Notes on the life and work of Álvaro Tomás

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Alvarus Thomas (fl. 1509), a Portuguese master at the University of Paris at the beginning of the sixteenth century, is still a poorly known historical figure. In his Liber de triplici motu *he presented a comprehensive and sophisticated analysis of the theory of proportions and of the science of motion of his time, in the characteristic form of the Calculatory tradition. Besides some interesting criticism of contemporary physical theories, this work is also relevant from the point of view of mathematics since Thomas achieves some surprising results in the study of infinite series.*
In this paper I summarize the present knowledge on Alvarus Thomas. I collect all biographical information currently available and present very briefly the contents of the Liber de triplici motu *adding some observations on its historical context and influence.*

Introduction

In his well-known work, *Los Matematicos Españoles del siglo XVI*, J. Rey Pastor devotes a brief chapter to the Portuguese Alvarus Thomas (or Álvaro Tomás[1]). After describing in a few pages the main mathematical contributions of the Portuguese scholar, Rey Pastor closes the chapter with the following paragraph:

> Sirvan estas notas sobre el *Liber de triplici motu* de incentivo para que alguien lo analice, tan minuciosamente como merece, y para que alguna corporación ibérica emprenda su traducción. De los eruditos portugueses esperamos que indaguen en sus archivos datos bastantes para trazar la biografia de este sutil ingenio, digno precursor de Pedro Núñez[2].

These words were written in 1926 but unfortunately such a programme of study on this "digno precursor de Pedro Nunes" remains to be accomplished.

Rey Pastor was not the first scholar to mention the work of Alvarus Thomas. In 1913, the great historian of science Pierre Duhem, in his *Études sur Léonard de Vinci* presented the first modern analysis of Thomas' work[3]. Duhem noted Thomas' erudition and brilliance, and commented that

> Les problèmes que ces maîtres et régents s'acharnent à résoudre, dont ils entrevoient parfois la solution, en dépit de leurs connaissances rudimentaires en Mathématiques, ce sont les deux grands problèmes de l'intégration des fonctions et de la sommation des séries. Et l'on se demande alors quels résultats ces hommes n'eussent point obtenus, quelle promotion ils n'eussent point imprimée aux Mathématiques s'il leur eût été donné de lire Archimède[4].

Following these pioneer studies, other historians of science, while investigating the contributions of sixteenth century authors to the development of physics and mathematics, pointed to the important role played by Alvarus

[1]For consistency with the rest of the text I will use the 'English' version of the name. The only exception is the title of this paper.

[2]J. Rey Pastor, *Los Matematicos Españoles del Siglo XVI* (Toledo: Biblioteca Scientia, 1926), p. 89.

[3]Alvarus Thomas was not, in an absolute sense, unknown to historians. His name is included in important bibliographic repertoires since the eighteenth century, such as the one by Barbosa Machado, *Bibliotheca Lusitana* (Lisboa, 1741), Vol. I, pp. 114-115, and appears in well-known nineteenth century studies: Martín Fernandez Navarrete, *Disertacion sobre la Historia de la Nautica* (Madrid: Imprenta de la Viuda de Calero, 1846), p. 126.

[4]Pierre Duhem, *Études sur Leonard de Vinci*, 3 Vols. (Paris: Hermann et Fils, 1906–1913), Vol. III, p. 543. [Information on A. Thomas in pp. 532–543].

Thomas. Of special interest is the work by the eminent historian of mathematics Heinrich Wieleitner, in which Thomas' techniques for the summing of infinite series are analysed[5]. In more recent years, scholars such as Marshal Clagett, William Wallace, Edward Grant and Edith Sylla devoted some attention to the work of Alvarus Thomas. Their studies on the significance of Thomas' contributions will be used throughout this paper. At this point it is sufficient to quote the evaluation made by William Wallace:

> At Paris [...] there can be little doubt that Thomaz was the calculator par excellence at the beginning of the sixteenth century, and the principal stimulus for the revival of interest there in the Mertonian approach to mathematical physics.[6]

