or 'respective terms', for example, 'father', 'son', 'double', 'half', etc.[35]

There is an obvious and somewhat less obvious part of this definition. For the former, one can firmly say that a predicate, to be essential, has to denote an absolute concept: indeed, a relative term, by its definition, cannot be predicated essentially, unless – as in some rather special cases – it does not connote anything besides the connotation of the subject (as e.g., in the sentence "the one who is unmarried is a bachelor"). On the other hand, however, it seems that the set of absolute terms contains more than the essential predicates; it would be at least hard to imagine something which is *essentially* two cubits long.

This doubt is supported also by an earlier passage in the *Summulae:*

> … So, he ["the author," s.c. Aristotle] says that some predicable terms signify substance without any extraneous connotation, and these are in the category of substance. Others signify, or connote, something in relation to [circa] substance, so that when they are said of a primary substance, they do not only signify what it is but also what it is like, if they are in the category of quality, and similarly with quantity and the others.[36]

[35] SD 3.4.1: *Duplici enim conceptu potest anima intelligere res. Uno modo sine comparatione earum ad inuicem, et sic mediantibus talibus conceptibus imponit anima ad significandum istos terminos 'homo', 'album', 'bicubitum'; tales ergo conceptus uocandi sunt 'absoluti', proprie et primo, et consequenter termini uocales illis conceptibus subordinati etiam dicuntur termini 'absoluti'. Alio autem modo anima intelligit res in ordine ad inuicem, comparando hanc ad illam, et tales conceptus uocantur proprie 'relatiui', et 'relationes', quia eis anima refert et comparat res ad inuicem. Et mediantibus illis conceptibus imponuntur ad significandum termini uocales quos uocamus consequenter 'terminos relatiuos', seu 'respectiuos', sicut sunt isti termini 'pater', 'filius', 'duplum', 'dimidium', et caetera.* Tr. Gyula Klima, 173.

[36] SD 3.1.8: *Dicit ergo quod quidam termini praedicabiles significant substantiam, sine connotatione aliena, et sunt de praedicamento substantiae. Alii significant, siue connotant, circa substantiam, ita quod dicta de primis*

Therefore, it seems that if one considers the proposition "Socrates is white," then it does have an extraneous connotation (namely his whiteness), therefore, it is not an essential predication, whether the term "white" be an absolute or a relative term. In fact, if we take notice of the latter passage then the exhaustive division is not between absolute and relative, but between absolute and connotative terms and concepts. Every relative term is connotative, but not vice versa.

The third distinction Buridan has to make is between singular and common concepts: a common concept is one which supposits for a number of individuals, in a way that it can stand for any of them. For example, the concept of "man" can stand as for Socrates as for Plato or anyone else in the same manner.[37] What we need for universal, necessary scientific statements are the absolute, substantial, common concepts which can be predicated essentially.

1.2. Demonstration

Beside necessity, however, as already noted in Aristotle's text, scientific knowledge has other characteristics as well; it has to be demonstrated and this involves that it has to be knowledge about causes. (As Buridan makes clear already in the *prooemium* of his commentary on the *Posterior Analytics, scire est rei causam cognoscere.*[38]) That demonstration concerns causes is clear from its definition: It "proceeds from true premises, which are first and immediate; from the prior and more known, and from the causes of the conclusions."[39] This definition has several parts, and Buridan analyzes them one by one.

substantiis non solum significant quid est, sed qualis, et sunt de praedicamento qualitatis, et sic de quantitate et aliis. Tr. Gyula Klima, 151.

[37] Cf. SD 1.3.5, 2.1.1.

[38] QAnPo I, prooemium.

[39] QAnPo I, q. 8, where Buridan quotes Aristotle: *demonstratio est ex praemissis veris, primis et immediatis, ex prioribus et notioribus et causis conclusionis.* For Aristotle, see *Posterior Analytics* 71 b20-22; AL IV, 113: *demonstrativam scientiam et ex veris esse et primis inmediatis et notioribus et prioribus et causis conclusionis.*

First of all, the premises of a demonstration have to be true. This requirement is quite obvious if one takes into consideration that nothing can be known unless it is true (as Buridan says, it would be absurd to say that you know that a human is a donkey). Since demonstration is a syllogism that provides knowledge, it can only proceed from such premises that are true and are known to be true.

Secondly, a demonstration has to proceed from first principles; a first principle is such that it is "indemonstrable because of its evidence."[40] A demonstration, therefore, has to consist of premises that are either themselves first principles and thus evidently known, or, if they are not, they can be further resolved into the first principles. For if a premise were not resolvable into a first principle, it would not be entirely known; therefore, the syllogism in which it stands would not provide real knowledge.

This consideration raises an issue; what are these first principles, or how many of them there are? Buridan does not treat this question here, but it is remarkable that he always uses the term "first principles" in the plural, which indicates that he does not see it necessary to derive all knowledge from the first logical principle, that is, from the principle of non-contradiction. In this, he is in sharp opposition with the contemporary Nicolaus of Autrecourt, who emphasizes throughout his letters that there is no certainty unless it derives from the principle of non-contradiction:

> The first thing that presents itself for discussion is this principle: 'Contradictories cannot be simultaneously true.' … Every certitude we possess is resolved into this principle. And it is itself not resolved into any other in the way a conclusion would into its premises.[41]

Indeed, in another place Buridan makes it clear that there are different kinds of principles with different origins:

[40] QAnPo I, q. 8: *Primum est idem quod indemonstrabile propter sui evidentiam.*

[41] *Secunda epistola ad Bernardum,* 2-3: *Et primum quod occurrit in ordine dicendorum, est istud principium: 'Contradictoria non possunt simul esse vera.' … Omnis certitudo a nobis habita resolvitur in istud principium. Et ipsum non resolvitur in aliquod aliud sicut conclusio in principium suum.* Translation is by L. M. De Rijk from Nicholas of Autrecourt, *His Correspondence with Master Giles and Bernard of Arezzo,* critical ed. with tr. (Leiden: E. J. Brill, 1994), 59.

> It must be noticed that there are two kinds of indemonstrable principles. Principles of the first mode are assented by the intellect when they are presented to it, that is, the intellect immediately assents to them if it knows their terms: for example, that there is something, or that man is an animal, or whiteness is a color…
> But principles of the second mode are not so immediately comprehended by the intellect; although they are indemonstrable, nevertheless, they require first the judgment of the senses, and the memory, and experience: for example, that every fire is hot, and that every rhubarb cures cholera; they are not immediately assented by the intellect, because if you have never seen any fire, or if you saw, you did not touch it, your intellect will not know, whether every fire is hot.[42]

The first kind of principles, therefore, are what we would call "analytic truths," when the predicate is either part of, or excluded by the subject. Principles of the second kind are acquired by experience; nevertheless, they can also serve as a basis of scientific demonstrations. This role of *a posteriori* principles, as will be discussed below, is enabled by Buridan's insistence on various degrees of evidence.

Finally, the premises of a demonstrative syllogism have to express the causes of the conclusion; this follows from the above-quoted definition of knowledge, according to which scientific knowledge must be knowledge of the causes. Buridan argues for the correctness of this definition in another *questio.* Knowledge in the strict sense has to exclude any doubt; but if it were not knowledge of causes, then a doubt would occur about why a thing is such as it is – therefore, it could not be knowledge in the strict sense.[43] For example, proper knowledge of a lunar eclipse not only affirms that it is a lunar eclipse, but it also has to be clear about why this lunar eclipse occurs, namely, that it is a result of the Earth being between the Sun and the Moon.[44]

[42] QAnPo II, q. 11.: *Deinde etiam notandum est quod duplicia sunt principia indemonstrabilia. … Modo principia de primo istorum modorum statim ab intellectu capiuntur cum sibi praesentantur, hoc est dictum quod intellectus statim assentit eis scito quid nominis illorum terminorum: uerbi gratia, quod aliquid est, quod homo est animal, quod albedo est color… Sed principia de secundo dictorum modorum non sic statim capiuntur ab intellectu; immo licet sint indemonstrabilia, tamen indigent primo iudicio sensus, et memoria et experientia: uerbi gratia, quod omnis ignis est calidus et quod omne rheubarbarum faciat choleram non statim concedit intellectus; unde posito quod numquam uidisses ignem uel, si uidisses, tamen non tetigisses, non esset intellectui tuo notum utrum omnis ignis sit calidus.*

[43] QAnPo I, q. 7: *Item, notandum est quod cum ibi diffiniatur scire potissime, illud excludit de scire omnem dubitationem. Et si non est scientia causae non excluditur omnis dubitation, quoniam adhuc dubitatur quare ita sit. Ideo ad scire ita difinitum exigitur scire causam.*

[44] Ibid.: *Non enim scio propter quod luna eclipsatur si solum scio quod luna eclipsatur; immo etiam oportet scire hoc totum quod luna eclipsatur propter terram interpositam inter se et solem prohibentem irradiationem eius a sole; et in hoc sciendo apparet quod scire continent notitiam conclusionis et praemissarum.* With this example

2. SOME PROBLEMS

The requirements of scientific knowledge set up by Buridan (together with Aristotle and almost all following him), therefore, are relatively easy to summarize: (1) it has to be necessary and universal; and (2) it has to be demonstrated, that is, it has to proceed from indemonstrable principles showing the causes of the thing in question. It is, however, far from obvious, whether it is at all possible to arrive at such knowledge.

First, it is difficult to argue for the possibility of universal and necessary knowledge if one maintains the *nihil est in intellectu quod non sit prius in sensu* principle.[45] According to this principle, all of our knowledge derives from the senses, which are directed towards the objects around us. There are at least two questions that such, in broad sense empiricist epistemology raises. Against the possibility of knowledge of the particular objects around us, several skeptical arguments had been induced from antiquity, and these acquired a special flavor in the late thirteenth-century debates on God's omnipotence, in which God was said to be able to maintain an evident knowledge in us even if its object is annihilated.[46] But even if one concedes that our senses do provide reliable knowledge of the objects around us, these objects do not at all seem to be universal or necessary, therefore, it is at least questionable whether they can provide us scientific knowledge in the strict sense as defined above.

Buridan follows the long tradition of defending the demonstration *propter quid* as the proper demonstration of science; Aquinas uses the same example when he argues that although we cannot conclude – at least in the sublunar world – from the cause its effect, it is possible to make the inference in the other way, from the effect to its causes. For Aquinas, see *Expositio libri Posteriorum Analyticorum* I, l. 16; II, l. 7.

[45] There has been quite much debate on the origin of this empiricist slogan, especially important in and after John Locke. It has been attributed to several Renaissance and early modern thinkers – as in Cranefield, "On the Origin of the Phrase 'Nihil est in intellectu quod non prius fuerit in sensu'," *Journal of the History of* Medicine 25 (1970): 77-80 –, but its earliest occurrence I know of is already in Aquinas; the quotation is from *De Veritate* q. 2. a. 3. arg. 19.

[46] This is a rather oversimplified restatement of the Ockhamist and post-Ockhamist skeptical concerns, but I will not go into this issue now. For a summary and a bibliography of the enormous amount of literature on the subject, see, e.g., Michael Frede, "A Medieval Source of Modern Scepticism," in *Gedankenzeichen*, ed. R. Claussen and R. Daube-Schackat (Tuebingen: Stauffenburg Verlag, 1988), 65-70; Étienne Gilson, "The Road to Scepticism," In Idem, *The Unity of Philosophical Experience* (San Francisco: Ignatius Press, 1999), 49-72 and Anneliese Maier, "Das Problem der Evidenz in der Philosophie des 14. Jahrhunderts," *Scholastik* 38 (1963): 183-225.

The second problem, also especially acute from the late thirteenth century, concerns the possibility of the knowledge of any causes. The Parisian condemnation of 1277 clearly questions the view that secondary causes are necessary in order to bring about an effect (for the same effect can be brought about by God alone),[47] and refutes the thesis that a given cause cannot bring about any effect but can only act in a determinate manner.[48]

Accordingly, the doubts that the "medieval Hume,"[49] Autrecourt, raises against the knowledge of causes are also twofold. First, causal relations in a sensory experience are never evident; what we can always see is that two objects act in a certain way, but we never see the causal connection between the first and the second act, and therefore we can never infer that one was the cause of the other.[50] But, secondly, even if we were able to posit a cause in one case, there is nothing which would assure that the same cause would act in the same manner, or that the same effect would be the result of the same cause. We might have a tendency to grant that the same causes bring about the same effect whenever they occur, or that the same effects have the same causes, but this can never be demonstrated and therefore cannot be known.[51]

[47] 63: *Quod Deus non potest in effectum causae secundariae sine ipsa causa secundaria*.
[48] 160: *Quod nullam agens est ad utrumlibet, immo determinatur.*
[49] Cf. Hastings Rashdall, "Nicholas de Ultricuria, a Medieval Hume," *Proceedings of the Aristotelian Society* 8 (1907): 1-27.
[50] *De epistola Nicholai Egidium*, 14.: *Dico hic quod, si per 'agentia naturalia' intelligatis ista agentia que sunt approximata passis et non impedita, sic ponunt suas actiones esse. Quare dico quod optime sequitur 'agens naturale est approimatum passo; et non est impeditum; ergo est actio'. Sed dico quod non est evidens evidentia descripta alicui quod in rerum universitate sint talia agentia, ymo nec quod sint ponibilia. Ne demonstratis omnibus que sunt requisita ad effectus, potero sustinere sine aliqua contradictione que posset inferri contra me, quod effectus huiusmodi non erit.*
[51] *Exigit ordo* 237: *De scitis per experientiam illo modo quo dicitur rheubarbarum sanat choleram vel adamas attrahit ferrum, habetur solum habitus conjecturativus, non certitudo, cum probatur quod certitudo per propositionem quiescentem in anima quae est illud quod producitur ut in pluribus a causa non libera est effectus ejus naturalis; quaero quid appellas causam naturalem; vel illam quae produxit praeteritum ut in pluribus et adhuc producet in futurum si duret et applicetur? Et tunc minor non est scita, esto quod aliquid sit productum ut in pluribus; non est tamen certum an sic debeat esse in futurum.*

3. THE METHOD OF ACQUIRING SCIENTIFIC KNOWLEDGE

Since Buridan, who has been labeled as the "quintessential empiricist of the fourteenth century,"[52] grants the premise that our knowledge derives from the senses,[53] he has to answer at least three questions about the possibility of scientific knowledge:

(1) How and why our senses are reliable;

(2) How we can arrive to universal and necessary knowledge; and

(3) How we can gain knowledge of causation.

3.1. Reliability of the senses

Since I cannot present here Buridan's reply to the skeptical arguments in its entirety,[54] it will suffice now to look at his arguments presented in the first book of his commentary on Aristotle's *Posterior Analytics.*[55] Here Buridan collects no less than fourteen arguments which would show that knowledge is not possible; they can be grouped into four main types.

The first group argues from the relativity of judgment and sensation. What humans judge pleasant, certain animals judge unpleasant and vice versa; what is healthy for a young man might not be healthy for an old one. Something that seems sweet for a healthy person may seem bitter for the ill.

The starting point of the second group of arguments is that the senses are often deluded, such as when standing on a moving boat on a river, one judges that the trees on the shore are moving. Similarly, visual perception is dependent on the medium through which we see, and if this medium changes vision also changes, as when the sun seems to be large and

[52] Edward Grant, "Jean Buridan and Nicole Oresme on Natural Knowledge," *Vivarium 31* (1993): 84–105, 84.
[53] See, e.g., QAnPo II, q. 11: *Debemus enim dicere quod actualis notitia principiorum non est nobis innata, sed acquisita.*
[54] It has been done by Jack Zupko in "Buridan and skepticism," *Journal of the History of Philosophy* 31 (1993): 191-221; see also Gyula Klima, *John Buridan* (Oxford: Oxford University Press, 2009), especially 239-258.
[55] QAnPo I, q. 2: *Utrum possibile sit nos aliquid scire.*

red at sunrise, but it is small and white during the day. Perfect vision would only occur if the medium were perfect, but we cannot attain this in the present life.

The third argument – in contrast with the first two – is characteristically medieval, as it argues from the omnipotence of God. Sense perception, according to Buridan – who in this respect is part of a long but by the fourteenth century heavily questioned tradition – is not direct in the sense that our sense organs are immediately connected to the objects themselves, but occurs through a mediator, the *species sensibilis.* It is possible, therefore, for God to preserve this *species* in us and by it the sensory experience, while annihilating the object of sensation. Since we can never know God's will, we can never demonstrate that this is not in fact the case.

Finally, although the target of the above arguments was the sensory process, the same could apply to the intellect as well. Since the sources of any intellectual process are the sensory experiences, if the latter are unreliable so is the former. But it has been shown that we cannot rely on our senses; therefore, the judgments of the intellect also lack the firmness required for knowledge.

Buridan's answer to these arguments is rather brief. He claims that we do have evident knowledge of some principles that are known *per se,* and about which the intellect cannot err. We also evidently know the conclusions that follow from these principles.[56] Of course, the main question that these arguments raise is not concerned with the evident knowledge of these logical principles (principles of the first kind in the classification above), but asks whether we can know anything *besides* them.

Before answering this second, more severe, question, Buridan gives some clarification. Knowledge requires certitude and evidence, that is, certitude of the truth and certitude of the assent. The former is needed because however firmly one assents to something false, this

[56] Ibid.: *Ad questionem tamen respondeo quod scire est nobis possibile: quia aliqua sunt principia nobis per se nota et nulli dubia; immo circa ea nullus potest errare, ut patet quarto Metaphysicae; deinde ex illis principiis possunt educi quaestiones per syllogismos formaliter evidentes, et etiam illae conclusiones sciuntur.*

cannot be called knowledge (Buridan mentions the example of the heretics, who firmly believe but not truly); and it is by the latter that knowledge differs from belief and from opinion. But Buridan makes a further distinction with regard to the concept of evidence, which can serve as a key to the problem raised by the skeptic.

> We have to notice that "evidence" is understood in many ways. One way in the strictest sense, and a proposition is evident in this sense when the intellect by its nature assents to the proposition and cannot dissent from it; and this is the mode in which Aristotle says the first principle is evident to us.
> Secondly, something is called evident when it is apparent somehow, and its opposite could not be apparent by any human reason; and this is the way the natural principles and natural conclusions are evident. And it has to be noticed that this evidence is not evidence in the strict sense: because about such propositions the intellect could be deceived by supernatural cause; for God can make a fire without hotness, and can make and conserve in my senses a sensible *species* without any object, and so by this evidence you would judge as if the object were present, and you would judge falsely. But this natural evidence is rightly called natural, because according to this one cannot be deceived in the common course of nature, even though he can by the supernatural power; and this evidence is sufficient for the natural sciences.[57]

Buridan's answer to the argument from divine omnipotence, therefore, does not claim that we can somehow exclude the possibility of delusion of such a kind; this we cannot, but natural science does not even require such exclusion. Instead, it is enough for natural science to rely on the presupposition that the common course of nature is not disturbed.

To the other arguments it is said that if our senses are in a proper disposition they do provide us with reliable information (in the common course of nature, one should amend). While in particular cases, the senses can err and can lead to false experiences, "many and good experiences that are examined in various cases, never deceive us."[58] To decide in a certain case whether a sense organ is in a proper disposition or not is the task of the intellect,

[57] Ibid.: *Sed de euidentia debetis notare quod 'euidentia' multipliciter accipitur. Uno modo propriissime, et tunc euidentia propositionis dicitur secundum quam intellectus per suam naturam cogitur propositioni assentire et non potest ei dissentire; et isto modo diceret Aristotiles quod primum principium est nobis euidens. Secundo modo 'euidentia' dicitur quia cuilibet apparet et per nullam rationem humanam posset oppositum apparere; et isto modo sunt euidentia principia naturalia et conclusiones naturales. Et notandum est quod haec euidentia non dicitur proprie 'euidentia': quia circa tales propositiones euidentes intellectus posset decipi per causam supernaturalem; quia deus posset facere ignem sine caliditate, et posset facere in sensu meo et conseruare speciem sensitiuam sine obiecto, et ita per istam euidentiam tu iudicares ac si obiectum esset praesens, et iudicares falsum. Tamen illa euidentia naturalis bene dicitur naturalis, quia secundum illam non potest homo decipi stante communi cursu naturae, licet deciperetur per causam supernaturalem; et haec euidentia sufficit ad naturalem scientiam.*

[58] Ibid.: *Quia licet experientia pauca et parum examinata saepe falat, tamen experientia multa et bene in diversis casibus examinataa numquam fallit.*

which, although it receives its data from the senses, exceeds them in its nobility and power. Although the source of our knowledge is sensation, the intellect is able to correct the errors of the senses, and does it with such evidentness which in turn provides knowledge.

3.2. Universal and necessary scientific propositions

We have seen that the most important characteristic of a scientific proposition for Buridan is that its predicate is an essential predicate, which, furthermore, denotes an absolute, substantial, common concept. But how can one form a substantial concept, if the sensory data are merely accidental? And even if a singular substantial concept is formed, how can it be turned into a common one, needed for a universal scientific proposition?

(1) The key to Buridan's solution to the first question is the concept of abstraction. The intellect, after conceiving and sorting out the confused sensorial data, is able to form a substantial concept from it:

> When I first have a confused concept which represents both substance and accident, as when I perceive something white, I do not only see the whiteness alone but something that is white, but when I perceive the same thing moving and changing from white to black I judge that it is not the whiteness [itself], and now the intellect has naturally the power to divide that confused concept, and to understand the substance abstractively from accidents, and the accidents abstractively from substance.[59]

The confused sensory data, therefore, enables the intellect to grasp the essential characteristic of a given object. That does not mean that the substantial concept is made up of the accidental ones (as the British empricists would suggest); as Buridan makes clear, a substantial concept contains nothing else than the substance.[60] On the other hand, this activity of the intellect does

[59] Ibid.: *Tertio modo abstractive ut quia habeo primo conceptum confuse et simul representatem substantiam et accidens ut cum percipio album nom enim solam albedinem video sed album et tamen postea percipio idem moveri et mutari de albo in nigrum judico hoc esse aliud ab albedine et tunc intellectus naturaliter habet virtutem dividendi illam confusionem et intelligendi substantias abstractive ab accidente et accidens abstractive a substantia.*

[60] QP I, q. 4, fol. 5 ra: *De substantia habemus conceptum simplicem quia conceptus hominis a quo sumitur iste terminus substantialis homo est conceptus substantie si homo est substantia; et ille conceptus non supponit nisi pro substantia quia si supponeret pro accidente vel pro composito ex substantia et accidente tunc non esset verum quod homo est substantia quia nec accidens est substantia nec compositum ex substantia et accidente est substantia sed precise substantia est substantia.*

not imply either that Buridan assumes some other source of knowledge apart from the senses; the matter with which the intellect can work is precisely the sensory data, which, however, the senses are just unable to analyze beyond some degree. Borrowing an illuminating example from Gyula Klima,[61] when one looks through a telescope at a star, he sees only the light of it; but the information carried by the very same telescope, by means of a spectral analysis, can yield information about its matter, age and other properties. In place of spectral analysis, it is our intellect which functions in everyday sensation; the intellect, which is not a passive receptor but an active agent that extracts further information from the sensed qualities. For example, if one sees Socrates as white, and then sees him as black, his intellect can inform him that the whiteness and blackness is not contained in the substance of Socrates. That is a piece of information, however, what the senses alone could not process.

(2) But, secondly, how can one form a *universal* concept from such essential, but still particular concepts? Buridan, due to his nominalism, cannot rely on the universality of the abstracted natures, a solution Aquinas could easily use;[62] but he can well take advantage again of the intellect's abstractive power and the characteristics of common concepts.

As noted above, a common concept is one that can signify many individuals indifferently; therefore, if the intellect continues the process of abstraction, described above in the *Physics* commentary, it finally arrives at a common concept. For example, considering the white Socrates and the white Plato, first the intellect observes that the whiteness does not belong to their substance; then, as it realizes that this whiteness is similar in both of them, it further abstracts the common concept of whiteness and humanness – a concept that is applicable to all white (or human) creatures of the world.[63]

[61] Cf. Klima Gyula, *John Buridan* (Oxford: Oxford University Press, 2009), 99.
[62] E.g., *Super Boethii Libri De Trinitate* q. 5 a. 2; *Summa Theologiae* I, q. 86. a. 1.
[63] Cf. QDA III, q. 8.

This solution, which assumes that the intellect – from finitely many observations – is able to arrive at a true, universal concept or proposition, rests on the strong assumption that one can call the intellect's natural inclination to verity:

> Experience, deduced from many observations and memories, is nothing else than induction from singulars, through which the intellect … due to its natural inclination towards verity, concedes to a universal proposition.[64]

These universal propositions might not bear the evidence of the first logical principle, but, as we have seen, they do not even need to.

3.3. Knowledge of causes

Buridan's reply to the question of whether a scientific demonstration must contain causes rests on the same principle as his reply to the problem of induction. In the *Physics* commentary, he proposes some objections that would deny that demonstrations can proceed from causes, and that knowledge of causes is altogether possible.[65] The most important of them derives probably from Autrecourt;[66] if there are two distinct things, *a* and *b,* then it is impossible to infer the existence of *b* from the existence of *a* – for if they are really distinct, God can maintain one while the other is destroyed, so the existence of one without the other does not entail a logical contradiction. Therefore, if we know that *a* exists, but nothing else, we can be never sure that *b* also exists. Now, causes and effects are distinct things; the cause does not contain its effect nor vice versa. In this case, however, one can never infer the

[64] QP I, q. 15, fol. 19 ra: *Experientia ex multis sensationibus et memoriis deducta non est aliud quam inductio in multis singularibus per quam intellectus … ex eius naturali inclinatione ad veritatem concedere propositionem universalem.*

[65] The *questio* is in QP I, q. 4.