Strangely, the impact of these authoritative voices in the Portuguese community has been practically nil. If we except the three brief pages that Gomes Teixeira devoted to Thomas in the *História das Matemáticas em Portugal*[7], and a short, but correct, notice in the most important Portuguese encyclopedia[8], there are no more detailed or reliable references to Thomas' scientific work, much less a careful analysis of his book. Garção Stockler, Rodolfo Guimarães and Pedro José da Cunha in their classic studies[9] do not mention Alvarus Thomas, and later historians of Portuguese science follow essentially the same pattern[10]. The most apt characterization of this state of affairs was perhaps Joaquim de Carvalho's assertion that Thomas was "[...] uma das figuras mais lamentavelmente esquecidas da nossa história científica."[11] Further evidence of the oblivion into which Alvarus Thomas has fallen in his own country is that references to his biography or work often contain innacuracies: caveat lector.

The objective of this paper is to provide a very brief introduction to the life and work of Alvarus Thomas. I do not claim to present here any new findings related to this Portuguese scholar, nor a detailed explanation of his work. However, the neglect into which this Portuguese master has fallen among his countrymen and the importance of his work justify that even such a modest project should be undertaken[12].

Biography

Biographical information on Alvarus Thomas is extremely scarce. As Rey Pastor remarked in the quotation reproduced above, this is an aspect were more work is required.

The facts of Thomas' life that can be ascertained on a documentary basis are very few and cover a time span of only about ten years[13]. The first piece of evidence we have is his book—as far as is known, his only work—published in Paris in 1509 (or 1510[14]). The complete title is: *Liber de triplici motu proportionibus annexis magistri Alvari Thomae Ulixbonensis philosophicas Suiseth calculationes ex parte declarans*, a translation of which runs as follows: "Book on the Three [kinds of] Movement, with Ratios Added, by Master Alvarus Thomas of Lisbon, Explaining in Part Swineshead's Philosophical [i.e. Physical] Calculations".

The "explicit" of the *Liber de triplici motu* states that it was "compositus per Magistrum Alvarum Thomam ulixbonensem. Regentem Parrhisibus in Collegio Cocquereti." Another document confirms that in 1513 Thomas was still teaching Arts, i.e. Natural Philosophy, in the same college.

Thus, Alvarus Thomas was born in Lisbon and acted as Master of Arts and "regens" in the *Collège de Cocqueret*

[5]H. Wieleitner, "Zur Geschichte der unendlichen Reihe im Christlichen Mittelalter", *Bibliotheca Mathematica*, Dritte Folge, Vol. 14, (1914), 150–168.

[6]W. Wallace, "Thomaz, Alvaro", in: C. C. Gillispie (Ed.), *Dictionary of Scientific Biography* (New York: Charles Scribner's Sons, 1970-1980), Vol. 13, p. 350.

[7]F. Gomes Teixeira, *História das Matemáticas em Portugal* (Lisboa: Academia das Ciências de Lisboa, 1934), pp. 95–97.

[8]F. Gama Caeiro, "Tomás, Álvaro", in: *Enciclopédia Luso-Brasileira de Cultura* (Lisboa: Editorial Verbo, 1963–1985), Vol. 17, p. 1643.

[9]Francisco de Borja Garção Stockler, *Ensaio Historico sobre a Origem e Progresso das Mathematicas em Portugal* (Paris: Officina de P. N. Rougeron, 1819); Rodolfo Guimarães, *Les Mathématiques en Portugal* (Coimbra: Imprensa da Universidade, 1900); Pedro José da Cunha, *Bosquejo Histórico das Matemáticas em Portugal* (Lisboa: Imprensa Nacional de Lisboa, 1929).

[10]To give but two examples, only the briefest of mentions is found in Joaquim Barradas de Carvalho, *Portugal e as Origens do Pensamento Moderno* (Lisboa: Livros Horizonte, 1981), p. 69; and in Luís de Albuquerque, "Matemática e Matemáticos em Portugal", in: Joel Serrão (Ed.), *Dicionário de História de Portugal* (Lisboa: Iniciativas Editoriais, 1965), Vol. IV, p. 222.

[11]Joaquim de Carvalho, "Influência dos Descobrimentos e da Colonização na Morfologia da Ciência Portuguesa do Séc. XVI", in: *Obra Completa* (Lisboa: Fundação Calouste Gulbenkian, 1982), Vol. III, p. 360. [Originally in: *Congresso do Mundo Português*, Vol. V (Lisboa, 1940)].

[12]My essential purpose is to introduce this author to a Portuguese audience. I will rely mostly on materials already published. A more extended and detailed study will be presented elsewhere.

[13]For biographical information on Thomas and indications of the original documents, see: Luís de Matos, *Les Portugais à l'Université de Paris entre 1500 et 1550* (Coimbra: Universidade de Coimbra, 1950), R. G. Villoslada, *La Universidad de Paris durante los estudios de Francisco de Vitoria, O.P. 1507–1522* (Roma: Gregorian University Press, 1938), and Luís Ribeiro Soares, *Pedro Margalho* (Lisboa: Imprensa Nacional-Casa da Moeda, 2000).

[14]Owing to a technical detail related to the academic calendar in Paris, there is some uncertainty on the precise date. Following most authors, I will use 1509. See L. R. Soares, *Op. cit.*, p. 225.

in Paris from, at least, 1510 to 1513. This *Collège* had been established in 1439, and although it never rose to the distinction of the *Collège de Montaigu* or the *Collège de Saint-Barbe*, it had among its teachers and students some leading intellectuals of the time[15].

The "regens" was generally a student of one of the higher Faculties (Theology, Law or Medicine) who payed for his studies by teaching Arts in a college. Indeed, it is known that Thomas enrolled at the Faculty of Medicine in 1513 and it is very likely that he studied there while teaching Arts at *Cocqueret*. He completed his *licentia* examinations in Medicine two years later and obtained his degree of doctor in 1518. In that same year he was appointed professor at the Faculty of Medicine. After 1521 his signature no longer appears in the University archives. What happened afterwards is not known.

Front page of the *Liber de triplici motu*

The fact that he was studying Medicine in 1513 and that he received a doctorate in 1518 makes us suppose that he was not yet a middle aged man at that time. On the other hand, the sound command of an impressive range of sources that he shows in his book and his teaching position in 1510 at *Cocqueret* are hard to imagine (but not altogether impossible) in a man in his early twenties. Comparing with the academic career of other Portuguese scholars in Paris at the same period, it is plausible to suppose that Thomas had arrived in Paris by 1500, as a young man of around 16-18 years of age, and that he wrote the *Liber de triplici motu* a few years after having finished his studies in Arts and before embarking on the study of Medicine. This would mean that he would have been born in Lisbon around 1480-85.

The presence of Alvarus Thomas in Paris is quite natural. After a period of lesser prominence during the fifteenth century, by the turn of the century the University of Paris had recovered the glory of past ages. It had established itself as the most reputable university in Europe, attracting students from everywhere except Italy where the local Universities disputed this leading position. It is known that Portuguese students had been sent to the University of Paris since as early as 1192. In the period 1500-1550 around 300 Portuguese attended the University of Paris[16].

In the first decades of the sixteenth century a remarkable group of Portuguese students was at Paris. Besides humanists, philosophers, and theologians, among the contemporaries of Thomas one finds men who will greatly contribute to the scientific history of Portugal. Such is the case of Pedro Margalho (1471?–1556), Francisco de Melo (1490–1536) and João Ribeiro, for example. Also outstanding was the group of Spaniards. Among others, Gaspar Lax (1487–1560), Pedro Ciruelo (1470–1554), Juan Martínez Silíceo (1486–1557), Juan de Celaya (1490–1558), were contemporaries of Thomas in Paris[17]. These Iberians would play an important role in the History of Science, which prompted a modern historian to comment that

> Among the many foreigners at Paris at the turn of the sixteenth century, no group is more interesting than that of the Spaniards and the Portuguese[18].

The history of the intellectual relations between these men is, to a great extent, still to be made. The study of their influence in the Iberian Peninsula is also a desideratum. To a greater or lesser extent these men seem to have been influenced by the Scottish nominalist John Major (1467–1550) who was, at the beginning of the sixteenth century, the leading intellectual figure in Paris. Major pontificated in what was perhaps the most important of the colleges of the University of Paris at the time, the *Collège de Montaigu*, but his pupils would eventually occupy chairs in all other colleges, thus extending his influence to the whole of the University of Paris. There is no evidence of Thomas being directly associated with Major or of having been his direct disciple, but no doubt he benefited from the intellectual environment around the Scottish master.