[66] Whether Autrecourt was really the target of Buridan's arguments here and elsewhere, can neither be proved nor disproved sufficiently. The former was attempted by Jack Zupko in "Buridan and Skepticism," *Journal of the History of Philosophy* 31 (1993): 191-221, while the latter by J. M. M. H. Thijssen in "John Buridan and Nicholas of Autrecourt on Causality and Induction," *Traditio* 43 (1987): 237-255.

existence of the effect from the existence of the cause, or the existence of the cause from that of the effect.[67]

In his answer, Buridan again refutes the claim that every demonstration should be reducible to the first logical principle; as he expresses it here,

> It is not necessary that every premise of a demonstration should be known evidently by a reduction to the first principle; there are many principles of demonstrations that are known to us by our senses or by memory or by experience.[68]

Thus, it is not impossible for the intellect to arrive at some knowledge of *b* from the knowledge of *a*, even if *a* and *b* are distinct entities; to use Buridan's own example, if one sees a man one can conclude that he has a heart, even if one does not see it directly. For we know – it is demonstrable – that a man cannot live without heart, while the minor premise, that the man lives, is evident from the senses.[69] It means that the knowledge of causes does not directly derive from sensory experience, but its source is an inference made by the intellect.

The intellect is capable of making this inference by the very same reason why it is capable of inductive generalizations; that is, by its natural inclination towards the truth. As Buridan notes here,

[67] QP I, q. 4, fol. 4 vb: *Item revertor ad arguendum quod non posset fieri notum unum ex alio quia de uno ad aliud non est consequentia evidens propter hoc quod consequentia non est evidens nisi secundum reductionem ad primum principium, et talis consequentia non potest reduci ad primum principium, quia primum principium fundatur in contradictione, et contradictio debet esse eiusdem de eodem et secundum rem et secundum nomen. Unde si a et b sunt alia ab invicem, nunquam esset contradictio a esse et b non esse; igitur non est evidens consequentia dicere 'a est ergo b est' et sic de quibuscunque aliis quantumcunque propinquam habentibus habitudinem ad invicem.*

[68] QP I, q. 4, fol. 5 vb: *Non oportet omnem premissam demonstrationis fieri notam et evidentem per reductionem ad primum principium; multa enim principia demonstrationum fiunt nota nobis per sensum vel per memoriam vel per experientiam.*

[69] QP I, q. 4, fol. 6 ra: *Quarta conclusio est quod in quibusdam per istam propositionem 'a est' non solitarie sed cum alia premissa ego possum demonstrative scire istam conclusionem 'b est', licet a sit aliud quam b et b aliud quam a. Verbi gracia non est tibi notum ad sensum quod cor est sed tibi est notum ad sensum quod homo est, igitur tu argues sic: Si homo est, cor est; sed homo est; igitur cor est. Minor patet ad sensum, et maior erit nota quando demonstratum erit quod non potest homo vivere sine corde.*

> Many things are evident to us by the intellect's natural inclination to verity; for if the fire is naturally inclined to warming, why should not our intellect be naturally inclined to assent many truths and to dissent from many falsities?[70]

Although Buridan often refers to this principle, it is rather hard to decipher its origin. As we might recall, Buridan distinguishes two kinds of principles; one is evident by the meaning of the terms and the other can be acquired by experience.

Now it is relatively clear that the principle of natural inclination is not of the first kind; it is obviously not an analytic truth. Therefore, as Jack Zupko has argued,[71] it has to be of the second kind, that is, a principle which is acquired by induction or repeated experiences. This solution, however, is again rather problematic. First of all, from which experience the principle would derive from is not entirely clear; one can sense the heat of a fire, and accept as a principle that every fire is hot, but can one experience in any way that our intellect is naturally inclined towards truth? A skeptical response to this question would inevitably be negative. But there is yet another problem with this solution, namely, that it seems that every principle of the second kind already uses the principle of the intellect's inclination towards verity; therefore, the latter cannot be one of the former. One can concede that every fire is hot only if one already asserts that the intellect naturally inclines toward truth, and so is able to generalize veridically our particular sense experiences of the hotness of fire.

All in all, Buridan can be said to have successfully argued for the possibility of scientific knowledge; we can trust our senses, which enable our intellect to acquire some information about the essences of things. From this, necessary and universal scientific propositions can be formed, given that the intellect, with its natural inclination toward verity, can generalize the acquired substantial concepts without losing their evidentness – an evidentness which is not the same as that of the first logical principle, but which is enough for

[70] QP I, q. 4, fol. 6 va: *Sepe certe fiunt nobis evidentie ex naturali inclinatione intellectus ad veritatem. Si enim ignis naturaliter inclinatus sit ab calefaciendum, quare non esset intellectus noster naturaliter inclinatus ad assentiendum multis veris et ad dissentiendum multis falsis?*

[71] Jack Zupko, "Buridan and Skepticism," *Journal of the History of Philosophy* 31 (1993): 191-221, especially 201-203.

the natural sciences. We can also acquire knowledge of the causes, since – in this weaker degree of evidence – we can infer the existence of one thing from that of another. Buridan's solution concerning universal knowledge as well as the knowledge of causes, however, rests on the principle of the intellect's natural inclination, which cannot be demonstrated within this framework.

Converging slowly on the main subject of this thesis, the role of sensory experience in Buridan's theory of science is twofold. First, there is a group of principles that can only be acquired by experience; they form the basis of scientific reasoning. On the other hand, however, the intellect, by its higher power, is able to overhaul or overrule any sensory experience if the circumstances are judged to be inappropriate. Therefore, even if the basis of scientific reasoning might be provided by experience, the final criterion of validity is always set by the intellect. Now we can turn to analyze how this twofold conception plays its vital role in Buridan's scientific practice.

PART TWO: METHODOLOGICAL PRACTICE

1. INTRODUCTION

To see, whether Buridan really applies the above-described methodology of acquiring scientific knowledge in his scientific practice, and more specially, in order to understand what role did experiment play in the latter, I selected to scrutinize the questions 7-11th from the fourth book of his *Physics* commentary *secundum ultimam lecturam.*[72] These five *questiones* form a relatively independent part within the whole work, inserted, just as in Aristotle, between the questions on place and that on time.[73] The first two of them deal with the natural and supernatural possibility of the existence of vacuum; then, in the next two, the nature of motion, and the motion in the void are elaborated; while the final question addresses the possibility of condensation and rarefaction.

The selection of this treatise on void might be justified by the density of the text; as a consequence, many characteristics of Buridan's general way of argumentation are apparent here, enabling it to serve as a representative example of the whole commentary. Accordingly, treating the relevant issues of the problem of the void, not strictly in the same order as Buridan does, I will pay special attention to the kind of arguments Buridan uses to support his claims, from which a more general picture can be gained on his methodological practice in natural philosophy. Although my focus will be exclusively on the questions of Buridan, in some cases, as a comparison might illuminate some of its important features, I will also refer to the commentaries of Roger Bacon and John of Jandun, and more occasionally to that of Robert Grosseteste.

[72] For a short recapitulation of the textual tradition of the commentary, see the Introduction to the Appendix.
[73] See QP IV, 1-6, 12-16. The corresponding parts of Aristotle's *Physics* are 208 a27-213 a11; 217 b29-224 a16.

2. THE NONEXISTENCE OF VACUUM

2.1. The questions of the existence of the vacuum

The question of whether a void exists, can be, and was indeed understood, in different ways before and during the Middle Ages, mostly originating from the part of Aristotle's *Physics*[74] where the author vehemently argues against those who supposed that it was possible, or perhaps necessary, for vacuum to exist.[75] Here, vacuum is defined as "a place with nothing in it;"[76] elsewhere it is described as "that in which the presence of body, though not actual, is possible."[77] Aristotle's rather antagonistic account, together with the commentary on it by Averroes,[78] was the usual starting point of the medieval discussion, being also the only one that could offer some information on the Presocratic concepts of void. In order to understand better both the history of, and the medieval – conceptually quite composite – arguments for and against the void, it is necessary to classify these various concepts, at least in a general way.[79]

(I.) The concept of *intracosmic void* implies that the void in question is, in some way, within the boundaries of the – supposedly finite – cosmos.

(I. 1.) If it is maintained that space is a corporeal dimension, existing independently of the magnitudes of bodies (being in a way similar to what later became the Newtonian concept of absolute space), then this space is either full, when there is a body in it, or vacuous, when

[74] Book IV, 6-9.
[75] On the history of the question from the Middle Ages to the seventeenth century, see Edward Grant, *Much Ado about Nothing: Theories of Space and Vacuum from the Middle Ages to the Scientific Revolution* (Cambridge: Cambridge University Press, 1981), for the medieval history, also Pierre Duhem, *Le Systeme du Monde: Histoire de Doctrines Cosmologiques de Platon a Copernic* (Paris: A. Hermann, 1913-1958), vol. 8, 7-168.
[76] Aristotle, *Physics*, 213 b31; AL VII, 156: *Ad quale autem se habet, oportet accipere quid significat nomen. Videtur iam vacuum locus esse in quo nichil est.*
[77] Aristotle, *De caelo*, 279 a14-15.
[78] AQP fol. 147ra B – 173rb F.
[79] A slightly different classification can be found in Grant, *Much Ado about Nothing…,* 9-23; for a detailed medieval discussion see BQP, 224.

there is none. Since Aristotle explicitly denied this conception of space,[80] he also refuted the concept of void that it might imply.

(I.1.a) The first way such a vacuum can be imagined is that it exists separately, like an empty room or vessel, without the walls, or the vessel itself, but still as a magnitude. The central questions arising from such a concept are whether it is possible that this vacuum exists, being a magnitude, therefore an accident without any substance; moreover, if the answer to the first question is affirmative then could it receive any body, which would seemingly result in a penetration of dimensions.

(I.1.b) The second way of the *per se* existing void space can be imagined is that of the – mostly ancient, but even some medieval – atomists;[81] the void, thus understood, is supposed to exist between the particles of any matter. This kind of vacuum, in contrast to the previous one, is *per definitionem* empty; it is not what contains the particles, but what is *between* them. Therefore, the main questions here are not the penetration of volumes, but the possibility of rarefaction and condensation, and, quite generally, whether it is necessary to posit such a mixed void in order to explain the observable phenomena.

(I.2.) The main problem with both of these conceptions was that they presupposed an absolute space, which is unintelligible in the Aristotelian framework. What could be imagined, however, even in this framework, was a vacuum that is not itself an entity or dimension, but that is produced when a body occupying a certain place is destroyed, while the place itself retains its shape; since there would be nothing in that place, it can be described as vacuous. The main questions about such a vacuous place concern the movement of a body which could be placed in it; whether it can move at all, and if so, in what direction, with what speed, and so on. They cover a large part of the medieval discussion on the void, not least because one of Aristotle's arguments against void space is a kind of *redactio ad absurdum*

[80] Cf. *Physics* IV, 1-5.
[81] For an overview on the medieval atomistic theories, see *Atomism in Late Medieval Philosophy and Theology,* ed. Christophe Grellard and Aurelien Robert (Leiden: Brill, 2009).

which shows the impossibility of movement in such a space,[82] while the absolute power of God clearly implied that such an empty place could exist.

(II.) As the problem of intracosmic void space was usually treated within the commentaries on Aristotle's *Physics* (more occasionally, on the *De coelo*), the question of *extracosmic void space* acquired a distinctively theological flavor, not to be treated, therefore, primarily within the questions of natural philosophy. From the related theological issues – God's location, his omnipotence, and the state of affairs before creation – the main questions that arose were whether an infinite void space exists or can exist beyond the boundaries of the world, and whether a void space existed before the creation.

As will be seen, Buridan does not make such clear distinctions between the various concepts of void. Although he distinguishes (I) and (II), and makes a clear division even between (I.1.) and (I.2.), he does not seem to be worried about (I.1.a) and (I.1.b) – a distinction clearly made, e.g., by Autrecourt[83] – or even usually neglects the possibility of separately *per se* existing void place altogether. Nevertheless, his arguments, in order to better understand their addressees, will be presented here along these lines. Because he treats the possibility of the extracosmic void not within the five questions where he treats all others, but within his treatise on infinity,[84] I will omit its discussion here.[85] As for the intracosmic void, I will first discuss its possibility with regard to natural powers, then present its supernatural possibility, followed by a recapitulation of Buridan's rather long treatment of motion. Finally, I will draw some conclusions on his methodology.

[82] Aristotle, *Physics*, 214 b12-216 b20.
[83] *The Universal Treatise*, tr. Leonard A. Kennedy, R. E. Arnold, and A. E. Milward, introd. L. A. Kennedy (Milwaukee: Marquette University Press, 1971), 90. For the Latin text, see Nicolaus de Autrecourt, "Exigit ordo", ed. Reginald J. O'Donnell, *Mediaeval Studies* 1 (1939): 179-280. I will refer to the page numbers of the English edition.
[84] QP III, q. 15.
[85] The relevant text is edited in J. M. M. H. Thijssen, *Johannes Buridanus over het Oneindige: Een Onderzoek naar zijn Theorie over het Oneindige in het Kader van zijn Wetenschaps- en Naturfilosofie*, 2 vols. (Nijmegen: Ingenium Publishers, 1988), vol. 2, 31-40.

2.2. The natural impossibility of an intracosmic void

The *questiones* of Buridan's *Physics* commentary follow the usual form: first the question is asked, and some primary objections are posited; then there are the arguments for the opposite (often from authority), Buridan's answer, followed by his reply to the objections brought up at the beginning.

The first question on the existence of void deals with its possibility naturally speaking, i.e., whether it exists naturally, or can come about by any natural power. The final answer is the usual medieval one, the negative. Buridan also follows the general twofold way of argumentation: on the one hand, the impossibility of void is supported both by reason and by various empirical observations; on the other hand, the arguments that would show that there are vacua in nature are refuted.

(a) The arguments against the existence of vacuum

After defining vacuum as an "unfilled place", therefore standing for place while connoting that there is nothing contained in it,[86] Buridan distinguishes two ways in which such a vacuum could be imagined, according to the two ways in which space or place can be conceived.[87] First, one might understand space as an entity, distinctly existing beside the magnitude of the bodies, which receives the bodies if they are placed in it. In that case, this space is either filled – when there is a body placed in it – or not filled; the latter can be called a vacuum which has the same magnitude as the body has, which would fill the vacuous place.[88] This absolute concept of space, however, is refuted by Aristotle, as well as by

[86] QP fol. 73 ra
[87] Buridan usually speaks about *spatium*, understanding it either as 'place' or as 'space', depending on the context.
[88] QP fol. 73 rb.

Buridan, who treats it in an earlier *questio*;[89] he argues at length that space is either nothing or something; if it exists separately from the magnitudes of objects, it must be something; but if it is something, then if a body is placed in it, that would result in a penetration of dimensions, which is impossible.[90] Now, since the first conception of void presupposed this first concept of space, the refutation of the latter implies the impossibility of the former.

In the second way, one can define space or place as the limit, or inner surface, of the surrounding body;[91] in this case, a vacuum can be imagined as a result of the annihilation of a body, the surrounding body remaining the same.[92] This is the concept of space that Buridan accepted in the previous *questiones*, therefore, the answer to this suggestion is the core of his answer to the possibility of the vacuum.

To better understand the concept of void that the aforementioned concept of space implies, Buridan introduces a thought experiment: Imagine, for example, that this inferior world were annihilated, with the heavens remaining the same; then the inner surface of the lunar sphere, which now contains this world, would be vacuous.[93] Buridan further analyzes this thought experiment to show that this case is impossible by any natural power.[94] (Although Buridan does not illustrate his argument, it might be better understandable with *Figure 1* below.)

This impossibility follows from the principle that two bodies cannot be situated by any natural power in such a way that they are outside each other, but neither touch nor are distant from each other – where 'distance' should be understood as measured by a straight line. This is, however, precisely what would follow if a void existed between the inner surfaces of the

[89] QP IV, q. 4.
[90] QP fol. 73 rb, see also fol. 67 vb; Aristotle's similar argument is in *Physics* 209 a5-7. For the history of the principle, see Edward Grant, "The Principle of the Inpenetrability of Bodies in the History of Concepts of Separate Space from the Middle Ages to the Seventeenth Century," *Isis* 69 (1978): 551-571.
[91] Aristotle, *Physics*, 212 a5; QP fol. 68 rb: *Tertia conclusio est quod locus est superficies corporis continentis locatum…*
[92] QP fol. 73 rb.
[93] Ibid.
[94] QP fol. 73 rb-va.

lunar sphere. For example, take *A* and *B* as the opposite poles of the lunar sphere; now these points, obviously, do not touch each other; consequently, they should be distant from each other. But they cannot be distant, according to the straight line drawn between them, because as the meaning of space, that of distance involves that there *is* something which can measure this distance. Since there is, by supposition, nothing along the segment *AB,* there is no distance either.

Buridan goes on to show that neither are the two points distant according to the concave inner surface of the lunar sphere. That, again, he argues, would result in the absurd consequence that the distance between two points could change while the points themselves remain exactly the same. In the first instant of the thought experiment, when the inferior world was not yet annihilated, the distance between *A* and *B* was the length of the segment *AB*; in the second instant, when there is nothing between the inner surfaces of the lunar sphere, this distance, according to the present hypothesis, would be the length of the semicircle *AB.* And since the semicircle *AB* is longer than the segment *AB*, that means that the distance between *A* and *B* changed, while the points *A, B* remained the same.

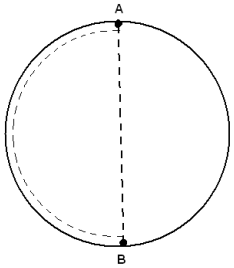

Figure 1.: The distance of A and B

This absurdity, therefore, shows that the thought experiment – the annihilation of the inferior world while the lunar sphere remains the same – entails an impossibility; therefore, a vacuum cannot exist, at least naturally, this way. This impossibility of existence was shown by purely logical reasoning; in the core of his answer, Buridan did not even refer to any empirical fact.

In addition to these demonstrations, however, there are two experimental arguments as well, which are meant to show that nature abhors a vacuum.

(1) The first is about a bellows, which shows that "we cannot separate one body from another, unless some other body intervenes."[95] By expelling the air from a bellows, which results in its sides collapsing and coming into contact, and by completely closing all its openings so that no air could enter, Buridan argues that one could never separate their surfaces. "Not even twenty horses could do it if ten were to pull on one side and ten on the other,"[96] he claims, nature so greatly resisting the possibility of producing a vacuum.

This bellows experiment, which, for Buridan was an experiment against the possibility of nature producing a void, later had quite a bright career.[97] In this form, it cannot be found either in Grosseteste or in Roger Bacon (the latter, though, uses far more *experimenta* than Buridan does), but in a much less elaborated form it is apparent in the *Physics* commentary of John of Jandun,[98] who describes it briefly as if it would have been familiar and evident for any of his readers.

Later, it was used by the Jesuits in the *Physics* commentary written at the University of Coimbra, and in the *Physics* commentary of Franciscus Toletus.[99] When, however, it encountered the anti-Aristotelian supporters of the vacuum in the sixteenth century, the experiment took a new turn. Bernardino Telesio, for example, transforms the whole experiment by stating that the sides of the bellows could be well separated if the force were large enough and the bellows strongly built; he insists that the scholastics failed precisely because they did not pay much attention to the appropriate means and circumstances of the experiment. He uses, therefore, basically the same experiment (but with a different outcome)

[95] QP fol. 73 va.
[96] Ibid.
[97] For the sixteenth-century developments, see Charles B. Schmitt, "Experimental Evidence for and against a Void: The Sixteenth-Century Arguments," *Isis* 58 (1967): 352-366.
[98] JQP IV, q. 11, fol. 60 vb: *Nunquam aliqua virtus elevaret latera follies, nec ab invicem separaret, sed quod prohiberetur natura universalis propter fugam vacui*.
[99] For quotation and full references, see Charles B. Scmitt, "Experimental Evidence for and against a Void…", 355.

as Buridan to show exactly the opposite thesis; as he explains, when the sides of the bellows are separated, void is produced between them.[100]

Whether Bernardino Telesio really constructed such a strong bellows to produce void, is not known. The first well-known case when such an experiment was actually performed was the famous experiment of Otto von Guericke, the inventor of the air pump in the second half of the 1650s.[101] He joined two copper hemispheres (the so-called "Magdeburg hemispheres"), and pumped the air out of the sphere; then, tying eight horses to each hemisphere, he showed that they could not separate them. As can be seen, the outcome of the experiment – although with slightly different means than in Buridan – is the same; Guericke, however, like Bernardino Telesio, draws the opposite conclusion and interprets his experiment to disprove the hypothesis of *horror vacui.*[102]

For Buidan's version, as far as we know, there were no attempts to carry it out with a real bellows and horses; nevertheless, Buridan draws his conclusion from its presumed outcome, which later became questionable. This *experimentum*, therefore, is rather a thought experiment; whether it was not performed because of technical difficulties (it would not have been easy to pump the air out of a bellows, and really attach it to twenty horses, especially because the air-pump had not yet been invented), or simply because it was thought to be unnecessary, probably cannot be clearly determined. The context and the mode of expression, however, at least indicate that for Buridan it is not a kind of *experimentum crucis* (which concept, to be sure, did not even exist in his time), but only an illustration or example. While he has no doubt about the outcome of the experiment, he does not bother at all about its

[100] *Bernardini Telesii De rerum natura,* ed. V. Spampanato (Modena: Formiggini, 1910-1923), Vol. I., p. 88: *Follem itidem si comprimas et occludas, ut nullus illabenti aeri aditus pateat, tum elevas expandasque, si pellis laxa gracilisque sit, dirumpi eam videas; maxime vero, si pellis crassa, densa et frangi ineppta sit. Igitur … in folle spatium vacuum fieri fatendum est.*

[101] On Guericke, see Ditmar Schneider, *Otto von Guericke: Ein Leben für die alte Stadt Magdeburg* (Wiesbaden: Vieweg – Teubner Verlag, 2002).

[102] His description of the experiment is found in *Experimenta nova (ut vocantur) Magdeburgica de vacuo spatio*, libri tertii (available at http://dlxs2.library.cornell.edu/cgi/t/text/text-idx?c=kmoddl;cc=kmoddl;view=toc;subview=short;idno=kmod052, last accessed March 3, 2010).

possible – either technical, or theoretical – difficulties, nor with the question of why would one need exactly twenty horses to show nature's resistance to a vacuum. He might have said in the same way either less or more, and that would not have changed either the alleged outcome of his *experimentum* or the conclusion drawn from it.

(2) The second experiment is with a hollow reed with one end placed in wine. If one, having its other end in his mouth, draws up the air that was in the reed, the wine would follow the air up, although it is heavy. That shows that nature prevents the formation of a vacuum so strongly that it forces the wine to follow the air immediately whenever the air is drawn out.[103]

This observation, in contrast to the previous one, must have been rather common, and indeed, many similar descriptions can be found from antiquity. As Edward Grant showed, it is apparent perhaps first in Philo, or in some form even in Aristotle;[104] after Averroes' commentary had been translated, it became a usual part of medieval discussion. Accordingly, although not in exactly the same form, a similar description can also be found in John of Jandun's commentary[105] and in that of Roger Bacon.[106]

Buridan, again, does not pay too much attention to the circumstances of the experiment, and in this case neither to its explanation, which he might have regarded as obvious. The wine moves contrary to its natural inclination (which would be towards its natural place, that is, downwards) because nature fights so heavily against a vacuum that it even violates one of its other principles.

[103] QP fol. 73 va.
[104] Grant, *Much Ado about Nothing…,* 80-81.
[105] JQP fol. 60vbE: … *minus enim malum est, quod aqua detineatur ibi sursum quam fiat ibi vacuum.*
[106] BQP 230: … *et quod aqua non descendat, accidens est innaturale, et ideo melius est quod quiescat quam quod corrumpatur natura et disposition vasis et ponatur vacuum.*

(b) Refutation of the arguments for the opposite

Before giving the answer presented above, Buridan raises some arguments and experiments which would point in the opposite direction. The first four of them are similar in character, and, resting on the same assumption, the answer to them will also be the same. The first is from local movement: if straight local movement exists, void also has to exist because a body, moving along a straight line obviously moves to *some* place. Now if in that place there is nothing, then some void exists; if there is a body, then – since two bodies cannot be at the same place – this body also has to move. However, in this latter case, repeating the question for this second body and so on, the absurd consequence would follow that whenever something moves rectilinearly, even the whole heavens would have to move with it.[107]

As can be observed, the only component of the argument that is grounded in experience is one of its premises, namely, that there *is* something, which moves rectilinearly. Otherwise, the conclusion follows from a simple imagination (perhaps that is why it is so appealing); if the bodies are conceived as solid wholes, which either move or do not move, then the one moving in a straight line would push all the others before it unless there is some vacuous place where there is no body.

This argument – as Buridan also notes – can be found in a similar form already in Aristotle;[108] it is also apparent in Grosseteste's commentary,[109] as well as in John of Janduns'[110] – whose arguments are almost verbatim the same as Buridan's – and even in

[107] QP fol. 72 vb
[108] *Physics* 213 b5 ff.
[109] GQP, 85: *Vere contingeret unum horum, scilicet aut nichil moveri aut quidquid movetur circulariter movetur, aut si quid movetur secundum rectum movetur, eciam celum sic moveri et turbari.*
[110] JQP, fol. 59 rbB: *Si non esset vacuum, non contingeret aliquid moveri localiter … Probatur consequentia: quia, si aliquid movetur localiter, aut movetur ad plenum, et recipitur in pleno, aut ad vacuum et recipitur in vacuo. Non primo modo, quia sic duo corpora simul essent in eodem loco, quod est impossibile…*

Nicholas of Autrecourt's *Exigit*.[111] One can quite safely say, therefore, that the argument from local movement was usual.