Even surrounded by men of great intellectual prestige, Thomas seems to have been a leading figure. One of his contemporaries considered him to be superior to Pierre d'Ailly[19] and modern historians confirm Thomas' intellectual position among his peers[20].

[15] See: André Tuilier, *Histoire de l'Université de Paris et de la Sorbonne* (Paris: G.-V. Labat, 1994).

[16] See: L. de Matos, *Op. cit.*

[17] Hubert Élie, "Quelques maîtres de l'Université de Paris vers l'an 1500", *Archives d'histoire doctrinale et littéraire du moyen âge*, **18** (1950–51) 193–243.

[18] Marshall Clagett, *The Science of Mechanics in the Middle Ages* (Madison: University of Wisconsin Press, 1959), p. 655.

[19] Such is the opinion of Gregoire Bruneau in his letter to Thomas printed at the end of the *Liber de triplici motu*.

[20] Villoslada, after extolling the famous Juan de Celaya, mentions Thomas saying that "El maestro lusitano era, por su ecletismo, su erudición y dialética invencible, gemelo de Celaya e superior a él como matemático". Villoslada, *Op. cit.*, p. 190.

The Calculatory Tradition

To understand the scientific contribution of Alvarus Thomas, a brief excursion into the achievements of medieval to late fifteenth century mechanical science is necessary. A complete description of these ideas is, of course, well beyond the scope of this paper. The interested reader is therefore directed to the relevant bibliography on this subject[21].

By mid fourteenth century the study of motion—a central and always problematic question in the *corpus* of aristotelian physics—was radically changed due to the contributions of a group of men at Merton College, in Oxford. In a period of about twenty years, the successive appearance of a number of texts on proportions and ratios, motion, and logical rules applied to physical questions, heralded a new approach to problems of natural philosophy. Of these, the most important were: Thomas Bradwardine, *De proportionibus velocitatum* (1328), William Heytesbury, *Regulae solvendi sophismata* (1335), John Dumbleton, *Summa logicae et philosophiae naturalis* (1349), Richard Swineshead, *Liber calculationum* (ca. 1350). Instead of pursuing an analysis of motion in the traditional categories of act and potency, these men adopted a formal and highly speculative analytical approach which considered motion essentially as a ratio. Their analysis of motion included detailed discussions on the possible types of motions (*uniformiter, uniformiter difformis, difformiter difformis*, etc.), the description of each of these different types of motion, and an inspection of the origin of each motion. These studies were abstract, without reference to any natural event or artifact, and made extensive use of logical techniques originally developed in other intellectual pursuits such as the study of language.

The original context of these discussions was the much debated question of the "intensio and remissio formarum", which is, basically, the question of how qualities varied in intensity. To the Oxford "Calculators" —such was the designation by which they came to be known, and Swineshead "the Calculator"—variations of velocity, that is, local motion, were treated as variations in the intensity of a quality, in the same way as color changes its hue or a body becomes warmer. But the problems they addressed had a much broader context than merely the question of understanding local motion (*motus localis*); calculatory techniques were also used in medicine and theology, for example. From the perspective of the history of mechanics, the contributions of the Merton school have been summarized thus by one of the most competent historians of medieval science:

> From the discussions of these four men at Merton emerged some very important contributions to the growth of mechanics: (1) A clear-cut distinction between *dynamics* and *kinematics*, expressed as a distinction between the *causes* of movement and the spatial-temporal *effects* of movement. (2) A new approach to speed or velocity, where the idea of an instantaneous velocity came under consideration, perhaps for the first time, and with a more precise idea of 'functionality'. (3) The definition of a uniformly accelerated movement as one in which equal increments of velocity are acquired in equal periods of time. (4) The statement and proof of the fundamental kinematic theorem [...][22]

These are no small intellectual accomplishments. Although to a modern reader the texts that these men produced are certainly prolix, confused and difficult to follow—a critique that some contemporaries also made—underneath this complexity lies an exceptional ability to seize upon and extract the mathematical features of the problem of motion. What is perhaps their greatest feat—sometimes considered the most outstanding medieval contribution to physics—was the statement and demonstration of the so-called "Mean Speed Theorem" for uniformly accelerated motion. In modern terms, this theorem asserts that a body in uniformly varied motion during a certain interval of time will traverse the same distance as a body with a uniform velocity equal to the instantaneous velocity at the middle instant, in the same interval of time. The power of this theorem lies in equating, for the purpose of calculating the distance traversed, an accelerated motion with a uniform motion. This theorem was proved by means of many different geometrical and numerical arguments and became the cornerstone of the studies of motion by the *Calculatores*.

The Calculatory tradition evolved significantly when it arrived on the Continent. In Paris, the ideas and techniques of the Merton approach were incorporated into the more realistic framework which had been worked out by fourteenth century thinkers such as Jean Buridan and Nicole Oresme. A salient feature of the Parisian achievements was the introduction of the notion of *impetus* in the analysis of motion.

[21] Good introductory works to this subject are: Edward Grant, *Physical Science in the Middle Ages* (Cambridge: Cambridge University Press, 1977); David C. Lindberg (Ed.), *Science in the Middle Ages* (Chicago & London: The University of Chicago Press, 1978); A. P. Juschkewitsch, *Geschichte der Mathematik im Mittelalter* (Leipzig: Teubner, 1964). For more detailed studies, see the work of Marshal Clagett cited before and also the following: Curtis Wilson, *William Heytesbury: Medieval Logic and the Rise of Mathematical Physics* (Madison: University of Wisconsin Press, 1956); Edith D. Sylla, *Oxford Calculators and the Mathematics of Motion, 1320–1350*, Harvard Dissertations in the History of Science (Garland, 1991); H. Lamar Crosby, Jr., *Thomas of Bradwardine. His Tractatus de proportionibus. Its significance for the Development of Mathematical Physics* (Madison: University of Wisconsin Press, 1955).

[22] M. Clagett, *Op. cit.*, p. 205.

The Contribution of Alvarus Thomas

The *Liber de triplici motu* is a sophisticated and technically complex piece in the *corpus* of the Calculatory tradition. The three types of motion mentioned in the title are local motion, augmentation and alteration. The book opens with a detailed discussion on the theory of proportions, in which the author presents systematically some of the most important results. The second part of the book is a discussion about motion. In this second part the author addresses the questions of "De motu locali quoad causam", "De motu locali quoad effectum", "De motu augmentationis", "De motu alterationis"[23].

The influence of Swineshead's *Liber Calculationum* is clear, but Thomas' exposition is more systematic and better organized. The first impression any reader has is the extent of Thomas' knowledge. His sources for mathematics range from the older Nicomachus or Boethius to the very recent edition of Euclid by Bartholomeus Zambertus (Venice, 1505). He is at ease with the Englishmen Swineshead, Bradwardine and Heytesbury, but also with Parisians such as Oresme, and with the Italians (Paul of Venice, James of Forli, etc.). The Portuguese master is in the exceptional position of knowing both the formal techniques of the Merton approach, the conceptual tradition of the Parisian school, and the Italian contributions[24].

But the contribution of Alvarus Thomas would not be correctly described by mentioning simply his role as the catalyst of the Merton tradition in Paris. From the perspective of his mathematical accomplishments the *Liber de triplici motu* contains remarkable results. Since it is impossible to even review its contents, I will simply comment on some aspects that relate to summing infinite series.

Thomas follows strategies typical of the Calculatory tradition, and by ingenious and complex use of the Mean Speed Theorem he manages to establish some suprising results. The approach used by Thomas can be better understood by using present day terminology. The reader can imagine that one is considering a modern graph with velocity represented in the vertical axis and time in the abscissas[25]. In such a depiction, a motion at constant velocity is represented by a horizontal line, and a uniformly accelerated motion by a straight line with some finite slope. A generic motion will be represented by some curve. In all cases, the total space traversed by the mobile is given by the area below the curve. Alvarus Thomas considers different types of motion. The question he tries to answer is inspired by the Mean Speed Theorem, but now for these much more complicated motions: Given a certain complex motion, what should the uniform velocity be such that a body moving with this constant velocity traverses, in the same time, the same distance as the body following the more complex motion?