So were the next two in this category, those from rarefaction and from condensation. The argument is, again, rather simple: if rarefaction or condensation exists, then void also has to exist; but one can observe the former, therefore, etc. Rarefaction or condensation is usually imagined as a kind of local movement where the particles of the matter are either coming closer to or further away from each other. That, however, is not possible either without the void receiving the particles (as in the argument from local movement), or without a void being produced between them.[112]

Finally, the argument from augmentation rests on the premise that during nutrition, some extrinsic thing enters the body of a living organ; now, if there had been no void before it entered, penetration of bodies would result, which is, again, impossible. Autrecourt also recapitulates this argument in quite a detailed way, and it is apparent, again, almost verbatim in John of Jandun's commentary.[113]

Buridan's overall, rather convoluted reply to these four arguments (that is, the one from motion, from condensation, from rarefaction, and from augmentation) is the following: (1) Granting that there is no void, as was shown above, if the arguments were valid it would

[111] *Exigit* 87: "It seems that there is a vacuum because otherwise it would follow that there could be no local motion in a straight line, either because two bodies would coincide, or because all things would have to move and change place in a single motion."

[112] QP fols. 72 vb–73 ra; GQP 85: *Sunt autem qui per rarum et densum et cetera. Hii intelligent per rarum corpus quod habet in se multas concavitates vacuas a contanto…* See also BQP 237-238: *Queritur utrum propter ista [s.c. rarefactionem et condempsationem] necesse sit ponere vacuum. Et videtur quod sic. Accipiamus aerem qui habeat quinque partes, et condempsatur in quatuor: hoc non potest esse nisi quod una pars recedat a loco aut quod una subintret dimensiones alterius aut quod recipiatur in aliquam vacuitatem; set primum est impossibile …, similiter et secundum, ergo tertium erit.* John of Jandun uses the same argument in JQP fol. 59 rb B: *Item, si non esset vacuum, non posset fieri rarefactio, nec condensatio corporum, quod est inconveniens et contra sensum. Et probatur consequentia: quia rarefactio sit per hoc, quod aliquae partes preexistentes in corpore segregantur et moventur, et partes remanentes fiunt magis distantes ab invicem mediante vacuo: si enim in spatio aliquot segregantur illae partes, remanebit aliquod corpus naturale et sensibile, tunc illud corpus esset aeque grossum et densum, sicut prius erat.*

[113] *Exigit*, 93; JQP, fol. 59 rbC: *Item, si vacuum non esset, non posset fieri augmentation: quod est inconveniens manifestum, et contra naturam animalium. Et probatur consequentia quia augmentation non potest fieri nisi adveniente aliquot corporeo, ut dicitur in Primo de Generatione. Illud autem corporeum aut recipitur in pleno, et sic dua corpora simul erunt, aut recipitur in vacuo, et sic habetur propositum.*

follow that there is no rectilinear local movement or augmentation, which – as experiments show – is not the case. (2) Rectilinear local movement and augmentation, without void, are only possible if there is condensation and rarefaction. (3) Condensation and rarefaction are possible even without any void. (4) Therefore, rectilinear local movement and augmentation are possible even if there is no void. (5) Therefore, the inferences ("if there is local movement/augmentation there is void," and "if there is condensation/rarefaction there is void") are invalid.

The turning point of this reply, as can be seen, is the nature of condensation and rarefaction and their possibility without void. After treating the questions of the supernatural possibility of the void, and motion in the void, Buridan assigns a whole *questio* to show that condensation and rarefaction indeed exist and to explain it without supposing the possibility of any vacuous place.[114]

First, as he notes, it is evident from experience that things can be condensed and rarefied – where condensation and rarefaction mean the change of the thing's extension without entering or divulging any other body from it. Such an experience is, e.g., the fermenting wine in a well-made jar, with its volume increasing so much that it can break the jar; or, air could be rarefied in such way that if a jar is only half-filled with wine this wine can come out through a hole in the bottom, although nothing enters the jar to refill it. Condensation can also be observed if a bottle is heated above the fire and its orifice put in water afterwards; in this case, when the air in the bottle cools down, it will condense, so that the water ascends in the bottle. Moreover, if a slat is violently bent, as in the case of a bow, its concave surface is much shorter than the convex one, which can only come about by the violent condensation of the interior, and the rarefaction of the exterior parts.[115]

[114] QP IV, q. 11.
[115] QP fol. 77 vb.

These examples, although not found in Grosseteste, Bacon, John of Jandun or Autrecourt in this form, are probably common observations that would have been familiar to the medieval reader. Given that the possibility of void is already excluded, they do indeed support Buridan's claim that rarefaction and condensation are possible.

Secondly, Buridan turns to explaining this possibility. His solution is the Aristotelian and common medieval one, which claims that condensation and rarefaction are not local movements but qualitative changes which produce a new dimension.[116]

Returning to the four arguments brought up for the necessity of positing a void, it is clear now that they contained an obvious mistake: the *petitio principii.* Motion, condensation, rarefaction, and augmentation were described in an atomist framework, where the particles of matter are imagined as being solid, unchangeable except for local movement, either approaching or receding from each other in the otherwise vacuous space. But if one rejects this hidden premise, then the arguments are not sound; local movement can be possible without a void if the matter before the moving thing is condensed, while the matter behind is rarefied; and the same is true of augmentation. Condensation and rarefaction, moreover, are to be explained not with reference to the local movement of particles, but with the help of qualitative change.[117]

The last, fifth, argument for the possibility of the void is called an *experimentum.* If there is a pot filled with ashes one can pour just as much water in it as if it were empty. The advocate of the possibility of vacuum interprets the experiment by saying that this is only possible, if a void exists between the parts of the ashes.[118] (The other variant, the existence of two bodies in the same place, is dismissed as evidently self-contradictory.)

[116] Cf. Aristotle *Physics,* 217 a20-b15; QP fol. 78 ra.
[117] QP fol. 73 vb.
[118] QP fol. 73 va.

This experiment already appears in Aristotle, who, in turn, traces it back to earlier authors not mentioned by name.[119] Averroes's treatment of it is worth quoting in its entirety, for that is the one Buridan refers to in his solution.

> And there is another argument, which is brought up as a proof by those who say that vacuum exists. Namely, they say that the same jar receives just as much water when it is full of ashes, as much water it receives when it is empty. And this I have not experienced, but if it is indeed so as they say, it has no other reason than the water being destroyed by the ashes, either entirely, if we assumed that between the parts of ashes, there is no air distributed in such a way that no parts of it remain in it, except some quality; or it is destroyed partly, and parts of the air, which is mixed with the ashes, emerge, while some parts of the ashes are dissolved. And this latter is more probable. And its sign is that when the ashes are squeezed, some parts of the water come out of them, but not all, and when the ashes dry out, [their quantity] becomes less than it was before.[120]

The passage, in itself, is quite obscure. Buridan summarizes its content saying that if the ashes are hot and dry, then they can make a great part of the water evaporate, while the rest can enter into the fine parts of the ashes which were previously occupied by the air.[121] What is, however, more important from the methodological point of view is that the Commentator, as he rightly admits, never performed the experiment – it might at least partly explain its obscurity – but for its outcome, believes those who have allegedly done so. (Interestingly, Autrecourt, when describing the experiment with reference to Averroes, accuses the Commentator of "neglecting such an easy experiment."[122] Whether he himself made it, of course, cannot be determined, but is at least dubious.)

[119] *Physics*, 213 b20

[120] AQP fol. 149M-150A: *Et hec est alia ratio particularis: et induxit ipsam pro testimonio dicentium vacuum esse. Dicunt nam quod idem vas tantum capit de aqua, quando est plenum cinere, quantum capit de aqua, quando est vacuum. Et ex hoc non sum expertus, et si est, sicut dicunt, non habet aliam causam, nisi quia aqua corrumpitur a cinere, aut secundum totum, si dixerimus quod inter partes cineris non est aer divisus ita, quod ex eo non remaneat in eo, nisi qualitas tantum, aut corrumpantur ex ea* [reading 'eo' for 'ea'] *partes aliquae, et aeri, qui est mixtus cum cinere, succedunt ex eo partes aliques, et dissolvuntur a cinere aliae partes, et hoc est verius. Et signum eius est, quoniam, quando cinis exprimitur, exit quedam pars aque ab eo, et non tota, et quando cinis desiccatur, revertitur minor quam erat.*

[121] QP fol. 73 vb.

[122] *Exigit*, 94.

Probably neither did Buridan perform it. But this "neglect" of Averroes, as well as of Buridan, whose solution is the same, is partly explainable by the fact that their main point is not about the experiment *as* an experiment (Averroes could have, for example, objected to the circumstances or means of its performance or could have questioned its outcome, which neither he nor his medieval followers did), but about its theoretical interpretation. Averroes gave another explanation for the same observable phenomenon, showing therefore that this observation alone does not necessarily involve the existence of a vacuum.[123] Accordingly, neither does Buridan discuss the experiment itself, and he even omits the closing words of Averroes's passage, where the Commentator at least gives a reason for choosing the one interpretation over the other.

The lack of empirical treatment, moreover, may be due to the logical role of the experimental argument; it is not meant to *decide* on the question, but only to give a counterexample to the otherwise settled answer. This being so, it suffices to refute it by an interpretation that relies on the already established theory.

For a brief summary of Buridan's arguments, it is worth noting that the primary objections (the ones from local movement, from condensation, rarefaction, augmentation, and from the pot with ashes) were pointing, without exception, toward an atomistic theory, therefore toward vacuum as understood in the atomistic sense. That is, however, the only sense among those distinguished above which Buridan, at least explicitly, does not deal with in his main answer. Although his first argument can be seen as refuting it too (since the atomistic void also presupposes some kind of absolute space), it rather concentrates on the elimination of the separately existing void.

[123] I am not advocating here the Duhem-Quine thesis, although these treatments of empirical data could serve as a good example for the insufficiency of observation. For more on this issue, see e.g., Pierre Duhem, *La theorie physique: son object, sa structure* (Paris: Vrin, 2007), 205-231.

Accordingly, all the experiments, including now the thought-experiments, which were adduced to support the existence of the vacuum, support it as understood in the atomistic sense – such as the pot with the ashes, the observations of motion, condensation, rarefaction, and augmentation. On the other hand, all the experiments which are to demonstrate the opposite thesis, i.e., that there is no vacuum, are dealing with the void as understood in the first sense, not as a distinct dimension, but as a vacuous place after the elimination of a contained body; that was the main target of the thought experiment, of the bellows, and the reed.

This remark leads to a rather general feature of Buridan's use of experiments, which can well serve as a closure to this chapter. First, his *experimenta* were either simple everyday observations (as the one of the jar filled with wine, or the possibility of local movement, etc.), or thought experiments, which were not, or could not even be performed (like the one with the bellows, or the imagination of a vacuum within the lunar sphere). Second, regarding their role, it can be seen that although they often served as supporting certain basic premises in the arguments (such as "rectilinear movement exists", etc.), beside this, relying on empirical data never plays a crucial role in Buridan's argumentation. The core of his whole argument against the possibility of the void was a thought experiment, which was never meant to be empirical; the real, or at least allegedly real, empirical observations served rather as illustrations either of his or of the opposite thesis. This insufficiency of empirical data, however, was not particularly medieval; as Silvia Manzo showed, it was a characteristic feature of the treatment of the void even by one of the alleged establishers of modern scientific method, Francis Bacon.[124]

[124] Silvia Manzo, "The Arguments on Void in the Seventeenth Century: The Case of Francis Bacon," *The British Journal of the History of Science* 36 (2003): 43-61.

2.3. The Possibility of Void by Divine Power

After refuting the natural possibility of void, Buridan continues to inquire into its supernatural possibility. The problem of void in connection to the divine power clearly appeared already in the Parisian condemnation of 1277; although it does not treat directly the existence of vacuum, it does imply, at least indirectly, that the void should be regarded as possible by divine power.[125] For if God is capable of anything that does not imply a logical contradiction, it follows that

> Every absolute thing that is distinct in place and subject from another absolute thing can by God's power exist when that other absolute thing is destroyed.[126]

This concept of the absolute power of God, quoted now from William Ockham, by Buridan's time had become part of the *suppositio communis*, implying that – as described in the previous *questio* – God is capable of destroying the earth while conserving the lunar orb in the size and shape it has now, thus creating a vacuum.

It is this part of Buridan's whole treatment of void (or perhaps his entire *Physics* commentary) that perhaps received the most attention afterwards, where he argues that it is impossible to treat questions of natural philosophy without entering into theological issues:

> And so, some of my lords and masters of theology have upbraided me for sometimes mixing some theological questions into that of physics; because the former do not belong to the artists. But I humbly reply that I would rather like not to be restricted in this way. But all the masters, when they begin their studies, swear that they will not discuss any purely theological question, as the end of the world or the Incarnation, furthermore they swear that if they come to discuss or determine a question that concerns the faith and physics, they will determine it according to the faith, and resolve their objections as they ought to be resolved. But see, if any question concerns faith and theology, this is one of them, namely, whether vacuum can exist. So if I want to discuss this, I must say what seems best to say about it according to theology, or according the oath, and I must avoid the objections for the opposite as much as it seems possible.[127]

The purpose of the assertion of this rather long passage, which does not directly pertain to the present question, is twofold: Beside assuring the reader that the answer will not be against the

[125] Cf. §. 49 [66]: *Quod Deus non possit movere coelum motu recto. Et ratio est, quia tunc relinqueret vacuum.* For the importance of the Parisian Condemnation in the development of the concept of vacuum, see Pierre Duhem, *Le systeme du Monde…,* vol. 8, 7, 35.
[126] William Ockham, *Quodlibetal questions* VI. 6, tr. A. J. Freddoso and F. E. Kelley.
[127] QP IV, 8, fol. 73 vb-74 ra.

principles of faith, it also implies that it is not possible to demonstrate this answer in the strict sense, but only as much as already relies on some concept of God's absolute power.

Buridan argues precisely this way, showing that the absolute possibility of vacuum does follow from this concept. As was shown in the previous question, there are two ways in which void can be imagined: first, as a simple volume without substance; and secondly, as an empty space, e.g., in a jar.

As Buridan shows, the possibility of vacuum as imagined in the first way follows from the fact that God is able to produce an accident without substance or maintain an accident without its subject. Since a simple volume without substance is an accident without subject, God can produce this simple volume, which would be a vacuum.[128] Moreover, although one can recall that a serious objection against such a possibility was that it would result in a penetration of dimensions (since such an empty volume is able receive a substance), this penetration is not impossible absolutely speaking; as Buridan asserts, God can create many subjects that are in the same place, or accidents in the same subject.[129] (Although he does not refer to it here, this is precisely the case in the Eucharist, where the piece of bread and the body of Christ occupy exactly the same place.[130])

Secondly, given two separately existing subjects God can maintain the one without the other; consequently, He can maintain the sphere of the heavens while annihilating the earth below it. In this case, a vacuum would result inside the sphere.[131]

After giving this answer to the main question, resting on the hypothesis of a certain concept of God's absolute power, Buridan answers the objections that were brought up in the beginning of the *quesio.* First, one might say that the possibility of void contradicts the Aristotelian definition of place (according to which place is the inner surface of the containing

[128] QP fol. 74 ra.
[129] Ibid.
[130] The example is cited by Buridan in QP III, q. 15.
[131] QP fol. 74 ra.

body), namely, that in this case, the "containing" body would not contain anything. But, as Buridan notes, this definition is strictly speaking not of "place" (*locus*) in general, but of a "proper place of a body" (*totalis locus proprius corporis*), and therefore applies only to the natural cases when there is no unoccupied place.[132]

The second objection stated – against the void in the second way – that if the earth were annihilated below the sphere of the heavens, then the inner surfaces of this sphere would be both touching each other (since there would be nothing between them), and not touching, given that they hold the same spherical shape as before. Buridan does not deal with this objection here, but he does so in the fifteenth question of the third book in a different context. The key to his solution is that in this hypothetical case there would be no space at all between the inner surfaces of the heavens.[133] It can be argued that they are distant from each other in such a case, not rectilinearly but according to the hollow surface.[134] On the other hand, as Buridan makes clear, the requirement of touching each other is not only that there be nothing between them, but that they be in the same, or at least in a commensurate, space, which criterion is not fulfilled in this case. As it is not meaningful to say that the body of Christ and the bread touch each other in the host of the Eucharist, similarly we cannot speak about the distance or touching of the vacuous surfaces of the heavens.[135]

Finally, the last objection claims that from the sentence "there is vacuum" (s.c. between the surfaces of the heavens) follows that "there is something," which is in contradiction with the presumption that "there is nothing" between them. As Buridan explains

[132] Fol. 73 vb; 74ra-rb.
[133] QP III, 15: *Dico igitur quod isto casu posito nihil esset infra sive intra concavum orbis lunae, quia totum ponitur annihilatum, et sic non esset aliquod spacium.*
[134] III, 15: *Dico igitur quod in predicto casu annihilationis eorum que sunt infra orbem lune, unus polus non tangeret alterum polum nec distaret ab altero polo secundum rectitudinem, quia non esset spacium rectum medium per quod distaret. Sed posset concedi distare secundum distantiam circularem vel curvam.*
[135] III, 15: *Nec tamen oportet eos esse contiguos, quamvis nihil esset inter eos, sicut nec poli orbis lune tangerent se, quamvis nihi esset inter eos secundum rectitudinem. Et ita concluditur quod plus requiritur ad hoc quod duo corpora tangant se quam quod inter ea nihil sit; et hoc forte quod plus requiritur, est quod se habeant ad invicem commensurabiliter et secundum determinatos situs partium unius et partium alterius. Unde nec proprie magnitudo corporis Christi tangit magnitudinem hostie, et illi lapides non sic haberent se ad invicem.*

in the third book, the first sentence is misleading; the sentence "there is vacuum" is not a type of "P exists" sentence, but it merely says that the surrounding sphere is vacuous. It does not say anything about the vacuum itself but only about the heavens which would be around it.[136]

The methodology of the whole *questio,* due to its hypothetical nature – the natural reality of which was previously excluded – is rather abstract; although it does apply some thought experiments or imagination, the main argument is based on abstract reasoning. In the third book, Buridan even explains this inequity, while speaking about the "spaceless" surfaces of the heavens:

> I say that in this case it is difficult to satisfy the imagination, because for the imagination it always appears that there is space, as for the senses it always appears that the Sun is not greater than a horse, and that it is much smaller than the Earth. But in these cases the intellect has to correct those appearances of the sense and imagination.[137]

Therefore, apart from the fact that experiences obviously cannot be applied in a case that is naturally impossible, one has to be cautious even about his own imagination, which can lead astray just as the senses do. As one can see here again, the final criterion has to be set up by the intellect, and this is what could serve with arguments even in the cases which surpass the realm of the senses or the imagination.

3. MOTION IN THE VOID

3.1. Aristotle

As it has already been mentioned, one of Aristotle's arguments against the possibility of void is a kind of *reductio ad absurdum,* which claims that if void existed, motion would be impossible in it. In fact, Aristotle uses several arguments, rather cryptic and hard to set apart,

[136] Ibid.
[137] QP III, 15: *Dico quod in hoc est difficile satisfacere imaginationi, quia semper apparet imaginationi quod ibi esset spacium, sicut semper sensui apparet quod sol non sit maior equo et quod sit valde minor terra. Tamen in talibus intellectus debet corrigere illas apparentias sensus et imaginationis.*

to show the impossibility of motion in the vacuum, but which can be summarized as follows.[138]

(1) Every movement presupposes some differentiation which is the cause of the movement itself. (For example, a heavy body moves downwards if there is some lighter body below it, or vice versa.) But since there is no such differentiation in the void – being a "homogenous nothing" –, there can be no movement.[139]

(2) Every movement presupposes that there is some natural movement, that is, the natural upward or downward motions of natural bodies. In the void, however, there is no "upward" or "downward"; therefore, there can be no natural motion either and, consequently, no motion at all.[140]

(3) As it is shown in the eighth book, projectile motion is only possible because of the medium: If something is projected, after leaving the mover it continues to move because the air – or any matter that surrounds it – pushes it forward. (According to the basic Aristotelian principle, there is no causation at a distance.) As there is no surrounding matter in the void, a body could not move with violent motion were the mover detached from it.[141]

(4) If a body were set in motion in the vacuum, it would never stop moving, since there is no hindering or resisting medium. Therefore, it either cannot move, or it would move on to infinity, the latter case being absurd.[142]

(5) In the void, every movement would be instantaneous, that is, a moving body would occupy each point of its course simultaneously, which would imply a contradiction. For in every motion the sole cause of succession in any change is the resistance of the medium,

[138] The literature on this part of Aristotle's *Physics* is abundant; the arguments themselves have been deemed "hardly intelligible" by Edward Hussey in Aristotle, *Physics: Books III and IV*, tr. and introduction by Edward Hussey (Oxford: Clarendon Press, 1983), 131, or "vexatious" by Helen S. Lang in "Aristotle's *Physics* IV, 8: A Vexed Argument in the History of Ideas," *Journal of the History of Ideas* 56 (1995): 353-376: 354.
[139] 214 b31-34.
[140] 215 a1-13
[141] 215 a14-18
[142] 215 a18-21. This is the argument which received the most attention from modern scholars, regarded as being close – at least in some respect – to the later principle of inertia. See Edward Grant, "Motion in the Void and the Principle of Inertia in the Middle Ages," *Isis* 55 (1964): 265-292.

given that the speed of any motion equals to the ratio or proportion of the moving force to the resistance. If in the void, by definition, there is no matter, then there is no resistance either; consequently, there cannot be any ratio or successive motion.[143]

How sound these arguments are within the Aristotelian framework, or how many of them there really are, what their relations are to each other, whether they support or weaken the validity of each other, are difficult questions that do not pertain to the present study. As will be seen, medieval thinkers did not pay equal attention to each of them (and their attention does not necessarily resemble the arguments' interest from the modern point of view), but they almost all shared the conviction that they were – indeed, they *had to be* – somehow wrong. As Buridan summarizes, for someone who argued that by divine power even the existence of vacuum is possible, the reason for rejection was simple:

> Aristotle granted these consequences [s.c., "if vacuum existed, a heavy body could move in it," and "if vacuum existed, no heavy body could move in it"] because he believed that the existence of vacuum is absolutely impossible [*simpliciter impossibile*], and from impossible anything follows. … But we cannot say this, because we grant that the existence of vacuum is possible, namely by the divine power, therefore we must not say that from this contradictories follow.[144]

The most-often-treated of Aristotle's arguments was the one which implied the instantaneous motion of any body in the void; Buridan writes a whole *questio* – the longest and most convoluted question of his entire treatment of the void – on whether resistance is a necessary condition of any successive motion. In order to answer Aristotle's argument a careful reconsideration of the nature of motion was necessary, which happened quite early, already in the commentary of Johannes Philoponus.[145] But the two most important theories that Buridan mentions by name while handling this problem are those of Avempace and Averroes.

[143] 215 a25-216 a8.
[144] QP IV, q. 10, fol. 77 ra.
[145] Most notably in his commentary on Aristotle's *Physics.*

3.2. Avempace and Averroes

Avempace's *Physics* commentary – which was perhaps the first commentary on the *Physics* in the West – had been written in Arabic, and it was never translated into Latin or into Hebrew. It was considered to have been lost until the 1960s, and although even an English translation has been published recently,[146] its understanding is still primarily based on those pieces that are quoted by Averroes in his own commentary.[147] Since this is not the proper place to fully treat and evaluate Avempace's dynamics, and since the medieval authors had only access to it by the commentary of Averroes, it will also suffice now to look at the latter.[148]

> This resistance which is between the plenum and the body which is moved in it, is that between which, and the power of the void, Aristotle made the proportion in his fourth book; and what is believed to be his opinion, is not so. For the proportion of water to air in density is not as the proportion of the motion of the stone in water to its motion in air; but the proportion of the cohesive power of water to that of air is as the proportion of the slowness occurring to the moved body by reason of the medium in which it is moved, namely water, to the slowness occurring to it when it is moved in air.
> For, if what some people have believed were true, then natural motion would be violent; therefore, if there were no resistance, how could there be any motion? For it would necessarily be instantaneous. What then shall be said concerning the circular motion? There is no resistance there, because there is no cleavage of a medium involved; the place of the circle is always the same, so that it does not leave one place and enters another; it is therefore necessary that the circular motion should be instantaneous. Yet we observe in it the greatest slowness, as in the motion of the fixed stars, and also the greatest velocity, as in the diurnal motion. And this is caused only by the difference in nobility between the mover and the moved. When therefore the mover is nobler, that which is moved by it will be more rapid; and when the mover is less noble, it will be nearer to that which is moved, and the motion will be slower – and these are his [i.e., Avempace's] words.[149]

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[146] Paul Lettinck, *Aristotle's* Physics *and its Reception in the Arabic World. With an Edition of the Unpublished Parts of Ibn Bājja's* Commentary on the "Physics" (Leiden: Brill, 1994).

[147] For the history of the textual tradition and a reinterpretation, see Abel B. Franco, "Avempace, Projectile Motion, and Impetus Theory," *Journal of the History of Ideas* 64 (2003): 521-546.

[148] I have slightly modified the translation of Ernst A. Moody from his "The Dynamics of the Leaning Tower Experiment (I)," *Journal of the History of Ideas* 12 (1951): 163-193, 185-186.

[149] AQP fol. 160D-G: *Ista resistentia, que est inter plenum, et corpus, quod movetur in eo est illa, inter quam, et potentiam vacui fecit Aristo[teles] proportionem in Quarto [Physicorum]. Et non est sicut existimatur de eius opinione. Proportio nam aque ad aerem in spissitudine non est sicut proportio motus lapidis in aqua ad motum eius in are: sed proportio potentiae continuitatis aque ad potentiam continuitatis aeris, est sicut proportio tarditatis accidentis rei mote ex illo, in quo movetur, verbi gratia aqua, ad tarditatem accidentem ei, quando movetur in aere. Quoniam, si esset, sicut estimaverunt aliqui, tunc motus naturalis esset violentus: ergo, si illic non esset resistentia, quomodo esset motus? Necesse est nam ut esset in instanti. Quid ergo dicetur de motu circulari? Et illic non est resistentia: quoniam illic non est divisio omnino: nam locus circuli idem est semper. Non itaque evacuatur unus locus, et alius impletur, necesse est igitur ut motus circularis sit in instanti. Sed nos*

There are several points in this rather dim passage which are worth noting, especially from Buridan's perspective.

First, it is clear that Avempace refutes the Aristotelian view that the ratio of the speeds of the same body in different media equals to the ratio of the medias' density (i.e., $V_1/V_2 = D_1/D_2$). What he affirms instead of this, however, is less clear; if we take the "cohesive power of the medium" to mean its resistance, then his formula might look like $D_1/D_2 = S_1/S_2$, where S means the slowness that is caused by the given media. What is interesting in this – at first sight almost tautological – equation is its presupposition. Saying that the density of the medium is not proportionate to the body's speed itself but only to the slowness it causes, presupposes that the body had already – independently of the medium – some *original* speed with which it moved, and the actual speed we see when, e.g., a stone moves in water, is the result of a subtraction, namely that of the caused slowness from this original speed.[150]

Second, Avempace's argument for his thesis is rather surprising in an Aristotelian framework. Instead of referring to particular examples of densities and speeds – which would have been quite impossible to measure with the necessary precision, let alone the "original" speed of the bodies – he takes the example of celestial motion. Supposing that there is no resistance in the heavens, according to Aristotle's formula the ratio of the speed of the stars to any earthly finite movement would be infinite, which is, however, not the case. This example can be regarded either as wrongly chosen and irrelevant, or as an amusing novelty. The former would derive from the Aristotelian principle that the heavenly bodies are moved by some distinctly existing Intelligences, therefore the principles of celestial motions are not to be confused with that of earthly physics; the latter would mean precisely the denial of this former Aristotelian principle, which would then enable a unified theory of physics, including

videmus in eo maximam tarditatem, ut in motu stellarum fixarum, et maximam velocitatem, ut in motu diurno: et hoc non est, nisi propter distantiam motoris in nobilitate a moto. Cum igitur fuerit nobilior, tunc illud, quod movetur ab eo, erit velocius: et cum motor fuerit minoris nobilitatis, erit propinquior moto: et tunc motus erit tardior et hec sunt verba eius.

[150] It is also worth noting that Avempace, contrary to Moody's reading, did not make this presupposition explicit.

astronomy as well as the physics of the sub-lunar region. Whether Avempace was conscious of the oddity of his example, cannot be determined.

Thirdly it is worth noting that Avempace in this passage only deals with natural motion, this is what all his examples – including that of celestial bodies – suggest: A stone moves naturally downwards in the air and in the water because it is heavy. What his standpoint would have been regarding violent motion is difficult to discern from this text; and while it is quite tempting to interpret him as saying that in such a case the "original" motion of the body would be its inertial movement, he does not even hint in this direction.

Finally, apart from mentioning the context in which Aristotle's thesis is found, Avempace does not at all address the question of motion in the void. Although one can easily reconstruct his answer as saying that successive motion in the void is possible (supposedly, the "original" motion of a body, with no resistance, means its movement in a hypothetical void), one has to keep in mind that this is an answer to a question that Avempace himself did not even ask.

All in all, Avempace's short paragraph is far from clear, and he was, indeed, interpreted in many ways even in the Middle Ages. Although it was never entirely clear what his own theory of motion had been, nevertheless, he indubitably offered an alternative explanation to that of Aristotle and thus he certainly accelerated the medieval debates on the issue of motion, especially on motion in the void.

As was already mentioned, Avempace was related to the question of motion in the void only by Averroes, who immediately concluded that if the opinion of Avempace were true, the argument of Aristotle, according to which motion in the void would be instantaneous, would not be valid.[151] Averroes' main problem with Avempace's treatment,

[151] AQP fol. 160G: *Et si hoc, quod* [Avempace] *dixit, concedatur, tunc demonstratio Aristotelis erit falsa. Quoniam, si proportio subtilitatis medii ad subtilitatem alterius medii est sicut proportio tarditatis accidentis moto in altero eorum ad tarditatem accidentem ei in alio, non sicut proportio ipsius motus, non sequitur ut illud, quod movetur in vacuo, moveatur in instanti.*

however, is rather metaphysical than physical; the Commentator accuses the latter of misunderstanding the concept of natural motion. While according to Avempace a body moves naturally when it encounters no resistance so that the movement we see is always a result of this natural motion and the resistance subtracted, Averroes claims that natural motion is just what we see.[152] (As Moody rightly points out, this question – that is, whether the natural is the actual or some ideal and nonexistent form of it – runs through the whole history of philosophy and science.[153])

Instead of this, therefore, Averroes sticks to Aristotle's solution; the ratio of the resistances of the media equals the ratio of the velocities. However, apart from emphasizing that this proposition is *per se manifesta*,[154] the Commentator does not give any decisive arguments to support his view – let alone any empirical evidence. Despite Averroes' lack of particular examples, interestingly, it was precisely Avempace who was labeled later as a Platonist, and even Moody regards the opposition between Avempace and the Commentator as that between rationalism and empiricism, calling the former as an exemplar of "the medieval realist, the rationalist, and the Platonist."[155]

The answers to the question between Averroes and Buridan are varied, but basically follow either Avempace or the Commentator. The former was defended by Aquinas, Roger Bacon, Petrus Olivi, Duns Scotus, and partly even by Ockham, while the latter was propagated by Albert the Great, Aegidius Romanus, and quite generally in the late thirteenth–fourteenth century.[156]

[152] AQP fol. 161B ff.
[153] Moody, "The Dynamics of the Leaning Tower Experiment (I)," *Journal of the History of Ideas* 12 (1951): 163-193, 190.
[154] AQP fol. 160I, 160M *passim.*
[155] Moody, "The Dynamics of the Leaning Tower Experiment (I)," *Journal of the History of Ideas* 12 (1951): 163-193, 190.
[156] For an overview on the history of the debate, see Ernst Moody, "The Dynamics of the Leaning Tower Experiment (II)," *Journal of the History of Ideas* 12 (1951): 375-422.

3.3. The Nature of Motion According to Buridan

Although the arguments in Buridan's treatment of the existence of void bear strong resemblances to that of Roger Bacon and John of Jandun, his considerations of motion is much more detailed and elaborate than that of the other two, using arguments and examples that are not found in the latter.[157] It consists of two questions in his *Physics* commentary, the first dealing with some general characteristics of motion itself, namely, whether there can be any motion without resistance, and the second directly addressing the possibility of motion in the void. His overall reply to the possibility of successive motion without resistance – when resistance is defined as "the inclination of the mobile towards the opposite disposition to that intended by the mover"[158] – is negative, but as will be shown, it has to be treated with appropriate care in certain cases. As Buridan outlines his answer at the beginning of the *questio,*

> If the mover exceeds [the resisting force], then movement results; and with whatever great proportion it exceeds, so fast will be the movement. And if there were no resistance, then instantaneous change would result, if the mover were instantaneously, that is, not successively applied to the mobile.[159]

The first question – as Buridan himself suggests – can be further divided into three: that of the motion of absolutely heavy and light bodies, the motion of mixed bodies, and the motion of celestial bodies. A common characteristic of the three is that throughout the *questio,* Buridan restricts his scope of inquiry almost entirely to natural non-violent motion that comes from natural non-voluntary movers.

(a) The motion of absolutely heavy and light bodies

First, speaking of the absolutely heavy bodies (*grave simpliciter*), Buridan proposes six theses or *conclusiones.* His overall argumentation can be reconstructed as follows:

[157] For Bacon, see BQP 232-236; for John of Jandun, JQP IV, qq. 11-13, fols. 60 vb-63rb.
[158] QP IV, q. 9, fol 74 rb.
[159] Ibid.

(1) If a mover is sufficiently applied to the moved thing, it cannot bring about succession unless there is some resistance.

(2) This also applies to the natural movement of heavy bodies.

(3) The absolutely heavy bodies do not have any intrinsic resistance.

(4) Therefore, the resistance must be external, that is, from the medium.

Unfortunately, Buridan does not argue here for the first point, which is the most interesting from the perspective of the present question. After defining succession as the movement itself connoting that "part after part, continually acquires its position during the motion, and not all parts simultaneously,"[160] he asserts that there is no succession without resistance, and therefore no movement either.[161]

In the case of the movement of heavy bodies towards their natural places (as, for example, the movement of a piece of earth downwards), there also has to be some resistance, since these movements are successive. Therefore, the basic question that arises is what this resistance consists of. Is this due to the matter of the heavy body? Or to something else, but still intrinsic to it? Buridan's answers to these questions are negative. As he notes, matter – in this case the first matter – does not have any determinate inclination towards any place, therefore neither does it have any determinate inclination towards the direction opposite to that of the mover. Concerning the second possibility, since absolutely heavy bodies by definition do not have any amount of lightness in themselves, and since their downward moving force is their heaviness,[162] there is no intrinsic principle that would resist this moving force.[163]

Having excluded resistance as a result of some intrinsic principle or force, Buridan can then conclude that it comes from the resisting medium. He goes on, however, to clarify what

[160] QP fol. 74 va.
[161] Ibid.
[162] Of course, Buridan uses the term "gravity" *(gravitas),* but as this has become such a loaded term since Newton's physics, I will use the more neutral alternative.
[163] QP fol. 74 va.

this resistance means. He argues that this resistance is caused by both that part of the medium through which the body actually moves, and by that part *from* which it moves. For example, if a stone falls, the resisting medium, on the one hand, is the air that it divides, and, on the other hand, the air above it, because the violent rarefaction this movement causes is contrary to the inclination of the air to maintain its shape and density.[164]

In the kinds of arguments Buridan uses in this part of the *questio* the references to any experimental or observational fact are only occasional. All but one of them are used to support the fifth thesis, that the medium does cause some resistance to the motion of heavy bodies. First, this thesis is evident by a simple observation; as one can see above a dusty land, the little particles of earth do not fall, but remain floating through the air for a long time. The explanation of this fact is that the moving power of the particles does not exceed the resisting power of the air, or does so only by a small amount, causing a low velocity or no movement at all.[165]

There are three pieces of observational (or at least partly observational) evidence to answer a possible objection to this fifth thesis, which states that beside the resistance of the medium there is an intrinsic resistance that the moving power has to overcome. It is hard to identify the exact source of this objection; the concept of intrinsic resistance can be clearly seen in Aquinas, who identified it with the body's quantity of matter (*corpus quantum*),[166] although this view never gained much support during the thirteenth and fourteenth centuries.[167] According to the objection cited by Buridan, one part of a stone resists the other

[164] QP fol. 75 ra.
[165] QP fol. 74 va.
[166] *Commentaria in octo libros Physicorum Aristotelis* IV, lectio 12: *Deinde, quia in gravibus et levibus remota forma, quam dat generans, remanet per intellectum corpus quantum; et ex hoc ipso quod quantum est in opposite situ existens, habet resistentiam ad motorem.*
[167] See Edward Grant, *Much Ado about Nothing...*, 38-41.

parts when falling, since all parts tend toward the center of the universe, and they cannot all achieve this end at the same time.[168]

After rejecting this objection by reason (saying that the center of the universe is not to be imagined as a point-like entity without extension[169]), Buridan offers four examples to demonstrate his answer.

(1) The first is a short one that comes without any further explanation: a whole stone falls faster than one of its parts, therefore the parts of it do not delay each other, but rather accelerate.[170] This claim is not supported by any reason nor by observation; probably it was regarded as a common sense experience or opinion that does not need any justification. Interestingly, however, one can find in Galilei the exact opposite thesis (namely that "in the case of bodies of the same material, the part and the whole move with the same speed"[171]), who treats his premise also as an obvious claim that nobody would question.[172]

(2) The second example is even more curious. As Buridan claims, we can see in a great amount of water that its parts do not oppose each other, that is, the upper parts do not incline to a lower place. Thus, one can imagine that a sailor descends to the bottom of the sea, having hundreds of gallons of water above himself; nevertheless, he does not feel the heaviness of this water because the water above does not tend downwards.[173] Although one can call this imagination today as obviously false, it is much more difficult to judge whether the claim itself would have been equally obviously wrong for Buridan had he tried at least to swim below some water. In any case, the imagined scenario does follow from the Aristotelian principle of motion, according to which the sole cause of the natural motion of a body is its

[168] QP fol. 74 vb.
[169] Ibid.
[170] Ibid.
[171] Galileo Galilei, *On Motion and On Mechanics*, transl. I.E. Drabkin and S. Drake (Madison: The University of Wisconsin Press, 1960), 31.
[172] On the thought experiments of Galilei, see Maarten Van Dyck, "Weighing Falling Bodies. Galileo's Thought Experiment in the Development of his Dynamical Thinking" (unpublished), available at http://www.sarton.ugent.be/index.php?id=35&type=file (last accessed: May 10, 2010).
[173] QP fol. 74 vb-75 ra.

heaviness relative to the surrounding bodies, and in this sense, the imagination, in the Buridanian framework, is correct.

(3) The next example, demonstrating the same claim about the parts of water, is no less entertaining. If one had a bath on the top of the tower of the Notre Dame in such a great amount of water that he could not carry in the air, he would not feel the heaviness of this water which would result from its upper parts inclining downwards, but only that heaviness, which resulted from the downward inclination of the water as a whole.[174] Again, it does not seem very likely that Buridan – or anyone else – ever tried to have a bath on the top of the Notre Dame cathedral (which had just been rebuilt and completed just at the time); this example rather serves as an illustration that helps one to better understand Buridan's claim.

(4) The last example of this group is admittedly a thought experiment. Granting that heavy bodies tend towards the center of the universe, suppose that the earth, as a whole, is lifted up to the sphere of the lunar orb. In that case, the whole earth, that is, each part of it, would incline to the middle along straight lines, without impeding or hindering the others.[175] Exactly why the movement of the earth in that situation should be imagined precisely this way is not specified; Buridan presents this thought experiment rather as a fact that – by repeating the thought experiment – could be easily checked by any of his readers.

It is also an example that supports Buridan's last, sixth thesis, namely that a falling heavy body has some resistance other than the medium through which it falls. Here Buridan refers to the pendulum; the lead of the pendulum, while moving, is not only resisted by the air, but even more by the cord that holds it.[176] The pendulum was probably quite a common object in Buridan's time, one that could have been observed by anyone; this example, therefore, is an everyday experience used for a specific purpose and interpreted in a specific way in order to serve this purpose.

[174] QP fol. 75 ra.
[175] Ibid.
[176] Ibid.

(b) The motion of mixed bodies

Having dealt with the natural motion of absolutely heavy and light bodies (earth and water, fire and air, respectively), Buridan addresses the issue of mixed bodies, that is, bodies which are composed of more than one of the four elements. As is shown elsewhere,[177] in whatever proportion a body participates in the elements, it participates in their lightness or heaviness in the same proportions, having therefore different parts that incline to different places.

Such a mixed heavy body, when it is moving downwards in fire, does not have any intrinsic resistance, since all its elements are inclined to be below the fire. Even if we often see that in the fire an absolutely heavy body descends faster than a mixed one, this is not due to the intrinsic resistance of the latter, but only to the fact that some parts of the mixed body (the parts from the element of fire) might not facilitate or support the descent.[178]

For a demonstration of this thesis, the following thought experiment is offered. Let us imagine two spheres of the same size and shape, one of them being absolutely heavy, while the other is composed equally of the four elements. Let the absolutely heavy sphere have eight amounts of heaviness; then the mixed sphere has also eight amounts proportionately: two amounts of heaviness by the earth, two by the water, two amounts of lightness by the air, and two by the fire. In this case, when moving downwards in the fire, all eight amounts of the absolutely heavy body support its descent, while only six amounts facilitate that of the mixed (that is, all except the fire). Therefore, the absolutely heavy body will descend faster, even if the resistance is the same, because it is moved by a greater power or force.[179]

When the mixed body moves within a sphere of air or water, however, it does have an intrinsic resistance which results from its mixed elements. Thus, the body described above

[177] E.g., *Questiones in Aristotelis* De Caelo et Mundo IV, q. 6; see also in *Questiones super Libros* De Generatione et Corruptione *Aristotelis* I, q. 4.
[178] QP fol. 75 rb-va.
[179] QP fol. 75 va.

would move downwards in the air, although its two amounts of fire would resist this movement. The case is similar with any upward motion in water, which would be resisted by the element of earth.[180]

Interestingly, in this part of the *questio* Buridan does not use any observational evidence, although with normal, everyday bodies being mixed bodies, this would have been the most appropriate place to do so. However, as the emphasis was laid primarily not on the description of their motion but rather on its explanation, this latter could be more easily done by recourse to some more fundamental principles (the nature of elements, their qualities and their mixtures).

(c) The celestial motions

The perhaps most complex part of the ninth *questio* is that dealing with the motion of celestial bodies. As noted above, an important argument of Avempace rested precisely on this movement; as there is no external resistance in the celestial sphere, if succession were entirely a result of the resistant medium, the celestial bodies would move instantaneously. Buridan, having conceded that resistance is a necessary condition of movement, has to answer how celestial bodies can move successively without it.

Buridan accepts the usual claim that no heavenly sphere has any resistance in its movement. It has no intrinsic resistance because the movement is its perfection and nothing is inclined against its own perfection; nor does it have any extrinsic resistance since it is not contiguous with anything.[181] There are six counterarguments raised against this claim; since Buridan's whole answer to the question rests on the refutation of these counterarguments, it is

[180] QP fol. 75 va.
[181] QP fol. 75 va-vb.

worth looking at them one by one. Since the second is the most problematic one, it will be treated at the end.

(1) The first objection is a statement of the general problem itself; if there is no resistance there should be instantaneous change. Buridan's answer to this objection is, at this point, rather simple; he makes a sharp division between voluntary and involuntary movers, stating that the former can move with whatever speed it wants to, that is, with finite speed even if there is no resistance. Since the spheres of the heavens are moved by the Intelligences, which are animate beings moving voluntarily, they move the heavens continuously and perpetually at any velocity as they wish.[182] Even if an Intelligence is said to have infinite power, this "infinitely" must be taken syncategorematically and never categorematically; that is, with whatever finite speed it moves, it can still move faster, but there is no such infinite speed with which it can move.

(2) The next objection (in fact the third one), still to the statement of the heavens having no resistance, claims that as there are diverse motions in the heavens (that is, the various motions of the different spheres), these motions can impede one another, just as the projectile motion of a stone is impeded by its fall. As Buridan notes, the movements of the heavens, contrary to that of a stone, cannot hinder each other, having no contrary inclinations.[183]

(3) According to the fourth objection, for a heavenly sphere any place is natural and convenient, therefore it aims to be also where it is not moving to, which is nothing else than resistance. Buridan gives two answers: first, the heavens, or the last sphere, are not *here* or *there*, it is not in a place; and even if it were, the convenient position of it would not be at rest, but in motion, for motion is the perfection of the heavens.[184]

[182] QP fol. 75 vb; 76 ra.
[183] QP fol. 75 vb; 76va-vb.
[184] QP fol. 75vb; 76vb.

(4) The next objection is advocated, among others, by Aquinas, and it is called the *incompossibilitas terminorum* argument;[185] it was often used to support the thesis that successive motion is possible and necessary even without resistance. The argument rests on the premise that for the same body, being in two places at the same time entails a contradiction; therefore, even if there is no resistance, a body cannot be both at the beginning of its motion and at the end simultaneously. That means that the body has to be at the beginning and at the end successively, that is, by successive motion. Buridan, unfortunately, does not discuss this argument in detail; supposing that the above described contradiction is not a *logical* contradiction, he claims that God is capable of placing a body, now in the heavens, instantaneously on the earth; therefore, the above argument is not valid with regard to supernatural powers.[186] (Of course, this is not really a counterargument, but merely a statement of the opposite thesis; the advocator of the *distantia terminorum* is saying precisely that even God could not bring about instantaneous movement being "P is in A" and "P is not in A" a logical contradiction.)

(5) The last objection asserts that the cause of resistance in the heavens is that it has to carry the fire within itself, which consequently hinders its movement just as a stone does if one has to carry it. As Buridan replies, there is no need to carry the fire, since it naturally strives to the will of the first mover, that is, to moving with the spheres.[187]

(6) Returning to the second, most serious objection, if one grants that moving only requires that the mover exceeds the resistance in power, then one could say that even a fly could move the heavenly spheres, since there is no resistance in them; this is, however, absurd. To this objection Buridan refers to an often-used argument stating that the limitation of an active power necessarily involves the limitation of its effect, even if there is no

[185] Aquinas, *Commentaria in octo libros Physicorum Aristotelis* IV, lectio 12. For the origins and history of the argument see Edward Grant, *Much Ado about Nothing...*, 27-30.
[186] QP fol. 75 vb; 76 vb.
[187] QP fol. 75 vb; 76 vb.

resistance.[188] From Buridan's point of view, however, this reply should be seen as rather dubious, for it seems to contradict what was said earlier, that resistance is a necessary condition for movement with a finite speed.

Buridan addresses this difficulty and first refers to the distinction between animate and inanimate movers made above; while the latter do not intend the motion itself, but only its end, and therefore can move instantaneously if there is no resistance, on the contrary, the former do intend the movement, and can produce it even without resistance.[189] Another serious problem arises here, however. By saying that a stone, if there is no resistance, *is* able to move with infinite speed, while a finite Intelligence is not (as stated above), does not Buridan mean also that the power of the stone is, finally, greater than the power of the Intelligence? This would be completely absurd.[190]

It seems that Buridan cannot solve this objection within his own system; as he himself admits,

> Without doubt, it does not seem to me that this objection can be well solved while maintaining the solution against which it argues, unless we grant some resistance in the heaven, or unless we agree with the opinion of Avempace.[191]

He goes on, indeed, to explain the opinion of Avempace, *subtilissimus philosophus*, and illustrate it with some examples. Avempace's opinion – as Buridan summarizes the paraphrase of Averroes – was that any resistance eliminated, by the limitation of the moving power the limitation of the effect results; so even in the downward motion of a heavy body without resisting medium, the movement would be of limited velocity. That means that the statement of Aristotle and Averroes, according to which the ratio of the density of the media is equal to the ratio of the speed a body moves in them, is false.[192]

[188] QP fol. 75 vb; 76 rb.
[189] QP fol. 76 ra.
[190] QP fol. 76ra-rb.
[191] QP fol. 76 rb.
[192] Ibid.

Here, however, Buridan differs from Avempace as well. As discussed above, the latter insisted that a body has an "original" speed, from which the slowness, resulting from the resistance, is subtracted; Buridan partly modifies this picture saying that there are *two* slownesses which have to be subtracted, namely the slowness which results from the medium and that which results from the limitedness of the mover. He illustrates this thesis with an example of two spaces (*a* and *b*), and a number of stones, distributed as follows. (Buridan does not provide any illustration.)

	a	*b*
0.	2	0
1.	3	2
2.	4	4

In space *a*, there are two stones at the beginning, while in space *b* there are none. At each step, one stone is added to space *a*, and two stones are to space *b*. In this case, the ratio between the number of stones in *a* and *b* changes: in the first instant, it is 3:2, in the second it is that of equality, and so on.

	a	*b*
0.	0	0
1.	1	2
2.	2	4

However, if one changes the initial setting so that both spaces begin with no stones in them, the rule of addition remaining the same, then the ratio will be the same throughout: that of 1:2.[193]

What precisely this illustration meant to show in Buridan's argumentation is not entirely clear. He seems to attribute the example to Avempace (although at least in Averroes' text, there is no such reference), and probably tries to demonstrate that the ratio of speed and resistance remains the same only if one subtracts the amount of slowness caused by the motive force at the beginning (that would be exemplified by the second case).

The second explanation Buridan gives refers to Aristotle, according to whom every effect needs an active power convenient to it, and vice versa.[194] As the sun can provide light and heat on the earth, but not in other parts of the universe, or as light can come through an

[193] QP fol. 76 va.
[194] Cf. Aristotle, *Physics* I, 188 a32.

opaque body, but not necessarily heat, no heat or coldness or any other created power is able to move the heavens unless God gives them this power. Therefore, it is not correct to say that a stone has greater power than the movers of the heavens, since they could not be moved by a stone.[195]

The last example or *imaginatio* of this group goes back to the problem of the instantaneous motion of the spheres. Also expressed elsewhere in Buridan's works, this explanation has received a great deal of attention and been regarded as an important step in the history of physics.

> Then, there is another imagination, which I cannot demonstratively reject. Namely that after the creation of the world, God moved the heavens with such motions as they move now, and while moving them, impressed an impetus in them, by which then they are moved uniformly, since that impetus, having no resistance, is never destroyed nor weakened. As we say that a projected stone after leaving the projector moves by the impetus impressed in it, but because of the great resistance – as of the medium, as of the inclination to another place – this impetus diminishes continually, and then ceases.[196]

Undoubtedly, this description points towards the possibility of a unified system of physics and astronomy. Here, however, this explanation is rather confusing, and seems to contradict Buridan's earlier theses; if the heavenly spheres are moved by an impetus, which – given no resistance – never ceases, does not it imply finally that resistance is not a necessary condition of successive movement?

It seems that there are two ways of interpreting this apparent inconsistency. One can either admit that Buridan's solution is, after all, inconsistent, and he changed his mind even within this one *questio,* first advocating the view of Aristotle and Averroes, then that of Avempace;[197] or one can say that due to this initial impetus given by God to the spheres, the spheres do not fulfill the criterion set up at the beginning of the *questio,* namely that the mover should be sufficiently applied to the moved object. Since this is not so, the consequence of instantaneous motion does not follow. Interpreted in this second way,

[195] QP fol. 76 va.
[196] Ibid.
[197] This seems to be supported by Duhem, *Le Système du Monde…,* vol. 8, 100-102.