Thomas cannot address the problem in the most general terms, but he considers complex motions that correspond to a division of the time axis in a geometrical progression. In each interval the velocity is assumed to be constant or uniformly accelerated. By this judicious construction and using the Mean Speed Theorem, Thomas is then able to calculate the total space traversed by the mobile and the corresponding uniform velocity which would make it traverse the same distance in the same time. It is not difficult to realize that, from a mathematical point of view, Alvarus Thomas is calculating the sum of an infinite series.

One of the motions considered by the Portuguese master corresponds to the series

$$1 + 2x + 3x^2 + 4x^3 + \cdots$$

Thomas is able to show that the sum of this series is equal to the square of the sum of the series:

$$1 + x + x^2 + x^3 + \cdots$$

In a typical Calculatory spirit, Thomas will stretch his techniques to the limit, considering motions progressively more complex. With this he is able to obtain remarkable mathematical results. For example, he shows that the series

$$1 + \frac{2}{1}x + \frac{3}{2}x^2 + \frac{4}{3}x^3 + \cdots$$

is bounded above by

$$1 + x + x^2 + x^3 + \cdots = \frac{1}{1-x}$$

and bounded below by

$$1 + 2x + 3x^2 + 4x^3 + \cdots = \frac{1}{(1-x)^2}.$$

[23] This is just a rough indication of the parts of the book. The *Liber de triplici motu* is divided into various parts, and each of these in chapters. It has 141 fls., printed in two columns in a small gothic font. I have used the copy at the Biblioteca Nacional, Lisbon.

[24] M. Clagett comments that "Thomas not only used the English works, but he was conversant with the Italian commentaries and paraphrases. He, then, has at his command the whole medieval mechanical tradition", *Op. cit*, p. 657.

[25] Although such a graphical representation can be traced back to Oresme, there are no such figures in the *Liber de triplici motu*, and even numbers appear only very rarely. The reader must bear in mind that the original context for which the book was written seems to have been the verbal disputations in *Sophismata*. In a fundamental study, Edith Sylla remarked that "it is the disputative context that apparently motivates Alvarus to many of his mathematical results". These are important questions which unfortunately cannot be pursued here. In any case, Sylla concludes that this disputative context had a positive impact on Alvarus' mathematical physics. See: Edith D. Sylla, "Alvarus Thomas and the role of Logic and Calculations in sixteenth century Natural Philosophy", in: S. Caroti (Ed.), *Studies in Medieval Natural Philosophy* (Florence: Olschki, 1989), 257-298.

Rey Pastor observed that several of the series analysed by Thomas would cause many difficulties even to present-day students. He is able to sum series such as,

$$1 + x + ax^2 + bx^3 + a^2x^4 + b^2x^5 + \cdots$$

or even,

$$1 + \frac{3}{2}\frac{1}{2} + \frac{5}{4}\frac{1}{2^2} + \frac{9}{8}\frac{1}{2^3} + \cdots$$

Naturally, there is no detailed inspection of the criteria of convergence of the series studied, nor an attempt at rigorous definitions. Nevertheless, Thomas is aware that while some of the series he proposed can be summed, others cannot, either because it is technically very difficult (or impossible) or because the partial sums of terms increase very rapidly.

Conclusion

At this point one would like to assess the influence of Thomas' book. Such an evaluation cannot, in general, be made since the impact and fate of Calculatory techniques in sixteenth century Europe is a question which has been investigated only recently. But I believe that enough evidence has already been collected to substantiate the claim that Thomas' book was well known and influential. Several of his contemporaries quote the book. Pedro Margalho, Pedro de Espinosa and Diego de Astudillo all include praise to Alvarus Thomas in their works. Juan de Celaya, who was a fellow teacher of Thomas at *Cocqueret* does not cite the Portuguese by name, but his *Expositio (...) in octo libros phisicorum Aristotelis*[26] was certainly inspired by the *Liber de Triplici Motu*. One other indication of a wide dissemination of the *Liber de triplici motu* is the number of extant copies. According to Wieleitner it is a "liber rarissimus", an opinion that several other historians have echoed[27]. But a cursory search trough the catalogues of major libraries around the world revealed to me more than 20 copies still exist today. For a work written in 1509 it is a significant number which hints at wide dissemination.