Buridan's solution would claim that if the mover is a *motor conjunctus* sufficiently applied to the moved object, that is, moving it continually, given no resistance instantaneous motion would result; but if the mover is such that it gave once an impetus to the object and left it afterwards, this impetus would remain the same and would cause movement with a finite, constant speed.

Although this second interpretation seems more promising that the first one, and it is tempting to see this theory as a predecessor of Newton's first law – if there is no resistance, the impetus never ceases even if the mover is no longer moving it – it also raises some difficulties in the Buridanian framework. In this case the basic principle of medieval mechanics, that of *omne quod movetur ab alio movetur,* which was also accepted by Buridan, requires an interpretation that would allow a mover to move even if it is not attached to the moved object. This interpretation was first proposed by James Weisheipl, who showed that even in Aristotle the principle does not require a *motor coniunctus*, and certainly not in the majority of medieval thinkers.[198] It is also supported by Buridan's treatment of the question, which, however, does not discuss this particular issue directly,[199] and at least this is the only way which would solve the present question for Buridan without him contradicting himself. Unfortunately, he omits further discussion of violent motions, neither is it entirely clear whether in this case the motion of the heavenly bodies should be seen as similar to any violent motion in the sub-lunar region.

Thus, Buridan's overall reply to the question of movement without resistance is rather problematic. On the one hand, he constantly insists on the claim that movement without resistance would be instantaneous; on the other hand, in the final part of the *questio,* he introduces his impetus theory into the picture, and seems to suggest that given an impetus, the successive motion it causes would continue with no corruption if there is no resistance.

[198] James A. Weisheipl, "The Principle Omne quod movetur ab alio movetur in Medieval Physics," *Isis* 56 (1965): 26-45.
[199] QP VII, q. 1: *Utrum quod movetur movetur ab alio.*

The turning point of the *questio* is, indeed, the theory of impetus; this is why in his later treatment of motion in the void, Buridan cannot apply the third argument of Aristotle (according to which there could be no violent motion in the void, since the efficient cause of such a motion is the surrounding medium, as in the case of a thrown stone, the air that pushes it from behind). Neither can he allude to Aristotle's fourth argument (the inertial consequence); on the contrary, he seems to accept this consequence at least as a possible result of movement by an impetus. The only remaining way, therefore, by which Aristotle's overall argumentation could have been saved was to maintain, by whatever great effort, that motion without resistance would be necessarily instantaneous; but as has been shown, there are some exceptions even to this rule.

Concerning the kinds of arguments used in this question, it is fairly clear that most of them are philosophical reasoning – that is, conclusions following from certain philosophical principles. Such are almost all of Buridan's claims, beginning from the motion of absolutely heavy and light bodies – that they do not have any intrinsic resistance, or that there is no succession without resistance – through the motion of the mixed bodies – when they have some intrinsic resistance and when they do not – to the motion of celestial bodies. Interestingly, the most reference to observation occurs in the first section; here they are mainly used to contradict a possible objection brought up by an opponent. The demonstration of the falsity of the opponent's claim, furthermore, is only made possible by the specific explanation of the (supposedly) observed phenomena, which explanation itself does not derive from any empirical data. The thought experiments in the second and third part are meant to show a possibility, the reality of which is, however, neither unambiguously defended, nor denied by Buridan.

3.4. Motion in a Hypothetical Void

The tenth question of the fourth book of Buridan's *Physics* commentary asks whether if vacuum existed, a heavy body would move in it. Buridan, however, again restricts his treatment to the natural movement of the heavy bodies; the more interesting case, that of violent motion, remains undiscussed.[200] The final answer to the question is twofold: on the one hand, a heavy body is not naturally capable of moving in the vacuum; on the other hand, it is capable of it by the divine power, but one cannot treat the nature of this movement with any certainty.

The setting of the first question is the one that has been already described in the previous *questiones*: the vacuum is imagined as resulting from the elimination of the earth while the sphere of air above retains its size and shape; in this case, the remaining air is called "vacuous". Further dividing the question, first, it can be imagined that a stone is within the sphere of air so that it does not touch the surface of this sphere. In this case, there is nothing problematic with the movement of the stone; it will move naturally by its heaviness as long as it does not touch the surface of the sphere, since it is the most proximate containing body that determines the movement of a stone. That the motion is not determined by the location of that containing body, nor by anything that is further from it, is well seen in the everyday example of a piece of wood ascending in water: it ascends in the same way whether the water is deep in a well or high in a vessel. As the wood ascends in the water until it reaches the surface, a stone can similarly move naturally in the vacuous air until it reaches the surface.[201]

Second, and more importantly, a stone in the vacuous air can be imagined as being outside the sphere of air, within the vacuum. Properly speaking, it is this sense of vacuum which is usually meant in the examination of motion in the void. Buridan's answer to the

[200] This omission is more interesting given that the question of violent motion occupied a whole questio in the commentary of Roger Bacon. See BQP 234-236.
[201] QP fol. 77 ra.

natural possibility of natural motion in the void is negative; a heavy body would not naturally move in the void, since it would lack any inclination to do so. A body has an inclination to move either because it is heavy and has some lighter bodies below it – in this case, it is inclined to move downwards until it reaches a place where it has only heavier bodies under – or because it is lighter than the bodies above it – in this case it is inclined to move upwards. In the vacuum, however, none of these conditions apply; therefore, a stone would have no inclination to move in either direction.[202]

On the contrary, as Buridan asserts, it could be moved in the void by the divine power, as even the earth could be moved rectilinearly, which implies that a void results in the place from which it moves.[203] It should be noted that a question arising from such an assertion is a double-counterfactual: (1) We know that there is no vacuum, but if there were (by divine power), would a heavy body move in it? – It would not, only by divine power. (2) Would the heavy body moving in the vacuum move instantaneously, or by some finite speed?

In answering the second question, Buridan recapitulates Aristotle's argument, which shows that natural motion in the void is instantaneous. First, if one accepts the Aristotelian principle that successive motion is only a result of the resistant medium, then the conclusion is evident. Second, if we suppose that a body moves in the void with a finite speed, then there is a ratio between this speed and that one by which it moves through the air. Now if this ratio is *a*, then if we take a medium that is *a* times subtler than the air, the body would move in this new medium and in the vacuum with equal velocity. This is, however, absurd.[204]

[202] QP fol. 77 rb.
[203] This is in fact a quotation of the Parisian condemnation of 1277 § 49 [66], quoted in n. 125 above. Buridan treats this problem more fully in QP III, q. 15.
[204] QP fol. 77 rb-va. Cf. Aristotle, *Physics* IV, 8, 215 b23-216a7.

As Buridan rightly points out, this argument is only valid if one grants the Aristotelian principle of motion, and denies that of Avempace. The latter, however, as Buridan admits, cannot be disproved, and should be accepted rather than the opposite one.[205]

All in all, Buridan does not give here a definite answer to his main question, whether – if God moved a body in the by-God-created vacuum – the body would move instantaneously or with finite speed in it. What one can reconstruct from his arguments is that neither of these is necessary.

On the one hand, as we have seen above, Buridan refutes the *incompossibilitas terminorum* argument which would guarantee that a heavy body would move with a finite speed even if there were no resistance. Although he discusses the argument in another context, one can easily apply it to the present case: if God is able to move the moon to the earth instantaneously through the air, He is surely capable of doing so if there is no air in between.

On the other hand, neither would this motion be *necessarily* instantaneous. As Buridan emphasized many times, he cannot demonstratively refute the view of Avempace, and inclines rather to accept than to reject it. His standpoint would have been more clearly shown had he discussed the nature of violent motion, which he omitted here as well as in his treatment of motion in general. Although some scholars tend to interpret him as saying that motion in the void would be necessarily instantaneous,[206] he could just as well have argued for the opposite thesis.

As has been shown, Buridan's reply to the problem of motion and motion in the void is rather confused and can be subject to many interpretations. Assuming that he was consistent throughout these two questions, his answer might be summarized as resting on two

[205] QP fol. 77 va.
[206] Edward Grant, *Much Ado about Nothing...,* 45-46; Anneliese Maier, *An der Grenze von Scholastik und Naturwissenschaft...*, 235-240.

basic distinctions. First, one has to distinguish between natural and violent motion, the former being the natural downward movement of a heavy body, while the latter is its movement upwards. Since there are no surrounding lighter bodies in the void which would serve as a motive force of the natural downward movement of a heavy body, there is no natural movement in the vacuum. Regarding violent motion, another distinction has to be made. If the mover is a *motor conjunctus* sufficiently attached to the mobile, then without resistance the movement caused would be instantaneous. On the other hand, if the mover only gives an *impetus* once and leaves the moved object afterwards, the *impetus* remains uncorrupted and moves the object with uniform speed.

His argumentation throughout these questions rests on a few premises from which the conclusions logically follow. The most reference to experience can be found in the treatment of the natural motion of heavy bodies; in other places, while discussing the characteristics of motion in general, Buridan rather makes use of some either in theory realizable or entirely unrealistic thought experiments. In the last part, while treating the motion in the void, also the imagination plays only a constrained use, and the main line of argumentation is strictly logical.

4. CONCLUSION

4.1. Observation, authority, thought experiment

Having examined Buridan's questions on the void, we might be able to point out some general characteristics of his method. Apart from pure logical reasoning, he uses two main kinds of arguments: that based on some sort of experience, and others that rely on imagination or thought experiments.

Concerning the first, Buridan's *experimenta* are of several kinds. Sometimes he relies on the direct awareness of everyday phenomena, such as on the observation of rectilinear motion, condensation or rarefaction. These observations are meant to demonstrate such simple statements as "rectilinear motion exists," "condensation is possible," and so on; they would have hardly been questioned by anyone, and were, indeed, widely used in natural philosophical reasoning.

Furthermore, Buridan uses other experiences that might still be regarded as common, but requiring more directed attention or more attentive design. The example of the hollow reed used as a drinking straw, the jar with fermenting wine, the motion of the pendulum, or the small particles of earth above a dusty land were certainly observed, but perhaps not noticed by everyone; once having called attention to them, they could well serve to support some of Buridan's theses.

Finally, many experiments were described but presumably not performed by Buridan or his readers; their outcome was accepted either because an authority or a supposedly expert person affirmed it, or because it easily followed from already accepted principles. The experiment with the pot and ashes, as has been already discussed, originates from Aristotle, and despite its actual falsity,[207] can be found in almost all *Physics* commentaries.[208] Similarly,

[207] I have to admit that, of course, I have not performed the experiment either, therefore methodologically I have no more support than Buridan in his statement.

the experiment with the bellows was not – probably even could not have been – performed, but was widely used to support the thesis of the nonexistence of vacuum. This – either implicit or explicit – reliance on authority was, indeed, a common feature of medieval natural philosophical reasoning;[209] as even Roger Bacon argued for it,

> First one should be credulous until experience follows second and reason comes third. … At first one should believe those who have made experiments or who have faithful testimony from others who have done so, nor should one reject the truth because he is ignorant of it and because he has no argument for it.[210]

On the other hand, the water on the top of the Notre Dame cathedral or the sailor descending to the bottom of the sea are examples that were probably never meant to be performed, because their result could be easily imagined as being a consequence of the elementary motions.

This remark leads to the second main group of Buridan's arguments, which are the even theoretically unrealizable *secundum imaginationem* demonstrations. One should notice that these thought experiments are not simple imaginations in the sense that anything could be imagined, but resting on some elementary principles, they proceed according to certain well-defined rules. As Peter King argued,[211] there was a whole genre of philosophical literature which served to establish these rules; the *obligationes* examined precisely what happens if a certain condition, *positum* is given – that is, when one can assent to or deny a sentence

[208] Although not in the commentary of Buridan, there is another famous, often-used, but never performed simple false example, which perhaps first appeared in Johannes Canonicus, but was still used in the fifteenth century. Arguing for the possible existence of void, a well-closed jar full of water is said to have been put outside in winter; when the water freezes, it is said to condense, therefore creating a vacuum above it in the bottle. Had anyone tried this experiment would have noticed that the water actually does not condense but expands when it freezes. For the long history of the argument see Charles B. Schmitt, "Experimental Evidence for and against a Void: The Sixteenth-Century Arguments," *Isis* 58 (1967): 352-366, 357-359.

[209] Another interesting example of "copied experiments," described by Alastair C. Crombie, concerns the determination of the depth of the sea by means that were not available at the time. See his *Robert Grosseteste and the Origins of Experimental Science 1100-1700* (Oxford: Clarendon Press, 1953), 24.

[210] *Opus maius* VI, 11: *Unde oportet primo credulitatem fieri, donec secundo sequitur experientia, ut tertio ratio comitetur. … Et ideo in principio debet credere his qui experti sut, vel qui ab expertis fideliter habuerunt, nec debet reprobare veritatem propter hoc, quod eam ignorat, et quia ad eam non habet argumentum.*

[211] Peter King, "Medieval Thought-experiments: The Metamethodoloogy of Medieval Science," in *Thought-Experiments in Science and Philosophy*, ed. G. Massey and T. Horowitz (Rowman & Littlefield 1991), 43-64.

following from such a *positum* – even if this *positum* is in fact impossible.[212] Most of Buridan's arguments for and against motion in the void are, indeed, of this latter kind, that is, of reasoning *per impossibile*; the initial setting is a specific concept of void (usually the earth being annihilated while the lunar orb remained the same), and the consequences follow from this setting and from the principles of the motion of elements and mixed bodies.

It is rather hard to determine what role these various kinds of experiments played in Buridan's overall argumentation. In the first question on the existence of vacuum, the thesis that void does not exist was first proposed as following from direct experience ("from such experimental induction it seems to us that there is no vacuous place"[213]), but the main arguments for this thesis mostly relied on thought experience and logical reasoning. The vacuum was imagined as a result of a certain thought experiment, although this imagination was proved to be impossible by the reasons following from the concept and properties of space. The bellows experiment and the hollow reed are used as examples supporting or illustrating Buridan's thesis, but the existence of void should be excluded not *because of* these examples. In the case of condensation and rarefaction, their existence is again shown by simple observation, but their explanation is given by means of logical reasoning. The experiments, like the pot with the ashes are used as examples, often for the opposite thesis.

The possibility of void by the divine power follows from a simple imagination and is explained by using the more general principle of God's omnipotence. In explaining the characteristics of void in more detail, Buridan even warns the reader against relying entirely on the imagination, since in such abstract cases it can well lead astray.

Finally, the treatment of the nature of motion and motion in the void, by its natural impossibility, could only rely on thought experiments and logical reasoning. Thus, the question of the possibility of motion without resistance is settled by an argument from the

[212] A good selection of the *obligationes* can be found in Lambert M. De Rijk, "Some Thirteenth-Century Tracts on the Game of Obligation I-III," *Vivarium* 12-14 (1974-1976): 94-123, 22-54, 26-42.
[213] QP fol. 73va.

elements and elementary motions; the experiments of the sailor under the sea or the bath on the Notre Dame are used to answer a possible objection, therefore supporting but not demonstrating Buridan's thesis. The thought experiment of God giving an impetus to the planets does have serious weight in the argumentation, but its status – and with it, Buridan's standpoint in the issue – is far from clear.

Generally speaking, therefore, direct observations are mostly used for proposing a thesis, while they have little role in the argumentative part of the questions. In the naturally impossible cases this direct observation is replaced by particular imaginations such as in the question on the existence of void by the divine power, but again, the use of these imaginations is rather restricted in the explanations, where the main role is played by universal logical reasoning.

4.2. Methodological theory and practice: A supposed anomaly

It is a view quite commonly held by historians of science and philosophy that there was a certain inconsistency between the methodological theory and practice of the Middle Ages. As Edward Grant once formulated it,

> There is a great anomaly in medieval natural philosophy. Aristotelianism was empirical and rooted in sense perception. … And yet we see very little direct observation in the questions literature on Aristotle's natural books.[214]

A similar view is held by John Murdoch[215] and by David Lindberg[216] as well.

[214] Edward Grant, "Natural Philosophy, Theology, and Reason in the Late Middle Ages," Lecture before Department of History and Philosophy of Science, February 4, 2000. Available at https://scholarworks.iu.edu/dspace/bitstream/handle/2022/95/HPS%20LECTURE%202-4-2000?sequence=1 (last accessed: May 12, 2010). Also expressed in his *A History of Natural Philosophy from the Medieval World to the Nineteenth Century* (Cambridge: Cambridge University Press, 2007), especially 215-225.

[215] John E. Murdoch, "The Analytic Character of Late Medieval Learning: Natural Philosophy Without Nature," in L. D. Roberts ed., *Approaches to Nature in the Middle Ages* (Binghamton, NY: Center for Medieval and Early Renaissance Studies, 1982).

[216] David C. Lindberg, *The Beginnings of Western Science* (Chicago: The University of Chicago Press, 2007), 362-363.

Although I could not give here a thorough account of the epistemology of Buridan, "the quintessential empiricist of the fourteenth century,"[217] one can pinpoint some already mentioned characteristics that can help to elaborate on this anomaly.

Although Buridan does indeed subscribe to the claim that all of our knowledge derives from the senses, this must be understood with certain restrictions even in the case of concept acquisition. First, as we have seen, the assent to or dissent from a certain sense experience is always given by the intellect; it is the latter that can judge whether the disposition of the senses or the medium is adequate enough for providing reliable information. Second, the acquisition of substantial concepts, although originating from sense experience, is again carried out by the intellect: It is the former which provides the sufficient data, but it is the latter that can grasp the essential characteristic of a given object. Finally, it is also the intellect's task to concede to a universal proposition by induction from the singular instances and to arrive at the knowledge of causes when only the effect is known.

It is not an accidental feature, therefore, that scientific reasoning – which, by definition, has to be universal and an explanation of causes – does not proceed primarily from experiences. As we have seen, experience does have an important role in the formation of theories, but not in their demonstration and causal explanation; thus, it corresponds precisely to the twofold role of sensory experience in the formation of scientific propositions, as was described in the first chapter. Although it is sense experience that provides the basis of our cognition, it alone cannot produce scientific concepts and even less scientific explanations. Therefore, the – in certain respect restricted – role of experience in Buridan's scientific practice, instead of contradicting, seems rather to directly follow from his methodological theory; experience, indeed, cannot have more weight in scientific explanations unless the fundamental scientific question ceases to be the question about causes.

[217] Edward Grant, "Jean Buridan and Nicole Oresme on Natural Knowledge," *Vivarium* 31 (1993): 84–105, 84.

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APPENDIX

1. INTRODUCTION

As Jack Zupko once succinctly noted, "the textual tradition of Buridan's *Questiones* on the *Physics* is a mess, to put it mildly."[1] The situation has not changed recently; the *Phsysics* commentary remained a rather difficult text to treat, not least because the authenticity of its different versions is still questionable.[2] Buridan lectured many times on Aristotle's *Physics* during his long career at the Arts Faculty, consequently, at present, six versions of his commentaries are extant; two of them were written in the form of an *expositio* (that is, a line-by-line commentary on Aristotle's work), three in the form of *questiones*, and one is a collection of *dicta*, with dubious authenticity.[3] Of the various forms, the *quesitones* is the most promising, because it treats its subject more thematically and explicitly, being therefore able to serve as a source for reconstructing Buridan's own natural philosophy. Concerning the *Questiones,* it also has a shorter (*questiones breves*) and a longer (*questiones longae*) version, the latter is often labeled as *secundum ultimam lecturam;* as Johannes Thijssen argued in more places, the former is an abridged version of the latter.[4] Therefore, my former considerations and this work-edition are based solely on that version, written probably after 1350, as it is available in an early printed edition from 1509.[5]

In the transliteration I followed the original text as closely as it was possible. Thus, I preserved the – not altogether consequent – spelling and the printed paragraphs, although the punctuation is mine. A few minor corrections were made in order to preserve the meaning;

[1] Jack Zupko, "Review of *John Buridan's Tracatatus de Infinito: Questiones Super Octo Libros Physicorum Secundum Ultimam Lecturam, Liber III, Questiones 14-19*, by J. M. M. H. Thijssen", *Speculum* 69 (1994), 439.
[2] For an introduction to the textual tradition, see Johannes M. M. H. Thijssen, *Johannes Buridanus over het Oneindige: Een Onderzoek naar zijn Theorie over het Oneindige in het Kader van zijn Wetenschaps- en Naturfilosofie* (Nijmegen: Ingenium Publishers, 1988), vol. 1, 58-82.
[3] Cf. J. M. M. H. Thijssen, *Johannes Buridanus over het Oneindige…*, vol. 1, 60.
[4] Cf. J. M. M. H. Thijssen, *Johannes Buridanus over het Oneindige…*, vol. 1, 68-72, and Idem, "The Short Redaction of John Buridan's Questions on the Physics and their Relation to the Questions on the Physics attributed to Marsilius of Inghen," *Archives d'histoire doctrinale et litteraire du Moyen Age* 52 (1986), 237-266.
[5] Reprinted as Johannes Buridanus, *Kommentar zur Aristotelischen Physik* (Frankfurt a. M.: Minerva, 1964).

these are always noted in the footnotes. The folio numbers refer to the original Parisian printed edition.

2. JOHANNIS BURIDANI SUBTILISSIME QUESTIONES SUPER OCTO PHISICORUM LIBROS ARISTOTELIS, LIBER IV, QUESTIONES 7-11.

QUERITUR SEPTIMO UTRUM POSSIBILE EST VACUUM ESSE.

72vb

ARGUITUR QUOD SIC <A1> rationibus quas facit Aristoteles:[1] quia si motus localis rectus est, vacuum est; sed ille est, ut omnes concedunt, ergo etc. Maior probatur quia quod movetur motu recto vel recipitur in plenum vel in vacuum; si in vacuum habetur propositum, si in plenum tunc vel illud plenum cedit vel non. Si non tunc est penetratio quod reputamus impossibile; si cedat tunc iterum cedendo vel recipitur in plenum vel in vacuum, et si in plenum queretur ut prius, et sic tandem oporteret uno moto omnia ante moveri et celum tumultuari et cedere quod est absurdum.

<A2> Iterum, quia aliquis respondendo rationi facte posset fingere quod si ego moveor ad ante non oportet quod aer michi cedens moveatur motu recto ad ante sed movetur localiter et quodammodo circulariter: aer enim quantum erat michi lateralis movetur ad repledum locum a quo ego exeo, et aer tamen anterior dispergitur lateraliter ad replendum locum quem occupabat ille aer qui prius erat michi lateralis. Ideo contra istam imaginationem ponitur alia ratio, s.c. supponendo quod per calefactionem vel frigefactionem et elementorum adinvicem transmutationem fit condensatio vel rarefactio et maioris vel minoris loci occupatio ut ex straminibus parve quantitatis generatur magna flamma et magnus fumus occupans valde magnum locum quam occuparent illa stramina. Tunc ergo arguitur sic. Cum ille ignis genitus occupat multum maiorem locum quam facerent stramina, oportet corpora circunstantia cedere ne fiat penetratio corporum et illis cedentibus alia iterum cedere, et sic tandem oportet celum 73ra
cedere nisi sint in corporibus alique vacuitates in quas corpora sic cedenda recipiantur vel nisi dicatur quod necesse est quantumcumque hic generatur de denso rarum ut ex straminibus ignis, tantumdem alibi oportet generari ex aere densus et simul utrumque horum fieri ut semper remaneat totum equale. Et sic dicere est omnino fictivum, quia ego experior quod ego libere possum quando placet michi comburere ista stramina quamvis alibi alia non sint in potestate mea; ergo potius ponendum est quod sit vacuum.

<A3> Item, sicut de rarefactione argutum est ita de condensatione arguitur: quia si condensatio est vacuum est, sed condensatio in hoc communiter conceditur, ergo vacuum est. Maior probabitur quia si aliquid corpus condensatur partes eius extreme undique moventur appropinquando ad centrum et recipiuntur sic movendo in plenum vel in vacuum. Si in vacuum habetur propositum; si in plenum hoc est impossibile nisi sit penetratio, quia non est possibile partes medias, s.c. versus centrum cedere. Quoniam qua ratione cederent ad unam partem eadem ratione ad aliam, ideo vel ad neutrum vel undiquaque quod est impossibile; et maxime quia undique partes exteriores moventur versus centrum ideo ex una parte possibile est partes centrales cedere quia exteriores obviarent eis.

<A4> Item, si augmentatio est possibilis in viventibus per nutritionem, vacuum est; sed illa est possibilis prout hic supponitur, ergo etc. Maior probatur quia supponitur quod nutriti quaelibet pars sit nutrita et augmentata et quod nutritio et augmentatio fiant adveniente ab extrinseco aliquo corpore, quod si recipitur in vacuum habetur propositum; et si in plenum quod non cedat erit penetratio quod reputatur impossibilis, et si illud plenum cedat tunc non nutritur nec augetur quia non recipit nutrimentum et hoc est contra suppositum quia supponitur quod quaelibet pars nutriti nutritur et aucti augetur.

<A5> Iterum, experimentum est quod pottus repletus cineribus potest tantumdem recipi de aqua quantum reciperet si non essent ibi cineres, et hoc non esset possibile nisi esset inter partes cineris magna vacuitas in qua illa aqua reciperetur vel nisi esset penetratio corporum, ergo etc.

<A6> Item, non apparet quare rarum esset minus ponderosum et magis transparens quam densum si totum utrobique esset solidum et continuum. Ideo posuerunt antiqui aliqui vacuum inmixtum corporibus propter quod est maior raritas et levitas etc. Et aliqui etiam, ut dicit Aristoteles,[2] vacuum inter corpora contigua dixerunt esse prohibens eorum continuationem tanquam omnia corpora essent ab invicem divisa; ideo auctoritate illorum arguitur quod vacuum sit. Item etiam auctoritate vulgari quia omnes communiter dicunt dolium aut pottum esse vacuus quando ab eo extractum est vinum.

OPPOSITUM enim determinat Aristoteles.