In what concerns the study of infinite series, Alvarus Thomas is the high point of an intellectual tradition which had reached its limits. The discursive approach to these mathematical problems would soon be abandoned, and forgotten, with the development of the much more powerful algebraic approaches of the seventeenth century. Jakob Bernoulli's *Tractatus de seriebus inifinitis* (1689) ushers in a new world in the study of infinite series. But in the study of local motion, the book of Alvarus Thomas was perhaps of much more relevance. It has been plausibly argued that the *Liber de Triplici Motu* may have been influential in the scientific formation of Domingo de Soto (1495–1560), either directly or via Soto's teacher in Paris, Juan de Celaya. A possible intellectual connection between Thomas and Domingo de Soto is of the utmost historical significance since it is known today that Soto was the first author to have argued that the free fall of bodies is a motion *uniformiter difformis* with respect to time. That is, in modern terms, that in free fall the body traverses spaces in direct proportion to the squares of the times of fall[28].

After the investigations of William Wallace, it is today agreed that Galileo was well acquainted with the results of the tradition of the *Calculatores* after Domingo de Soto. It is very likely that it was from this knowledge that Galileo first noticed the correct law for the free fall of bodies, which he presented at the beginning of the seventeenth century[29]. In this sense, the role of Alvarus Thomas, as a leading figure in the Calculatory tradidion that ultimately led to Galileo's outstanding contributions, needs to be noted. But there is more to interest Portuguese readers in this fascinating story. Galileo's knowledge of the ideas and techniques of the *Calculatores* was drawn from his study of the lecture notes of the Jesuit professors at the Roman College. In the efficient Jesuit network of colleges the Calculatory tradition underwent a diffusion originating in the Iberian Peninsula—a direct consequence of the return to the Peninsula of former students at Paris, and in particular, of the teaching of Domingo de Soto. In fact, a substantial number of manuscripts from Jesuit colleges confirms that in the last decades of the sixteenth century the terminology and notions of the *Calculatores* were being used in the analysis of the nature of motion in Portugal[30].

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[26] [Juan de Celaya], *Expositio magistri ioannis de Celaya Valentini in octo libros physicorum Aristotelis, cum questionibus eiusdem secundum triplicem viam beati Thomae, realium, et nominalium* (Paris, 1517).

[27] Wieleitner gives a detailed bibliographical description of the Munich copy and mentions that it displays, written by a later hand, the inscription *Liber rarissimus*; Rey Pastor, certainly drawing from the German scholar, calls it "un libro rarissimo" and likewise Gomes Teixeira says that "o livro de Álvaro Tomaz é muito raro".

[28] Domingo de Soto, *Super octo libros physicorum Aristotelis questiones* (Salamanca, 1545). For biographical information on Soto, see: V. Beltrán de Heredia, *Domingo de Soto: Estudo Biográfico Documentado* (Salamanca: Biblioteca de Teólogos Españoles, 1960); For the physical questions see the many papers by William A. Wallace. One of his later works contains references to prior writings: William A. Wallace, "Domingo de Soto's "laws" of motion: Text and context", in: Edith Sylla and Michael McVaugh (Eds.), *Texts and Contexts in Ancient and Medieval Science* (Leiden: Brill, 1997) 271–303.

[29] Galileo Galilei, *Galileo's early notebooks: the physical questions*, a translation from the Latin with historical and paleographical commentary [edited by] William A. Wallace (Notre Dame: University of Notre Dame Press, 1977); William A. Wallace, *Galileo and His Sources: The Heritage of the Collegio Romano in Galileo's Science* (Princeton: Princeton University Press, 1984).

[30] See the works by W. Wallace: "Late sixteenth-century Portuguese manuscripts relating to Galileo's early notebooks", *Revista Portuguesa de Filosofia*, 51 (1995) 677–698; "Domingo de Soto and the Iberian roots of Galileo's science", in: Kevin White (Ed.) *Hispanic Philosophy in the Age of Discovery* (Washington DC: Catholic University of America Press, 1997), 113–129.