PRIMO INTENDO LOQUI de possibilitate esse vacuum quantum ad potentias naturales, et post aliquid modicum dicetur de potentia supernaturali. Et oportet sicut dicit Aristoteles premittere quid nominis aliqui ergo descripserunt vacuum: quod vacuum est in quo nichil est vel in quo non est corpus sensibile vel etiam in quo non est corpus.[3] Et iste non sunt bone descriptiones quia sic se habent puncta indivisibilia punctum esset vacuum immo etiam sic Deus esset vacuum quia in eo non est corpus nec aliquid aliud, saltem secundum istum modum essendi in aliquo secundum quem intendebant de vacuo, licet sint in eo omnia sicut in efficiente vel in fine. Sic etiam una species intelligibilis esset vacuum cum nichil esset in ea. 73rb

Isti ergo deficiunt quia mittunt genus ponendum in diffinitione vacui, s.c. locum. Oportet ergo dicere quod vacuum est locus non plenus. Nam si esset possibile vacuum esse, ista nomina ‘plenum’, ‘vacuum’ essent passiones huius nominis ‘locus’, supponerent enim pro loco; et ultra ‘plenum’ connotat quod in illo loco sit corpus contentum ab eo, et ‘vacuum’ connotaret quod non sit corpus contentum in eo. Et ista nomina ‘vacuum’ et ‘plenum’ essent adinvicem privative opposita quorum substractum esset ille terminus ‘locus’ de quo essent innata dici successive et non simul. Privatio autem est innata describi per suum substractum et per habitum sibi oppositum cum dictione negativa ut quod ‘cecus est’ est oculus non habens visum vel carens visu; ideo rationabiliter potest dici quod vacuum est locus non plenus. Ex eo autem locus dicitur non plenus quia non est in eo corpus contentum ab eo, ideo vacuum dicitur locus in quo non est corpus contentum ab eo.

Postea notandum est quod sicut potest dupliciter imaginari locus, ita etiam dupliciter potest imaginari vacuum. Nam si esset spacium preter magnitudines corporum naturalium in quo non cedente reciperentur corpora naturalia de quo spacio unumquodque corpus naturale occuparet partem sibi equalem, sicut multi imaginati sunt, illud spacium sine dubio deberet poni esse locus et esset locus plenus quando in eo et cum eo adequate corpus naturale esset, et diceretur vacuus quando in eo vel cum eo non esset corpus naturale. Et sic apparet quod vacuum esset dimensio corporea tanta secundum longitudinem latitudinem et profunditatem quantum esset corpus naturale per quod illud vacuum repleretur si poneretur in eo. Et videtur quod secundum istam imaginationem que est satis vulgaris locutus est Aristoteles in libro Predicamentorum de loco ubi dicit quod loci particule que obtinent singulas particulas corporis ad eundem terminum communem copulantur ad quem et corporis particule.[4] Et ideo bene dicit Commentator quinto Metaphisice[5] quod Aristoteles sepe in Predicamentis locutus est secundum famositatem non secundum veram determinationem, s.c. de illis quorum propria perscrutatio pertinebat ad alias partes philosophie.

Nunc ergo dicendum est quod nec est vacuum isto modo nec potest esse naturaliter quia non est locus tale spacium, ut prius determinatum est,[6] ergo nec vacuum est tale spacium. Quia vacuum si est locus ut dictum est, et etiam in tractatu de loco diximus non posse esse

tale spacium naturaliter, quia esset penetratio dimensionum et accidens sine substantia, et non proficeret, immo esset frustra, et hec dicta fuerunt prius.[7] Alio modo secundum Aristoteles[8] ponitur locus esse superficies corporis continentis locatum; et tunc si vacuum esset, deberet imaginari sic: quod ex loco pleno auferetur corpus contentum vel annichilaretur loco remanente in sua figura, videlicet quod latera loci non approximarentur adinvicem. Verbi gratia, imaginando quod iste mundus inferior annichilaretur totaliter celo remanente in sua magnitudine et figura sicut est nunc; si enim sic esset, tunc superficies orbis luneque modo est locus repletus ipso mundo inferiori esset locus vacuus, quia non esset in eo aliquid corpus contentum ab eo immo nec aliquid spacium nec aliqua dimensio. Immo nichil ergo deberet imaginari quod intra latera orbis lune esset vacuum secundum extensionem rectam de uno polo ad alium polum sibi oppositum secundum situm vel de uno latere ad aliud latus sibi oppositum secundum situm: quia omnino nichil esset intra huiusmodi latera, ideo affirmativa esset falsa quod diceret quod intra esset vacuum, sed vacuum esset mobilis res quia esset orbis lune vel pars eius, s.c. superficies concava ipsius. Et secundum istam imaginationem dicendum est quod nec est vacuum, nec potest esse naturaliter; quod probatur primo quia sequitur quod essent aliqua duo corpora extra invicem secundum situm quod nec tangerent se nec distarent a se saltem secundum rectitudinem quod non est possibile per naturam licet non sit impossibile simpliciter s.c. per potentiam divinam. Consequentia patet quia poli in orbe lune non essent adinvicem proximi sive tangentes se, et tamen etiam non distarent ab invicem secundum rectitudinem, quia distantia est per dimensionem intermediam sive per spacium intermedium et nullum esset. 73va

Item, secundum naturam illa non distant abinvicem per latera orbis lune inter quae nichil esset medium, et sic esset in proposito. Si aliquis diceret quod adhuc illi poli distarent ab invicem per latera orbis lune intermedia que non esset distantia secundum rectitudinem sed secundum curvitatem, tunc sequitur quod non est naturale, s.c. quod poli magis distarent tunc quammodo quia modo non distant nisi intantum quanta est longitudo diametri recte protensi de polo ad polum, et illa distantia esset ablata et non remaneret distantia nisi longior, s.c. illa curva modo. Non est naturale quod due partes corporis continentis distent aliquando plus aliquando minus illo corpore remanente semper in sua magnitudine non mutata et similiter in sua figura et secundum se totum et secundum quamlibet sui partem, et etiam quod quaelibet pars illius corporis remaneat proxima et immediata cum parte cui prius erat proxima et immediata; et tamen sic esset in proposito de spera lune et de suis partibus.

Item, omnis propositio uiversalis in scientia naturalis debet concedi tanquam principium quod potest probari per experimentalem inductionem; sic quod in pluris singularibus ipsius manifeste inveniant, ita esse; et in nullo, nunquam appareret instantia. Sicut enim bene dicit Aristoteles[9] quod oportet multa principia esse accepta et scita sensu memoria et experientia, immo aliquando non potuimus scire quod omnis ignis est calidus. Sed per talem inductionem experimentalem apparet nobis quod nullus locus est vacuus, quia ubique invenimus aliquod corpus naturale, s.c. vel aerem vel aquam vel aliud. Et iterum, nos experimur quod non possumus unam corpus ab alio separare quin interveniat aliud corpus. Unde si perfecte obstruerentur omnia foramina follis ad adinvicem ita quod non posset aer subintrare, nunquam possemus latera follis ab invicem elevare; immo nec viginti equi hoc posset, si decem traherent ad unam partem et decem ad aliam. Nunquam enim separarent latera follis ab invicem, nisi aliquid rumperetur vel perforaretur per quod aliud corpus posset intercidere. Et per calamum cuius unum conum ponis in vino et alterum in ore tuo tu attrahendo aerem existentem in calamo attrahis vinum movendo ipsum superius licet sit grave; propter hoc quod aerem quem tu attrahis necesse est sequi aliquid corpus semper immediate ut non sit vacuum, et sic sunt multe alie experientie mathematice. Ideo debemus concedere quod non potest naturaliter esse vacuum, tanquam scitum per illum modum, qui est

sufficiens ad ponendum et concedendum principia in scientia naturalis; et per hanc inductionem habetur quod non sit vacuum per aliquid istorum duorum modorum prius dictorum, semper enim videmus corpora naturalia consequi adinvicem tangendo nec inter ea movere spacium sine corpore naturali ut sine aere vel aqua vel huiusmodi.

Tunc respondendum est AD RATIONES PRINCIPALES.

73vb

<Ad1-3> Ad primam que est de motu locali recto et ad secundam que est de hoc quod ex denso sit rarum, dicendum est quod rationes ille bene procederent nisi corpora circunstantia condensarenter, sed quia condensantur ideo non oportet ultra ea alia corpora cedere vel moveri. Ita quod non dico quod oporteat omnem condensationem fierei per generationem unius substantie ex alia, immo nec per infrigidationem; sicut post magis dicetur et ita etiam ratio que arguit quod 'si condensatio est vacuum est' solvetur quando videbitur de modo rarefactionis et condensationis.[10]

<Ad4> Ad rationem quod est de augmentatione dicendum est in libro De generatione, ubi apparet quod non quelibet pars eius quod augetur augetur.[11]

<Ad5> Ad rationem de cineribus Commentator[12] bene dat causam propter quam ita est, s.c. enim cineres si sint novi et maxime sunt calidi et sicci et activi virtualiter, ideo agunt in aquam infusam evaporando magnam partem sive quantitatem ex ea et etiam virtute aque sub intrantis plures partes subtiles cineris vel etiam inter cineres incluse exeunt aqua intrante non enim erant partes cineris continue adinvicem sed erat multus aer interclusus et sic tandem possibile esset quod iste pottus plus reciperet de aqua quam si non essent ibi cineres sicut etiam si in illo potto essent frustra ferri igniti et candentis.

<Ad6> De alia ratione dicetur quando dicetur de rarefactione et condensatione;[13] omnino enim negatur quod rarum vel leve sit per vacuum vel mixtione vacui cum pleno etc.

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[1] *Physics* IV, 6, 213 b3-9.
[2] *Physics* IV. 9, 216 b22 ff.
[3] *Physics* IV. 7, 213 b31.
[4] Cf. *Categories*, 4, 7, 9.
[5] The reference is probably to Averroes' *Metaphysics* commentary, fol. 125 va-vb.
[6] QP IV, q. 1.
[7] QP IV, qq. 1-6; especially q. 2.
[8] *Physics* IV, 4, 212 a6.
[9] *Posterior Analytics* I, 18, 81 a38-b9; II, 19, 100 a3-5.
[10] QP IV, q. 11.
[11] Cf. *On Generation and Corruption* I, 5.
[12] AQP IV, 2, fol. 149M-150A
[13] QP IV, q. 11.

QUERITUR OCTAVO UTRUM POSSIBILE EST VACUUM ESSE PER ALIQUAM POTENTIAM.

ARGUITUR QUOD NON <A1> quia per nullam potentiam possibile est quod implicat contradictionem vel ad quod sequuntur contradictoria; sed ad vacuum esse sequuntur contradictoria. Probatur quia sequitur si vacuum est quod ipsus est locus per eius descriptionem dicentem quid nominis, sed etiam sequitur si vacuum est quod ipsum non est locus quia non conveniret sibi descriptio loci – s.c. superficies corporis continentis – quia nichil contineret.

<A2> Item, sequitur alia contradictio, verbi gratia si orbis lune maneret in sua magnitudine et figura isto mundo inferiori annichilato, sequitur quod latera celi esssent ad invicem proxima et tangentia quia nichil esset intermedium; et non essent tangentia neque proxima quia hoc non posset compati illa figura orbicularis.

<A3> Item, sequitur alia contradictio, s.c. quod inter latera celi esset vacuum et quod inter latera celi nichil esset; hoc enim implicat contradictionem, quia cum prima sit affirmativa requiritur ad veritatem eius quod termini supponant pro aliquo ideo sequitur intra latera celi est vacuum ergo intra latera celi est aliquid, et hec contradicit isti inter latera celi nichil est.

OPPOSITUM ARGUITUR quia Deus posset annichilare omne quod est sub orbe lune manente orbe lune in magnitudine et figura in qua est, et tunc concavum orbis lune quod modo est plenum isto mundo inferiori, esset vacuum, sicut si dolio remanente Deus annichilaret vinum quod est in eo absque hoc quod intraret vel fieret in ipso aliquod aliud corpus iam dolium esset vacuum.

ET IDEO aliqui dominorum et magistrorum meorum in theologia improperaverunt michi de hoc quod aliquando in questionibus meis phisicalibus intermisceo aliqua theologica, cum hoc non pertineat ad artistas. Sed ego cum humilitate respondeo quod ego bene vellem non esse ad hoc astrictus. Sed omnes magistri, cum incipiunt in artibus, iurant quod nullam questionem pure theologicam disputabunt ut pote de terminate vel de incarnatione, et ultra iurant quod si contingat eos disputare vel determinare aliquam questionem que tangat fidem et 74ra
phisicam, eam pro fide determinabunt et rationes dissolvent prout eius videbuntur dissolvende. Constat autem si aliqua questio tangit fidem et theologiam ista est una de illis, s.c. utrum possibile est esse vacuum. Ideo si ea volo disputare oportet me dicere quod de ea apparet michi dicendum secundum theologiam vel esse per iurum, et evadere rationes ad oppositum prout apparebit michi possibile. Et non possem solvere eas nisi moverem eas, ergo sum ad hec facienda coactus. DICO ERGO quod duplici modo possemus imaginari vacuum, sicut dictum est in alia questione;[1] et possibile est utroque modo vacuum esse per potentiam divinam. Et hoc est michi creditum et non ratione naturali probatum, ideo nec istud intendo probare sed solum dicere modum secundum quem hoc apparet michi possibile. Primo ergo, quantum ad primum modum imaginandi vacuum esse, ego pono quod Deus potest facere accidens sine subiecto, et potest accidentia separare a subiectis suis et separatim conservare; ideo potest simplicem dimensionem creare absque hoc quod cum ea sit aliqua substantia vel etiam aliquid accidens distinctum ab ea. Secundo videtur michi quod non est apud Deum impossibilis penetratio dimensionum, immo ipse potest plura corpora facere esse simul in eodem subiecto vel in eodem loco, absque hoc quod differant ab invicem secundum situm, s.c. absque hoc quod unum sit extra alterum secundum situm. Ergo Deus potest facere simplicem dimensionem sive spacium ab omni substantia naturali separatum in quo vel cum quo absque hoc quod cedat recipi possunt corpora naturalia; et hoc vocabatur vacuum secundum primam imaginationem prius narratam.

Deinde de secundo modo imaginandi, credo, sicut prius arguebatur, quod Deus posset annichilare istum mundum inferiorem conservando celum magnitudines et figuras quales et quantas nunc habet, et concavum orbis lune esset vacuum, et de hoc et de dubitationibus circa hoc accidentibus dictum fuit satis in decimaquinta questione tertii libri. Et nunc ultra concludo correlarium de quo aliquando queritur, s.c. quod possibile esset per vacuum vel per partes vacui videre et audire; quia Deus posset aerem consevare in magnitudine et figura in qua nunc est circa aquam et terram, et annichilare aquam et terram et omnia que in eis contenta sunt, et sic ille aer esset vacuus. Et si Deus in illo aere sustentaret duos homines proper invicem, ipsi viderent se invicem per illum aerem, et possent loqui adinvicem sicut faciunt nunc. Et dictum fuit prius[2] quod illa superficies aeris que est vel esset locus non est indivisibilis secundum profunditatem; immo est bene eius tertia pars vel quarta pars aeris secundum eius divisionem orbicularem, ideo in illa superficie aeris que esset locus vacuus possent poni homines et animalia et a Deo sustineri, s.c. in illa profunditate aeris.

Tunc respondeo breviter AD RATIONES.

<Ad1> Ad primam ego dico quod illa descriptio loci quatenus (?) dat Aristoteles non est simpliciter bona descriptio huius termini locus, quia propter quemcunque casum possibilem non debet propositio universalis falsificari in qua diffinitio affirmatur de diffinito, et tunc si esset vacuum non omnis lcus esset continens locatum. Sed Aristoteles dedit istam descriptionem quia credidit quod non posset esse locus vacuus; et cum hoc etiam ego dico 74rb
quod ista est valde bona descriptio huius termini ‘totalis locus proprius corporis’, ita quod si hec omnia locus proprius corporis equiualeret in significatione huic termino *b*, illa descriptio esset bona descriptio huius termini *b*; omnis enim locus proprius alicuius corporis est superficies corporis continentis illud corpus immediata ei et diversa, etc. Et de hoc etiam descriptio indendit Aristoteles dare illam descriptionem, ideo bene valle bene dedit eam; et cum hoc etiam Aristoteles non intendit dare et verificare istam descriptionem nisi secundum casus naturaliter possibiles, ideo ad hoc bene dedit eam secundum exigentiam sue intentionis. <Ad2-3> De aliis duabus rationibus dictum est in tertio.[3]

[1] QP IV, q. 7.
[2] QP IV, q. 5.
[3] QP III, q. 15.

QUERITUR CONSEQUENTER NONO UTRUM IN MOTIBUS GRAVIUM ET LEVIUM AD SUA LOCA NATURALIA TOTA SUCCESSIO PROVENIAT EX RESISTENTIA MEDII.

ARGUITUR QUOD NON <A1> quia dicit Commentator[1] universaliter quod in omni motu oportet esse resistentiam mobilis ad motorem; ergo ex illa proveniret aliqua successio quamvis medium nichil resisteret.

<A2> Item, ipse dicit quod in omni motu mobile est quodammodo contrarium motori; et contrarium resistit contrario.[2]

<A3> Item, successio est in motu celi et tamen ibi non est resistentia medii, quia non est ibi medium aliud quam ipsum mobile; ergo in motu celi ipsum mobile resistit, et pari ratione videtur esse ita de aliis.

<A4> Item, sequitur quod tota illa successio esset violenta quod est falsum. Falsitas consequentis patet quia illa successio non est aliud quam ipse motus, ideo si illa esset violenta ille motus esset violentus quod est falsum. Sed consequentia prima manifesta est ex descriptione violenti tertio Ethicorum:[3] violentum enim est quod est a principio extrinseco cum passum ad hoc nullam vim conferat, et sic est in proposito.

<A5> Item, motus ille non est solum ex medio vel ex resistentia medii immo magis et principalius est a motore; ergo similiter est de successione quim non sit aliud illa successio quam ille motus, ut dictum est.

<A6> Item, oportet assignare in quo genere cause seu causandi illa successio esset ex illa resistenti quod non apparet facile.

OPPOSITUM DICIT Commentator[4] quia aliter nichil valeret processus Aristotelis ad probandum quod in vacuo si esset grave moveretur in instanti vel etiam ad probandum quod equali velocitate movetur in pleno et in vacuo.

NOTANDUM EST quod successio non est aliud quam motus neque etiam tarditas aut velocitas est aliud quam motus. Sed tamen hoc nomen ‘successio’ manifeste connotat quod continue pars post partem acquiratur dispositio secundum qua est motus et non tota simul, et si hoc nomen ‘motus’ hoc significat vel connotat ex hoc statim sequitur quod successio non solum provenit a resistentia medii, immo principalius a motore, sicut prius arguebatur.

Deinde notandum quod resistentia vocatur inclinatio mobilis ad oppositam dispositionem ei quam motor intendit, et si potentia resistens superet in resistendo potentiam motoris in movendo tunc ab illo motore non fit motus; immo etiam non fieret motus, si essent equales adinvicem (hec in resistendo et illa in movendo). Sed si motor superet, tunc fit motus, et quanto in maiori proportione superat tanto sit motus velocior. Et si nulla esset resistentia tunc fieret mutatio instantanea si movens instanter applicaretur mobili et non successive. Verbi gratia, si Deus instanter crearet unum magnum lucidum in aere tenebroso, instanter fieret lumen intensum et non prius remissum quam intensum et instanter etiam ad tantam distantiam ad quantam posset illuminare et non prius prope quam longe. Et hec dicta sunt vera de motoribus naturalibus prout naturale distinguitur contra voluntarium, sed non oportet quod sint vera de motoribus per volutatem liberam quia non oportet quod moveant maxima velocitate qua movere possunt sed maxima quam simul volunt et possunt. Et ideo quicquid ego dicam donec ego loquor de motu celi ego volo quod intelligatur de motibus qui fiunt a potentiis naturalibus, s.c. non voluntariis immo nichil intendo ad presens dicere nisi de motoribus inanimatis. 74va

<T1.1> Tunc pono primam conclusionem, s.c. quod impossibile est motore sufficienter applicato mobili esse motum sine resistentia, quia si non est successio (s.c. quod pars post partem et non tota simul acquiritur dispositio secundum quam innatus est esse) motus non est motus sed mutatio instantanea. Sed non est talis successio nisi resistentia sit ut dictam est, ergo etc. Nec obstat si Deus sine resistentia moveat successive quia non est determinatio ad talem successionem nisi per voluntatem liberam, s.c. Dei, et hoc est exclusum a proposito.

<T1.2> Secunda conclusio sequitur, quod necessse est in omni motu naturali gravis deorsum esse resistentiam motori. Hec sequitur ex precedente conclusione quia omnis talis motus est successivus et non est mutatio instantanea.

<T1.3> Tertia conclusio est quod in talibus motibus materia prima non resistit motori quia materia prima vel ad nullum locum inclinat et ad nullam dispositionem vel si passive dicatur habere incilnationem et appetitum tamen indifferenter habet inclinationem ad illud quod motor intendit sicut ad oppositum. Ideo quanta esset eius inclinatio illa non prohiberet quin motor moveret, et hoc non vocamus resistentiam. Resistentia enim est inclinatio per modum activum, s.c. determinata ad unum, ita quod non ad oppositum et ad aliud cuius oppositum motor intendit. Et talis inclinatio non convenit materie quia indifferens est omni forme vel dispositioni possibili inesse rebus naturalibus.

<T1.4> Quarta conclusio est quod simpliciter gravi nichil est intrinsecum quod resistat motori moventi ipsum grave natura deorsum; et voco illud pure et simpliciter grave quod nullum habet gradum levitatis. Consequentia patet quia motor illius gravis est sua gravitas et forte cum hoc sua forma substantialis intendentes locum deorsum, et non resistunt sibi ipsis nec materia etiam resistit, ut dictum est, nec sunt accidentia que etiam resistant quia nullum est accidens quod inclinat ad oppositum locum nisi illud sit levitas vel aliquis gradus levitatis.

<T1.5> Quinta conclusio est quod in motu naturali simpliciter gravis deorsum medium per quod ipsum movetur resistit motori. Hoc apparet quia quanto medium est densius tanto est tardior motus; et si est tardior hoc est propter maiorem resistentiam, ergo medium resistit.

Item, terre pulverisate videmus partes ita parvas existere sursum in aere quod non moverentur deorsum vel valde tarde moverentur quamvis essent simpliciter graves et quod gravitas sua sit motor intendens locum deorsum; et non potest reddi causa quare sic tarde moverentur vel forte non moventur nisi ex eo quod aer in quo sunt vel per que innate sunt moveri resistit, et quod potentia motiva earum vel non superat resistentiam vel in valde parva portione superat propter illarum partium nimiam parvitatem. 74vb

Item, in tali motu est resistentia, ut dicit secunda conclusio, et non ex aliquo quod sit in ipso gravi, ut dicit quinta conclusio, et non apparet quod extrinsecum possit magis resistere quam medium quod oportet dividi; ergo ipsum resistit.

Sed contra hanc conclusionem obicitur quia medium non inclinat ad oppositum eius quod motor intendit, ergo non resistit. Consequentia patet ex prius dictis; antecedens probatur quia si aqua descendit per aerem sicut gravitas movens aquam inclinat ad esse sub aere ita levitas aeris inclinat ad esse supra aquam; ideo aer in aqua existens ascenderet, et aqua in aere existens descenderet, et hee inclinationes non repugnant sibi invicem sed consonant.

Solutio dico quod licet dicte inclinationes non repugnant sed consonant, tamen est alia inclinatio, s.c. quod unumquodque corpus naturale appetit suam continuationem quia virtus unita est fortior seipsa dispersa; grave autem non potest descendere nisi dividendo medium, ideo inclinat ad divisionem medii, et huic inclinationi resistit inclinatio medii ad sui continuationem. Et iterum, si est aer sub aqua et aqua supra aerem aqua inclinat ad descensum per viam rectam quia illa est brevior, et aer inclinat ad ascensum etiam per viam rectam; et hec non possunt fieri quia non est possibilis penetratio corporum, ideo sic resistunt sibi

invicem, et oportet unum eorum dividi vel lateraliter moveri per viam obliquam; et sic est resistentia.

Unde sic circa hoc notandum quod aliqui propter modum nunc tactum ponunt in motu naturali gravis deorsum resistentiam intrinsecam, videlicet quod ponatur grossus lapis descendens omnes partes eius tendunt ad centrum secundum rectam viam, et extremes partes laterales non possent recedere ad centrum secundum rectam viam partibus mediis prohibentibus, ideo videtur quod partes gravis habeant sibi invicem quamdam prohibitionem vel resistentiam contra inclinationem eorum ad centrum; et hoc videtur esse contra quintam conclusionem prius positam. Sed michi videtur respondendum supponendo quod nichil est centrum vel medium mundi quod sit res indivisibilis sicut imaginaretur punctus in linea, immo centrum vel medium mundi est res magna longa lata et profunda ut totalis terra vel aliqua pars quantitativa ipsius; nec locus qui est inferius et summe deorsum est medium mundi immo est continens medium mundi. Et ideo etiam lapis motus deorsum non intendit nec inclinatur ad medium mundi indivisibile. Immo si non esset aliquid grave nisi iste lapis sed quod totum esset aer ubi nunc sunt terra et aqua iste lapis inclinaretur et moveretur ad hoc quod fieret medium mundi, et ad hoc et non ad aliud omnes partes eius simul tenderent et inclinarent, et tandem ille lapis fieret medium mundi nec ad hoc partes eius impedirent se invicem.

Item, totus ille lapis simul moveretur multo velocius quam moveretur una pars eius deorsum, ergo non impediunt nec retardant se ad invicem sed potius iuvant et velocitant.

Iterum, ad huc oportet imaginari quod alicuius magne aque continue una pars respectu alterius partis non appetit esse inferius si sint equalis gradus in levitate et gravitate; et ideo si nauta descendit ad fundum maris, ut habeat super humeros centum dolia aque, ipse non sentit gravedinem illius aque quia illa aqua que est supra ipsum non inclinat ad amplius esse deorsum; sed respectu aeris inclinaret si aer esset interior. Et iterum, quamvis aqua non esset in suo loco naturali sed multum alte in vase ut in cacumine turris Beate Marie, tamen una pars respectu alterius non inclinaret ad esse deorsum. Ut si aliquis esset ibi in balneo et haberet tibiam suam in fundo ita quod supra eam esset magna quantitas aque quam ipse in aere non posset portare, tamen non sentiret pondus illius aque, s.c. quia illa aqua in respectu aqua inferioris vel circunstantis non trahit nec inclinat ad esse inferius licet totalis aqua cum vase respectu aeris inferioris vel circunstantis inclinaret ad esse inferius. Sic ergo ego dico de totali terra que non est medium mundi quod nondum solum pars eius media quiescit naturaliter, immo etiam partes eius extreme nec amplius habent inclinationem ad punctum medium quod imaginatur esse centrum. Et ita etiam credendum est quod si totalis terra esset nunc elevata simul usque ad orbem lune ipsa non tenderet ad punctum quod imaginatur esse centrum, immo ipsa et omnes partes eius simul tenderent ad hoc quod illa totalis esset medium mundi et ita ipsa et omnes partes eius una inclinatione continua tenderent et moverentur per viam rectam ad occupandum tantum locum absque hoc quod pars media et partes extreme inclinarent aliquo modo vel resisterent contra invicem. 75ra

<T1.6> Tunc iterum pono sextam conclusionem, s.c. quod aliquando in motu naturali gravis deorsum est aliud resistens a medio per quod ipsum movetur, et hoc primo apparet rudi exemplo, s.c. quod plumbum in horologio descendit continue et naturaliter per suam gravitatem intrinsecam, et tamen plus resistit corda ad quam pendet quam medium per quod descendit sed etiam patet sine artificio. Si enim lapis descendit in aere, oportet aerem inferiorem dividi, et cedere et fieri quamdam violentam condensationem ut post videbitur; ita oportet aerem superiorem consequi ad replendum locum a quo ille lapis recedit, quod non potest esse sine aliqua divisione vel distractione partium aeris superioris vel circunstantis, contra quam distractionem aer ille superior habet inclinationem, quia dictum est quod habet naturaliter inclinationem ad permanendum in sua continuatione, et oportet etiam in aere

superiori fieri quandam violentam rarefactionem, ut dicetur post, ad cuius oppositum aer naturaliter inclinatur; et ita aer superior per huiusmodi inclinationes resistit aliqualiter.

Dicto de puro et simpliciter gravi et levi dicendum est de aliis gravibus et levibus. Et oportet hic aliqua supponere ex libro celi et mundi ex quarto[5] et ex illis que in isto quarto debent declarari et probari, ego suppono quod si esset aqua pura et in dispositione sibi convenientissima qualitas secundum quam inclinaretur ad essendum sub aere et supra terram esset ita simplex sicut qualitas terre pure que inclinaretur ad esse in infimo loco elementorum. Et hoc est ita intelligendum quod licet in tepido sit gradus alterius rationis quod tepidum remitteret frigidissimum et alterius rationis quo remitteret calidissimum quia ille est gradus caliditatis et iste est gradus frigiditatis, tamen non sic esset in proposito immo eadem qualitas omnino; et secundum eundem gradum omnem ipsius moveret: aquam deorsum si esset in aere et sursum si esset in terra, et resisteret motui sursum vel deorsum si esset intermedia, s.c. in loco naturali. Et ita de aere quantum ad esse in medio aque et ignis[a] et quantum ad moveri 75rb
superius si esset in aqua et inferius si esset in igne, hec non probo hic sed suppono, tanquam probanda in secundo celi et mundi.[6] Deinde etiam suppono ex eodem quarto celi et mundi[7] et etiam ex primo et ex libro de generatione[8] quod mixtum prout participat aliquo[b] modo qualitates naturales elementorum vel aliquos gradus eorum, participat enim aliquid de caliditate ratione ignis et aeris et aliquid de frigiditate ratione terre et aque, et ita etiam participat aliquid de levitate et aliquid de gravitate. Et ita qualitas gravis vel levis mixti motiva ipsius secundum locum non est simplex sicut erant qualitates elementorum, sed somposita ex partibus et gradibus diversarum rationum et inclinantibus ad diversa loca. Istis visis pono conclusiones.

<T2.1> Prima conclusio est quod cum aer existens in aqua ascendit et existens in igne descendit, ille aer in tali motu nullam habet resistentiam intrinsecam. Quia non per materiam, ut dictum fuit, nec per formam quia illa inclinat ad esse supra aquam et sic ad ascendendum et ad esse sub igne et sic ad descendendum, nec per qualitatem motivam ipsius pari ratione, ipsa enim tota ex et quilibet gradus eius inclinat ad esse sub igne et supra aquam; et nullus dicit quod sit resistentia per alias qualitates naturales ipsius aeris. Et similiter diceretur de aqua que naturaliter ascenderet in terra et descenderet in aere; dico enim bene quod si esset aqua in terra ascenderet naturaliter si terra circunstans esset fluxibilis ut faciliter posset moveri ad replendum locum a quo illa aqua ascenderet.

<T2.2> Secunda conclusio est quod grave mixtum si esset in igne descenderet naturaliter et non haberet resistentiam intrinsecam. Quia non haberet ex ratione aeris aque vel terre vel participationis suarum qualitatum, quia hec omnia inclinant ad esse sub igne, et sic inclinant ad descendendum, non ergo resistunt descensui. Sed etiam nec esset resistentia ratione ignis vel qualitatis quam ratione ignis illud mixtum participat, quia illa qualitas in igne et respectu partium ignis circunstantium nec inclinat ad esse superius nec ad esse inferius, unde omnino satiatus est appetitus ipsius ignis ad esse in loco naturali, sive sit superius sive inferius. Dum tamen sit supra aerem et quod non habeat supra aliquid gravius se, omnino nulla est resistentia ex parte illius quamdiu est in spera ignis; licet ex parte eius bene esset resistentia quando exiret a spera ignis. Et proportionabiliter etiam debet poni quod grave vel leve mixtum cum existens in terra ascenderet, nulla esset resistentia intrinseca donec exiret a terra; et hoc apparet proportionabiliter modo posito quod terra esset bene et faciliter fluxibilis ad replendum locus a quo illud ascenderet; sed quia non sic est fluxibilis sed solida, ideo non solum prohiberetur ascensus talis mixti, immo etiam prohiberetur ascensus levis simplicis, s.c. aeris existentis in profundis cavernis terre.

[a] Corr. *aeris*
[b] Corr. *participata liquo*

Tamen contra istam secundam conclusionem obicitur quia pure et simpliciter grave si esset in spera ignis velocius descenderet per illum ignem quam grave mixtum habens aliquos gradus levitatis; et hoc non videretur esse nisi quia illi gradus levitatis resisterent.

Solutio: concedo quod velocius descenderet, sed hoc non esset quia gradus levitatis resistunt, sed quia non iuvant ad descendendum. Verbi gratia, sit globus pure gravis et alius 75va
globus mixti equaliter ex quattuor elementis, et sint similes in magnitudine et figura. Et habeat globus gravis, s.c. terre, octo gradus gravitatis, ita globus mixti habebit octo gradus proportionales illis, s.c. duos gravitatis ratione terre, duos etiam gravitatis ratione aque, duos levitatis ratione aeris, et duos ratione ignis. Modo in descendendo per ignem omnes octo moverent simul ad descensum illius terre, et ad descensum illius mixti non moverent nisi sex, quia duo ex parte ignis nec moverent nec resisterent. Ideo terra moveretur sive descenderet velocius propter maiorem virtutem moventem licet resistentia non sit maior aut minor.

<T2.3> Tertia conclusio est et videtur michi ponenda quod grave vel leve mixtum quando naturaliter movetur in aere vel in aqua sursum vel deorsum habet intrinsecam resistentiam, supponendo quod sit mixtum ex quattuor elementis ita quod de cuiuslibet elementi virtute aliquid participat. Conclusio probatur quia gradus gravitatis quos habet ratione terre inclinant ad locum deorsum, s.c. ad esse sub aqua et aere, ideo si movetur sursum per virtutes aliorum elementorum dominantes, tamen illi gradus ex parte terre resistunt propter inclinationem ad oppositum. Et similiter gradus levitatis quos habet ratione ignis inclinant ad locum ignis, s.c. ad esse super aerem et aquam, ideo si descendit per gravitate terre vel aque dominantem, tamen illi gradus ex parte ignis resistunt propter inclinationem ad oppositum. Sed aliqui volunt istam rationem solvere dicentes quod in tepido gradus caliditatis et gradus frigiditatis simul existentes non habent adinvicem contrarietatem nec agunt vel patiuntur adinvicem, ita ergo in gravi vel levi mixto gradus levitatis non repugnant gradibus gravitatis vel econverso ideo nec sibi invicem resistunt, solutio dico quod in tepido gradus et frigidatis et caliditatis non agunt in invicem nec in aliud consimiliter tepidum, sed illud tepidum ageret in calidius ratione sue frigiditatis vel resisteret ei, et etiam ageret ratione sue caliditatis in frigidius vel resisteret ei. Et ita etiam dico quod mixtum ex gravitate aliqua terre et levitate aliqua ignis ita se habet quod nec gravitas in levitatem nec levitas in gravitatem agit, nec etiam in respectu corporis consimiliter gravis et levis agerent inclinando ad esse supra vel infra illud; sed tamen in respectu gravioris existentis superius aliud mixtum ratione levitatis moveret se superius nisi esset nimia resistentia extrinseca vel nisi esset tanta virtus aut maior inclinans ad inferius. Nec magis dissimile est de motu celi de quo alique rationes tangebant et de illo motu pono conclusiones.

<T3.1> Prima est quod primum mobile nullam habet resistentiam intrinsecam motui suo vel motori, quia primi mobilis perfectio naturalis est continue moveri et non in aliquo termino vel situ quiescere; sed omne ens naturale naturaliter inclinatur in suam perfectionem et non in oppositum, ergo primum mobile naturaliter inclinatur ad semper moveri et nunquam quiescere, ergo non resistit motui vel moventi. Et pari ratione diceretur quod nulle naturales dispositiones illius primi mobilis resisterent, omnia enim disposita sunt et ordinata ad movendum.

<T3.2> Secunda conclusio est quod quelibet spera celestis movetur sine resistentia intrinseca; et hec conclusio apparet sicut prior quare etc.

<T3.3> Tertia conclusio est difficilis, s.c. quod nulla spera celestis in motu suo vel in 75vb
motibus suis habet aliquam resistentiam. Probatur quia non habet resistentiam intrinsecam, ut dictum est, nec extrinsecam, quia non ex parte Dei et intelligentiarum, quia ille secundum Aristotelem[9] nullo modo adversantur adinvicem nec aliquid potest resistere potentia divine propter eius infinitatem; nec ex parte celorum et motuum potest esse quod unum alteri resistat,

quia non invicem continua sunt nec colligata propter quod unus orbis debeat alteri resistere vel alterum trahere aut pellere.

Sed tamen contra istam conclusionem sunt difficiles rationes. Prima est ex quo non est ibi resistentia deberet fieri mutatio instantanea non autem temporalis secundum dicta prius.[10]

Secunda ratio est quia sequitur quod musca vel saltem intelligentia que non esset fortioris potentie quam musca posset movere celum, etiam velociori motu quam nunc moveatur motu diurno; quia ad movendum vel etiam ad movendum velocius non requiritur maior potentia nisi ad agis superandum resistentiam.

Item, nos videmus manifeste quod in celo mobili si sint motus plures diversi et diverse inclinationes una resistit alteri et retardat vel impedit alterum motu. Verbi gratia, si lapis proicitur lateraliter et velociter, non poterit cadere deorsum per longum tempus, quia motus ille lateralis et velor impedit vel resistit inclinationi quam ille lapis habet per suam gravitatem ad movendum deorsum. Cum ergo eadem spera duplici motu moveatur a duplici motore, s.c. motu diurno et in obliquo circulo, oportet quod motus unus resistat alteri motui et retardet ipsum et econverso.

Et iterum, oportet imgainari ibi aliam causam resistentie et retardationis, quia in quocunque loco vel ubi celum fuerit est sibi naturale et conveniens, ideo appetit ibi esse sicut materia appetit formam quam habet per modum delectationis, ut dicitur in primo libro.[11] Quamvis etiam per modum desiderii appeteret ad ubi, sicut materia aliam formam, et ita appetitus ad ubi quod habet est quedam resistentia motui ad alterum ubi.

Iterum, beatus Thomas[12] adhuc in omni motu locali imaginatur aliam resistentiam, s.c. incompossibilitatem terminorum; non enim est possibile naturaliter quod idem lapis sit simul sursum in spera ignis et in terra et in locis intermediis, s.c. in aqua et aere, quia oporteret ipsum distare a seipso quod est impossibile; ideo necesse est si sit in spera ignis et post in loco terre quod hoc sit successive, prius in aere et post in aqua et tandem in terra. Et ad hoc vadit auctoritas Aristotelis quarto huius[13] dicentis quod prius et posterius in motu provenit ex priori et posteriori in magnitudine, s.c. in spacio in quo est motus; unde in sexto huius dicitur[14] quod oportet motum tempus et spacium dividi proportionaliter in partes priores et posteriores et quod in nullo eorum est dare primum. Hoc enim totum provenit ex incompossibilitate essendi simul terminos magnitudinis, ita ergo impossibile est quod simul sol sit in oriente et in occidente; oportet quod sit successio licet non esset aliunde resistentia.

Item, adhuc aliter imaginatur resistentiam ex eo quod celum secum trahit ignem in spera sua et supremam regionem aeris, prout hoc arguitur de stella comata in primo Metheorum.[15] Et in hoc tractatu ignis et aer resistunt inclinationem habentes ad ibi quiescendum, sicut lapis si deberes ipsum trahere post te resisteret et retarderet ambulationem tuam.

Ista sunt bene difficilia, sicut michi videtur, quibus non obstantibus apparet michi quod motus corporum celestium vel eroum motibus nichil resistit.

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Ideo ad primam rationem dicitur primo quod intelligentia movet voluntarie, ideo non movet quacunque velocitate[a] potest sed quanta vult. Et iterum, intelligentia non intendit aliquem terminum finalem in quo celum debeat quiescere, quia si ipsa intenderet ipsa forte faceret instanter celum esse in illo termino eo quod non haberet resistentiam. Sed ipsa intendit movere secundum se non propter esse in termino, quia perfectio celi continue consistit in continue moveri non in esse motum nec in esse alicubi in quiete; ideo successive et continue et perpetuo movet qua velocitate intendit et vult movere.

[a] Corr. *voluntate*

Contra istas solutiones obicitur quia licet intelligentia non moveat forte quantumcunque potest velociter sed quantum vult, tamen possibile est de intelligentia virtutis finite quod velit movere quantumcunque potest velocissime, et tunc cum non sit resistentia videretur sequi infinita velocitas.

Ad hoc respondetur quod non est dare maximam velocitatem qua potest movere, quia 'infinita velocitate potest movere' capiendo infinita sincathegoreumatice, sed non potest movere infinita velocitate capiendo infinita cathegoreumatice quia illa non est possibilis etiam per potentiam divinam. Ideo negatur quod possit movere vel etiam velle movere maxima velocitate qua potest movere. Unde etiam ista concederetur quod quantumcunque potest movere velociter, ipsa potest velle movere ita velociter; sed hec reputaratur impossibilis: quantumcunque ipsa potest movere velociter, ipsa movet vel vult movere velociter. Verum etiam est quod ista solutio non solveret argumentum secundum quid erat de musca, ideo illa solutio datur ad principalem rationem satis apparens, videlicet quod ex terminatione potentie active provenit terminatio in effectu licet nulla sit resistentia; unde maiorem effectum intensiorem et perfectiorem faceret maior potentia et minorem minor licet nulla esset resistentia. Verbi gratia, magis lucidum vel lucius facit lumen intensius ad maiorem distantiam quam minus lucidum. Et etiam debile calefactivum, si approximaretur calefactibili non habenti autem aliquem gradum frigiditatis nec habenti aliquam resistentiam, tamen non faceret in eo caliditatem intensissimam nec multum intensam, sed proportionatam sue virtuti. Motus ergo qui est effectus intelligentie virtutis finite non fieret infinite velocitatis sive infinite intensus licet intelligentia illa moveret secundum extremum sue potentie. Unde Aristoteles et Commentator ut puto crediderunt quod intelligentie saltem alie a Deo movent quantumcunque velociter possunt movere; unde dicunt quod si in celo adderetur una stella, intelligentia non amplius moveret ipsum vel tardius moveret,[16] licet ista solutio sit satis subtilis. Tamen videtur esse contra dicta quia prius dictum est: quod si non esset resistentia, fieret mutatio instantanea. Et ad hoc est dicendum quod hoc verum est de virtutibus naturalibus inanimatis de quibus tunc erat sermo, propter hoc quod ille non intendunt motum secundum se sed intendunt terminum, ut lapis existens sursum intendit esse deorsum. Ideo si non esset resistentia, faceret se instanter deorsum, et non indigeret facere motum nec faceret, sed propter resistentiam non potest instanter facere se deorsum immo indiget quod per motum auferat resistentiam ideo facit motum.

Sed adhuc hec omnia non videntur sufficere, quia secundum istam solutionem sequitur quod virtus movens lapidem deorsum esset fortior quam virtus movens speram lune aut solis, quod omnino videtur ficticium dicere et absurdum. Consequentia probatur supponendo quia omnis virtus activa vel motiva est finita excepta virtute illa quod Deus est, ideo virtus intelligentie moventis lunam in obliquo circulo est finita. Cum ipsa secundum Aristotelem sit intelligentia alia a Deo, et sic quocunque mobili dato ipsa non posset infinita velocitate movere ipsum, sed etiam esset determinata ad certam velocitatem, sic quod non posset ipsum movere velocius. Hoc oportet concedere secundum predictam solutionem. Tunc ergo ego arguo quod virtus lapidis *b* sit fortior quia illa virtus est maior que aliquid mobile certum datum infinita velcitate potest movere ipsum quam illa que nullum mobile certum datum potest infinita velocitate movere ipsum, et capio semper 'infinita' sincathegoreumatice. Sed nullum mobile datum intelligentia posset infinita velocitate movere, ut dictum est. Virtus autem lapidis illum lapidem infinita velocitate potest movere in qua proportione minoraretur resistentia in illa, vel in conserva proportione maioraretur velocitas; sed saltem per potentiam divinam in infinitum, s.c. in subduplo, in subcentuplo, et sic sine statu posset minorari resistentia, ergo in duplo et centuplo et sic sine statu posset intendi vel augeri velocitas. Et sic illa virtus motiva lapidis, licet sit finita, non est terminata ad effectum finitum, quod est contra predictam solutionem. Et non oportet hic recurrere ad potentiam divinam et supernaturalem in

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dicendo quod resistentia possit diminui in subduplo etc., immo Aristoteles hic ponit in isto loco quod quantacunque subtilitate medii data potest in quacunque proportione dari subtilior et minus resistens.[17] Verum est tamen quod hoc dictum Aristotelis non credo esse verrum nisi per potentiam supernaturalem, sed tamen credo ipsum verum esse. Sine dubio non apparet michi quod illud argumentum posset bene solvi sustenendo solutionem contra quam arguit, nisi concedendo resistentiam in celo, vel nisi recurrendo ad opinionem Avempeche subtilissimi philosophi in omnibus in quibus Commentator recitat eum.[18] Erat autem eius opinio, sicut credo, quod omni resistentia circunscripta sive in faciendo aliam rem ex determinatione potentie moventis provenit determinatio effectus, et quod tanta potentia non posset effectum maiorem producere vel intensiorem. Et ita oportet dicere quod licet in motu gravis deorsum non resisteret medium nec aliquid aliud, tamen si gravitas vel aliud movens inclinaret ad movendum illud grave inferius, motus esset determinate velocitatis. Ideo neganda essent que dicunt Aristoteles et Commentator,[19] s.c. quod si sit idem movens vel equale in movendo idem grave vel consimile per diversa media et dissimilia, motus ad motum se habebunt in simili proportione in velocitate et tarditate sicut medium ad medium in subtilitate et grossitate sive in magis aut minus resistendo. Hoc enim non esset verum, quia imaginando quod sit aliquid gradus tarditatis ex determinatione moventis omni resistentia circunscripta, tamen resistentia medii addit alios gradus tarditatis; et tunc non quantum ad tarditatem moventis sed quantum ad tarditatem additam ex resistentia medii valerent ille proportionalitates, quas ponit Aristoteles de velocitate et tarditate in motu ad subtilitatem et grossitatem medii. Et secundum hoc etiam oportet corrigere quod ante dictum fuit, s.c. quod quanto est maior proportio secundum quam virtus motiva superaret resistentiam tanto esset motus velocior, et quanto minor tanto tardior, et quod si non esset resistentia non esset successio. Hoc enim totum non esset verum nisi quantum ad tarditatem additam defalcando aliam que esset ex determinatione potentie. Verbi gratia, in spacio *a* sunt duo lapides et in spacio *b* nulli; tunc utrobique ponantur lapides alii, et quandocunque in spacio *a* ponitur unus in spacio *b* ponuntur duo. Constat quod mutabitur proportio lapidum numeralis spacii *b* ad lapides spacii *a*: nam in prima appositione erunt in spacio *a* tres lapides et in *b* duo, et est proportio sex qui altera, s.c trium ad duo, et in secunda appositione erunt in *a* quattuor lapides et in *b* quattuor, et erit proportio equalitatis. Sed tamen defalcando duos primos lapides prius presuppositos semper quantum ad alios manebit eadem proportio, quia semper lapides *b* erunt dupli ad lapides *a*. Et non apparet michi quod ista imaginatio Avempeche possit demonstrative reprobari vel probari, sed adhuc si hec imaginatio quam non nego non concederetur apparet michi alia imaginatio que etiam sicut michi videtur non posset demonstrative improbari licet non sit secundum opinionem Aristotelis. S.c. quod non quaelibet virtus activa potest in quodlibet passivum agere, sed determinata in determinatum, et hoc bene dicit Aristoteles primo Phisicorum:[20] caliditas enim ageret caliditatem in corpus opacum sibi approximatum, lucidum autem non ageret in ipsum lumen nec color in suam speciem; et sol non calefacit corpora celestia, calefacit tamen corpora inferiora; nec gravitas aut levitas, caliditas vel frigiditas possent movere celum. Diceretur ergo quod nulla est virtus creata quod moveat celos nec quod posset movere celos nisi Deus daret adhuc ei virtutem, sed Deus movet eos quanta velocitate vult et sicut vult. Nec sequitur quod potentia gravis sit maior aut equalis potentie divine licet infinita velocitate possit movere; quia si aliqua virtus movet tali velocitate talem resistentiam, non erit maior virtus sed equalis que duplici velocitate movebit subduplam resistentiam.

76va

Adhuc est alia imaginatio quam nescirem demonstrative improbare, s.c. quod a creatione mundi Deus movit celos tot et talibus motibus sicut nunc moventur, et movendo impressit eis impetus per quod postea movebantur uniformiter, propter hoc quod illi impetus cum non habeant resistentiam nunquam corrumpuntur et diminuuntur, sicut nos dicimus lapidem proiectum post recessum a proiciente moveri per impetum sibi impressum, sed tamen

propter magnam resistentiam tam ex medio quam inclinatione ad alium locum ille impetus continue diminuitur et tandem cessat. Et secundum istam imaginationem non oporteret ponere intelligentias appropriate moventes corpora celestia, immo etiam non oporteret quod Deus moveret ea nisi per modum generalis influentie, sicut nos dicimus quod ad omne quod sit ipse cooperatur. Et etiam cum ista imaginatione posset salvari quid dicunt Aristoteles et Commentator, s.c. quod ubi est resistentia, proportio motus ad motum in velocitate vel tarditate est sicut proportio ad proportionem moventium ad suas resistentias, et quod si non esset resistentia, non esset successio; et hoc etiam potest salvare ista imaginatio que non ponit celos moveri per tales impetus, sed ab ipso Deo. Imaginatio autem Avempeche non aufert opinionem Aristotelis et Commentatoris de hoc quod motus ad motum in velocitate et tarditate sit sicut medii ad medium in subtilitate et grossitate. Item, per omnes istas tres imaginationes solutum est secundum argumentum, omnino enim absurdum est dicere quod in infinitum parva potentia posset movere celos.

Ad tertiam rationem dico per hoc quod pila voluitur super terram movetur recte de termino ad terminum melius quam si non volueretur; motum enim plures in eodem mobili non retardant vel impediunt se invicem nisi sint secundum inclinationes contrarias vel ad terminos incompossibiles. Sic enim gravitas et impetus in proiectione sibi invicem resistunt, sed hoc in celo non est quia omnino possunt simul stare motus plures eiusdem spere super diversos polos absque impedimento unius ab altero. 76vb

Ad quartam rationem dicitur quod celum saltem ultima spera nec est in ubi nec est in loco, et si esset in loco vel ubi tamen non esset sibi naturale vel conveniens esse ibi in quiete, sed in motu, qui est perfectio quedam ipsius celi.

Ad quintam dico quod nullus terminus per quem possit esse resistentia vel inclinatio vel qui aliquid operetur ad motus celi est assignandus in celo, nec partes fluxus, sicut prius dicebatur in tertio huius;[21] nec etiam ibi est incompossibilitas terminorum quantum ad ea que spere mote sunt intrinseca, et iterum incompossibilitas terminorum non sufficit ad hoc quod mutatio sit successiva, quia in mutatione instantanea esset incompossibilitas terminorum immo etiam corpus quod est in celo Deus posset facere instanter esse in terra.

Ad aliam conceditur bene quod prius et posterius in motu est propter prius et posterius in magnitudine vel in spacio una cum resistentia, ut lucidum non prius illuminaret prope quam longe, sicut dicebatur.

Ad ultimam dico quod non debet imaginari quod celum trahat secum igenem vel aerem, quia esset motus violentus, et oporteret quod celum esset illi igni colligatum, quod non est ita. Sed ignis naturaliter insequitur locum suum, et naturaliter inclinatur voluntati primi moventis, quia omnia sunt naturaliter gratia ipsius et gratia ipsius operantur. Nec ignis illic habet inclinationem ad quiescendum, nisi quiete opposita motui recto secundum quem recederet ab illo loco suo naturali; et si ignis ibi ex toto quiesceret adhuc non impediret motum celi cum sibi non sit continuus nec colligatus.

Tunc igitur respondendum est AD RATIONES PRINCIPALES.

<Ad1> Prima auctoritas Commentatoris est concedenda de motibus gravium, sed illud mobile quod resistit gravi descendenti non est illud grave sed est medium quod movetur quia dividitur. <Ad2> Et eodem modo procedit secunda auctoritas, medium enim per quod movetur et dividitur, quoddammodo habet inclinationem contrariam motori vel eius inclinationi per quam resistit ei.

<Ad3-5> De aliis rationibus apparet ex dictis nisi de ultima, que querit in quo genere cause resistentia se habet ad successionem vel motum. <Ad6> Ad quod ego dico quod resistentia est activa causa non quia agat motum cuius resistit sed quia innata est agere ad

oppositum eius quod motor agit. Multis modis dicitur hoc nomen ‘causa agens’ vel ‘activa’, sicut dictum fuit in secundo libro,[22] et videtur michi quod ista questio est bene longa et difficilis et convenienter potuisset fuisse divisa in tres, s.c. una de pure et simpliciter gravibus et levibus, alia de gravibus et levibus non pure et simpliciter, et alia de celo; et sic dividat eam qui voluerit.

[1] AQP IV, 3, fol. 161K.
[2] Ibid.
[3] *Nicomachean Ethics* 1110 a2-5.
[4] AQP IV, 3, fol. 160G-H.
[5] *De caelo* IV, 4-5.
[6] *De caelo* II, 294 b1; IV, 311 a15 ff.
[7] *De caelo* IV, 311 b1.
[8] *De generatione* II, 330 b1 ff.; 334 a20 ff.
[9] *De caelo* II, 288 b20.
[10] In T1.1 of this question.
[11] *Physics* I, 192 a24.
[12] *Commentaria in octo libros Physicorum Aristotelis* IV, lectio 12.
[13] *Physics* IV, 219 a10.
[14] *Physics* VI, 233 a14-17.
[15] *Meteorology* I, 214 b35 ff.
[16] Aristotle’s fullest treatment of this issue is in *Metaphysics* XII, 8 (for Averroes, the corresponding passages in the *Metaphysics* commentary are on fols. 313-337), although I could not find any matches of the example described by Buridan.
[17] I.e., in *Physics* IV, 215 b29-31.
[18] AQP IV, 3, fol. 160D-G.
[19] *Physics* IV, 215 a24-b11; AQP fols. 159-162.
[20] *Physics* I, 188 a32.
[21] QP III, q. 8.
[22] QP II, q. 7.

QUERITUR CONSEQUENTER UTRUM SI VACUUM ESSET GRAVE MOVERETUR IN EO.

ARGUITUR QUOD SIC, <A1> quia Aristoteles probat quod in instanti moveretur,[1] ergo moveretur in vacuo.

OPPOSITUM tamen itendit et dicit Aristoteles.

ISTA QUESTIO sicut formata est una condicionalis que equivalet uni consequentie, s.c. isti consequentie 'vacuum est, ergo grave movetur in eo.' Ideo questio facta non querit nisi utrum ista sit bona consequentia 'vacuum est, ergo grave movetur in eo.' 77ra

<T1> Et statim ponitur prima conclusio, s.c. quod Aristoteles concessisset istam consequentiam tanquam bonam, et similiter istam 'vacuum est, ergo nullum grave movetur in eo,' quia ipse credidit quod simpliciter esset impossibile vacuum esse, et ad impossibile sequitur quodlibet. Ideo concessisset istas 'si vacuum esset grave moveretur in eo' et 'si vacuum esset nullum grave moveretur in eo,' quod esset motus in eo in instanti et quod non esset, et sic de aliis. Nec tales conditionales contradicunt sibi invicem, sicut iste non contradicunt sed sunt simul vere 'si tantum pater est pater est' et 'si tantum pater est nullus pater est;' sed oporteret contradictoriam conditionalis accipere preponendo toti propositioni negationem cadentem super totam propositionem. Sed non possumus sic dicere, quia nos concedimus quod vacuum esse est possibile, scilicet per potentiam divinam, ideo non debemus dicere quod ad hoc sequuntur contradictoria.

<T2> Ideo dico pro secunda conclusione quod ista non est bona consequentia: 'vacuum est, ergo grave movetur in eo,' quia posito quod vacuum esset cum hoc sit possibile tamen forte nullum grave esset in eo, vel licet esset grave in eo tamen forte quiesceret aut per potentiam divinam aut aliter.

<T3> Tertia conclusio est quod etiam ista non est bona consequentia: 'vacuum est, ergo grave non movetur in eo;' quia possibile est quod moveretur saltem per potentiam divinam, sicut diceretur. Ideo iste condicionales sunt negande 'si vacuum esset, grave moveretur in eo,' 'si vacuum esset, grave non moveretur in eo.'

<T4> Quarta conclusio est quod possibile est grave moveri in vacuo, scilicet per potentiam divinam; hoc enim non minus est possibile quam totum mundus moveri motu recto, et de hoc dictum fuit in decima quinta questione tertii libri, sed magis eundo ad intentionem Aristotelis. Et querentium ponamus casum quod vacuum sit, verbi gratia quod aere circundante speras aque et terre remanente in sua quantitate et figura orbiculari sicut nunc est, et quod omnia que sunt infra illum aerem essent annichilata ita quod iste aer esset vacuus secundum imaginationem dudum positam; et lapis esset positus in illo aere vacuo. Utrum moveretur naturaliter descendendo respondeo quod dupliciter potest imaginari quod lapis esset positus in illo aere: uno modo quod esset infra latera concavitatis illius aeris sicut sunt nunc terra; et qua aliomodo quod esset inter superficiem concavam et superficiem convexam illius aeris, ut si esset in media regione aeris.

<T5> Et tunc erit quinta conclusio quod si esset in aere lapis[a] secundo modo ita quod haberet aerem sub se, ipse moveretur deorsum naturaliter per suam gravitatem donec esset sub aere et quod non haberet aerem sub se, quia incliationes gravium et levium ad movendum superius vel inferius sunt secundum exigentias corporum sibi proximorum. Verbi gratia, lignum existens in aqua ascenderet ad esse supra aquam si illa aqua esset in vase detenta in loco altissimo, sicut si esset in profundo putei; ubicunque ergo gravius et levius essent

[a] Corr. *vacuo*

proxima adinvicem, si gravius esset supra levius grave inclinaretur ad descendendum et leve ad ascendendum, donec levius esset supra gravius et gravius infra levius. Ideo lapis ille descenderet per illum aerem donec esset sub eo. Sic ergo concederetur quod grave per suam gravitatem moveretur naturaliter in vacuo, et vacuum etiam vel pars vacui moveretur naturaliter ascendendo, quia quantus esset lapis descendens tantus aer ascenderet naturaliter de illo loco vel situ in quem lapis descenderet ad replendum locum a quo lapis ille descenderet. 77rb

<T6> Sexta conclusio est quod de priori modo concludo quod lapis sit in vacuo, s.c. si ille lapis esset omnino sub illo aere tangens ex uno latere superficiem concavam illius aeris, ille lapis non moveretur nec amplius descenderet per suam gravitatem. Hec conclusio probatur quia ille lapis nichil haberet sub se levius ideo nullam inclinationem haberet ad esse sub aliquo alio quam sub illo sub quo iam erat.

Item, si ille lapis inclinaretur ad motum deorsum, hoc esset vel propter recedere a celo vel propter accedere ad medium mundi. Non propter primum, quia quocunque moveretur tamen non magis distaret a celo quam ante, quia nulla distantia esset nisi per dimensionem illius lapidis et dimensionem aeris et ignis quod omnes manerent. Immo forte si ille lapis non amplius tangeret speram aeris nec aliud corpus ipse nec esset proximus celo nec distans a celo nec secundum aliquem situm se haberet ad celum. Et hoc sufficiat quod dictum fuit in decimaquinta questione tertii libri. Sed etiam nec ille lapis descenderet vel moveretur propter accedere ad medium mundi, quia nichil esset magis in medio mundi quam ille lapis vel quam aer esset, cui ille esset continuus; et si moveretur motu recto, tamen nec ad aliquid corpus accederet nec ab aliquo recederet etc., sicut dictum fuit in tertio huius. Sed aliquis poterit dicere quod vacuum imaginabitur dimensio simplex sine subiecto naturali et qualitatibus naturalibus existens commensurative ubi nunc sunt terra et aqua, s.c. infra latera illius aeris.

<T7> Et tunc est alia conclusio quod adhuc ille lapis non moveretur naturaliter per suam gravitatem, quia non esset infra[a] gravius nec supra levius, nec recedendo ab aere haberet aliquod corpus superius vel inferius sibi proximum grave vel leve, gravius aut levius. Ideo sicut bene dicit Aristoteles,[2] non esset ratio quare magis deberet inclinari ad superius vel inferius ad unum latus vel ad alterum nec valeret ratio de maiori recessum a celo et de maiori distantia, quia hoc facit ad inclinationem naturalem ratione simplicis dimensionis, sed si facit hoc est ratione qua celum aliquando influit propinque et remote et non esset influentia virtutis naturalis si non esset substantia naturalis receptiva illius. Et nos supponimus ac illa simplex dimensio esset sine aliqua alia virtute naturali, quia posito quod esset cum ea gravitas vel levitas, tunc forte aliud esset dicendum. Et iterum si vacuum poneretur esse talis simplex dimensio separata et immobilis tamen illa non esset naturaliter penetrabilis, ideo non posset lapis moveri per eam.

<T8> Octava conclusio quod si grave simplex moveretur per suam gravitatem in vacuo ipsum moveretur in instanti et eque velociter in pleno sicut in vacuo, propter nullam esse resistentiam; et Aristoteles ad hoc format duas rationes in textu.[3] Prima probat quod in instanti quia secundum diversas proportiones moventium ad resistentias sunt motus differenter tardi aut veloces; sed nulla esset proportio vacui ad plenum in resistendo, ergo neque velocitatis ad velocitatem. Et tamen esset proportio velocitatis ad velocitatem si fieret in tempore, quia omnis temporis finiti ad omne tempus finitum est proportio; ergo non fieret in tempore. Et tamen si fieret motus, ipse fieret vel in tempore vel in instanti; ergo fieret in instanti. Secunda ratio Aristotelis est ad probandum quod eque velociter moveretur in pleno sicut in vacuo, quia si moveretur in vacuo, moveretur in aliquo tempore, cum necesse sit omnem motum fieri in tempore. Etiam in pleno moveretur in tempore licet longiori, et illorum temporum esset ad 77va

[a] Corr. *supra*

invicem certa proportio, quia utrumque tempus esset finitum; sit ergo gratia exempli proportio centupla, s.c. quod tempus in quo movetur per plenum sit centuplum ad tempus in quo movetur per vacuum. Deinde ponatur quod illud plenum sive corpus quo locus est repletus subtiliter in centuplo; tunc in centuplo velocitabitur motus et in sub centuplo minorabitur tempus, et sic erit velocitas in pleno equalis velocitati in vacuo, et tempus equale tempori, et tamen adhuc erit plenum illud in quo erit tale corpus in centuplo subtilius etc. Sed contra istam rationem obicitur quia Aristoteles supponit quod corpore subtili dato possit dari in quacunque porportione voluerimus subtilius, et hoc est falsum, sicut non est dare quocunque calido in infinitum calidius. Dicitur licet non per potentiam naturalem tamen per potentiam divinam quocunque subtili dato vel raro vel calido in infinitum est dare subtilius rarius et calidius.

Notandum tamen quod hec octava conclusio et eius rationes posite sunt ex suppositione quod non sit vera opinio Avempeche posita prius quam tamen nescirem improbare et cui magis consentio quam opinioni opposite et que opinio Avempeche si concederetur illa octava conclusio non esset concedenda, nec valerent rationes Aristotelis, sicut ex dictis potest probari. Sed dimitto hec omnia, adhuc aliqui querunt: posito quod in aere sic vacuo esset homo in inferiori et concavo aeris, et ibi per potentiam divinam salvaretur, utrum ille homo posset extra illum aerem extendere vel movere suas tibias et sua brachia, cum tamen illic nullum sit spacium. Et est questio similis, s.c. utrum si esset homo ultra speram ultimam, ipse posset movere ultra illam sua membra, s.c. brachia.

<T9> Et de hoc pono ultimam conclusionem quod homo sic posset movere membra, quia nichil extrinsece ei resisteret, nec valet dicere quod non posset illic brachium ponere vel elevare quia nullum esset ibi spacium in quo posset manum suam extendere. Dico enim quod spacium non est nisi dimensio corporis, et spacium tuum dimensio corporis tui; et antequam elevares brachium ultra illam speram nichil esset ibi, sed brachio elevato esset ibi sacium, s.c. dimensio brachii tui. <Ad1> TUNC DICO ERGO ad auctoritates Aristotelis in principio questionis positas quod Aristoteles non intendebat dicere quod in vacuo fieret motus in instanti etc., sed intendebat istam conditionalem, s.c. quod ‘si in vacuo grave esset, ipsum moveretur per suam gravitatem in instanti’ etc. Et hoc est concessum si non conceditur opinio Avempeche, quia consequens est impossibile simpliciter, ideo volebat ex hoc Aristoteles concludere quod impossibile esset grave per suam gravitatem moveri in vacuo, et hoc etiam concessum est licet dictum sit quod posset in eo moveri per potentiam divinam etc.

[1] *Physics* IV, 215 a25-216 a8.
[2] *Physics* IV, 215 a5-14.
[3] *Physics* IV; the first argument is 215 b13-22; the second 215 b23-216 a7.

QUERITUR UNDECIMO UTRUM RAREFACTIO ET CONDENSATIO SUNT POSSIBILES SIVE UTRUM POSSIBILE EST ALIQUID RAREFIERI AUT CONDENSARI.

ARGUITUR QUOD NON, <A1> quia si esset condensatio, singule partes circunferentiales corporis quod condensaretur ferent adinvicem proximiores movendo se versus centrum illius corporis, et sic partes dextre non cederent sinistris sed moverentur contra eas nec partes ante partibus retro nec partes infra partibus supra; sed impossibile est sic eas moveri contra invicem, quia vel reciperentur in plenum non cedens et sic esset penetratio dimensionum que reputatur impossibilis, vel reciperentur in vacuum quod etiam est impossibile naturaliter, ergo.

<A2> Similiter etiam arguitur de rarefactione, quia oporteret partes circunferentiales undiquaque elongari ab invicem, et tunc etiam inter eas remanerent vacuitates, vel oporteret 77vb
ab extrinseco intrare alia corpora inter illas partes sic ab invicem recedentes quod non apparet possibile.

OPPOSITUM TAMEN APPARET in multis per multas experientias.

NOTANDUM EST quod aliquando capiuntur rarefactio et condensatio improprie, s.c. quando inter corpora grossa sunt corpora subtilia interclusa ut quod inter partes lane sunt multe partes aeris, et tunc pondus lane videtur minorem locum occupare et exinde densius, si comprimantur partes lane simul quia exeunt partes aeris. Et iterum, emissa compressione lane partes lane elongantur ab invicem, et subintrant inter eas partes aeris circunstantis, et sic videtur cumulus lane maiorem locum occupare et esse rarior. Et iste modus est bene possibilis, sed non est nisi methaphorice dicta rarefactio vel condensatio de quibus non intelligimus nunc. Sed rarefactio dicitur proprie, si corpus prius existens minus fiat maius nullo corpore extrinseco subintrante inter partes eius; et condensatio etiam dicitur proprie, si corpus prius existens maius fiat minus nullo corpore exeunte ab eo quod ante esset inclusum inter partes eius. Et est proprietas huius rarefactionis vel condensationis quod eius quod rarefit quelibet pars quantitativa rarefit, et eius quod condensatur quelibet pars condensatur. Et ita quod quelibet pars rari est rara, et densi densa, quod non est in condensatione et rarefactione improprie dictis: in prius dicta rarefactione cumuli lane essent partes dense, s.c. lane, et partes rare, s.c. aeris.

<T1> De huiusmodi ergo proprie dictis rarefactione et condensatione ponitur prima conclusio quod rarefactio et condensatio sunt possibiles per calefactionem et frigefactionem. Ista conclusio patet primo si concedamus elementa generari ex se invicem: aqua enim est densior aere et aer rarior aqua, et ita fit ex denso rarum et ex raro densum; et hoc est rarefactio, condensatio. Et hoc etiam apparet de musto novo posito in dolio bene obstructo quod parando calefit et tumescit, et sic augetur quod oporteret rumpi dolium si non fieret apertura. Hoc etiam apparet de fiola vitrea, que si calefiat super carbones, aer interior calefit ita quod si verso culo fiole os eius ponatur in aqua, tunc quando aer qui est in fiola refrigerabitur apparebit ita condensari et fieri minor quod oportebit aquam ascendere in fiola ad replendum ne sit vacuum. Et omnino manifestum est plurimis experientiis, et concessum quod rarefactio et condensatio sunt isto modo possibiles.

<T2> Secunda conclusio ponitur quod condensatio est possibilis per compressionem absque hoc quod illud corpus quid condensatur frigefiat vel alteretur secundum primas qualitates. Hoc probatur primo per motum localem rectum, aliter enim corpore recte moto oporteret concedere vel vacuum vel penetrationem corporum vel quod omne corpus ad ante cederet vel tandem celum, sicut arguebatur in principio septime questionis huius quarti, et sic respondeatur sicut ibidem notandum fuit. Tunc arguitur ratione sequente que ibidem posita fuit et deducta.

<T3> Tertia conclusio sequitur quod etiam rarefactio est possibilis absque alteratione eius quod rarefit secundum primas qualitates, quia non apparet quare magis sine alteratione secundum primas qualitates debeat esse possibilis condensatio quam rarefactio, et quia sicut argutum est de condensatione ita rationibus conversis argueretur de rarefactione. Nam si corpore recte moto oportet ad ante fieri condensationem ita retro oportet corpora sequi vel tandem celum ut non sit vacuum, et sic oporteret ea rarefieri vel etiam celum sequi. Et etiam, 78ra
sicut ex denso generatur rarum oportet corpora circundantia et tandem celum cedere nisi fiat condensatio vel nisi simul oporteat tantundem generari ex raro densum alibi. Ita sicut ex raro generatur hic densum oportet corpora circundantia et tandem celum consequi nisi fiat rarefactio, vel nisi oporteat alibi sicut simul tantundem fieri ex denso rarum, puta ex aqua aerem. Rationes enim hinc inde sunt proportionabiliter se habentes.

Item, hoc apparet per experientiam: videtur enim michi quod aer isto modo magis sit faciliter rarefactibilis aut condensabilis quam aqua vel aliud magis grossum. Unde videmus quod si dolium plenum vino sit perfectissime bene ligatum et obstructum, et perforetur inferius ad trahendum vinum, vinum non exibit vel valde modicum exibit, quia non potest aer subintrare ad replendum pro eo quod exiret. Sed cum dolium fuerit semiplenum aere, tunc quamvis sit bene obstructum, multum de vino exibit per foramen, quia aer ille potest ad multam quantitatem rarefieri ad replendum pro eo quod exit. Et sic nichil posset exire nisi fieret infra dolium rarefactio vini vel aeris, ex quo dolium est bene obstructum et quod est forte et non faciliter plicabile. Et est notandum, ut michi videtur, quod talis condensatio vel rarefactio est quasi violenta corporibus que sic rarefiunt vel condensantur. Data enim dispositione aeris quantum ad raritatem et densitatem sibi convenientissima, si ultra sine alteratione secundum primas qualitates rarefiat vel condensetur – per hoc quod ab extrinsecis comprimitur vel quod per extrinseca trahitur ad replendum ne sit vacuum – hoc est preter eius propriam inclinationem. Et ideo tendit et inclinatur naturaliter ad revertendum ad statum priorem sibi convenientissimum, et revertitur naturaliter comprimente remoto sicut aqua calefacta moveret se ad refrigerationem. Et forte quod in violentis incurvationibus lignorum habet locum huiusmodi rarefactio et condensatio; nam cum arcus quasi rectificatus et habens superficiem concavam quasi equalem secundum longitudinem superficiei convexe, tamen quando multum incurvatur, oportet superficiem concavam fieri multo breviorem et superficiem convexam longiorem quod forte est per violentam condensationem partium interiorum, et violentam rarefactionem exteriorum; ideo remoto incurvante revertitur velocissime et impetuosissime ad naturalem rectitudinem.

<T4> Quarta conclusio apparet michi probabilis quod in omni rarefactione generatur magnitudo sive dimensio ut prius argutum fuit in primo huius,[1] quando querebatur de distinctione magnitudinis a substantia et qualitate. Non enim per solum motum localem partium sit condensatio, quia tunc cum ego possim velociter movere aerem localiter ego ita possem sine alteratione condensare aerem quantum natura posset per alterationem, quod est falsum. Et hec ratio fuit deducta ubi dictum, et iterum possunt ad hoc apponi persuasiones; aliter enim sequeretur quod rarefactio esset motus vilior et minus nobilis quam condensatio, quod videtur falsum, cum elementa rariora ponantur nobiliora. Consequentia patet quia videtur nobilius quod corpus naturale uniatur quam quod dispergatur, cum virtus unita sit fortior seipsa dispersa et condensatio esset tanquam unio et approximatio partium corporis ad invicem rarefactio autem esset quasi dispersio.

Item, si non sit ibi principaliter nisi motus localis tunc corpus illud naturaliter movebatur motibus contrariis secundum singulas partes, quia contra invicem – hec ad dexteram, alia ad sinistram etc. – et hoc non videtur convenire naturaliter et principaliter aliis ab animatis. 78rb

Item, si in naturali rarefactione non genetur alia dimensio faciens distare, non apparet quo appetitu vel qua inclinatione partes alongabuntur ab invicem. Non enim apparet ratio quare partes caliditatis que generantur appeterent elongari ab invicem, vel etiam quare partes aeris vel forme eius vel materie eius appaterent elongari ab invicem. Non enim debent se odire, ideo non apparet unde et quomodo proveniret naturalis rarefactio.

Item, dimensio reddit extensum, sicut caliditas calidum vel lumen luminosum; ideo videtur rationabile quod sicut plus de caliditate vel de lumine reddit subiectum magis calidum vel luminosum et minus de caliditate vel lumine reddit ipsum minus calidum vel luminosum, ita plus de dimensione reddit magis extensum et minus minus. Unde sicut plus de qualitate reddit intensius ita plus de dimensione reddit extensius. Sed iterum, quia in argumentis tangitur de penetratione dimensionum, ideo de hoc est aliquid dicendum. De quo notandum est quod penetratio de qua loquimur non est prout sagitta penetrat hostium vel corpus hominis dimittendo partes eius et intrando inter eas cedentes sagitte; sed intelligimus de penetratione prout duo corpora quantum ad eorum dimensiones essent simul non distincta ab invicem secundum situm. Et tunc dico quod plures dimensiones sic esse vel fieri simul potest intelligi dupliciter. Uno modo quod una sit subiectum alterius, sicut materia forme vel etiam substantia accidentis, aut etiam quod idem sit subiectum eorum, ut substantia plurium accidentium. Et sic concedunt esse simul plures dimensiones et plura corpora omnes qui ponunt quod omnis res extensa sit magnitudo et dimensio. Alio modo quod plures dimensiones possibiles naturaliter extra invicem existere vel etiam extra invicem existentes fiunt simul secundum eundem situm, et hoc illi dicunt esse impossibile. Sed hec opinio reprobata fuit in primo huius,[2] ideo dimitto eam hic. Et ideo ego do aliam distinctionem quod plures dimensiones esse simul et non reddere subiectum extensius et maius quam faceret una illarum est impossibile, sicut plures gradus albedinis in eodem reddunt illud albius quam faceret unus illorum. Sed plures dimensiones esse simul et reddere subiectum extensius non est impossibile, et ita est in rarefactione, quia cum dimensione precedente generatur in eadem materia alia dimensio, sicut cum gradu caliditatis precedente et alius gradus generatur, et inde materia redditur extensior. Et ita finaliter concluditur quod rarefactio non est motus ad quantitatem secundum quam generatur magnitudo sicut secundum calefactionem caliditas et secundum illuminationem lumen. Et accidit quod <non> sit motus localis, quia si per potentiam divinam esset aer sine aliquo corpore continente, ipsum posset rarefieri et non mutaret locum, quia non haberet locum. Tamen verum est quod aliquando, ut in septimo huius Aristoteles dicit[3] non esse motum per se ad illas dispositiones que acquiruntur per modum sequele, ad alios motus et sic, s.c. per modum sequele, ad calefactionem et frigefactionem vel compressionem vel huiusmodi acquiritur vel corrumpitur dimensio in rarefactione vel condensatione; ideo solet dici quod non sit per se motus ad quantitatem in condensatione vel rarefactione. Ex dictis apparet bene quod sit dicendum AD RATIONES quae in principio questionis fiebant. Non enim est penetratio corporum in condensatione, sed corruptio dimensionis; nec in rarefactione advenit dimensio ab extrinseco, sed generatur et educitur de potentia, scilicet materie, sicut et alie forme.

[1] QP I, q. 8.
[2] Ibid.
[3] *Physics* VII, 250 a28 ff.