

# GALILEO'S *DE MOTU ANTIQUIORA* NOTES FOR A REAPPRAISAL

*Raymond Fredette*

*This lecture is dedicated  
to my venerable master  
Raymond Klibansky (1905- )*

## **Abstract**

In this lecture, I will briefly furnish first some relevant personal life events of my intellectual involvement with the *De motu antiquiora* (DMA) to satisfy a legitimate curiosity about this obscure scholar who for all practical purposes published only one article in *Physis* back in 1972, disappeared for more than twenty years, and suddenly comes back. The main intent is to reappraise the conflicting diversity of how scholars from Viviani (1674) down to Giusti (1998) reacted to this Pisan autograph on local motion which Galileo did not publish but never discarded, but also to emphasize the need in our community for less “psittacism”, that is, more rereading of the original textual sources instead of “parroting” secondary ones however authoritative, and more replicating of the experimentations these texts contain.

During my teens, I developed a strong taste both for science and for philosophy, so much so that after majoring in 1959 with a B.A. in chemistry and a minor in biology, instead of entering medical school as expected, I decided to register at the Institut d'Études Médiévales of the Université de Montréal. There, for five years, I had the immense privilege of having fallen in the hands of the best teachers, amongst them Benoît Lacroix, Mathieu de Durand, Henri-Iréné Marrou, Etienne Gilson, Paul Vignaux and Raymond Klibansky. If I am here today, it is thanks to them and to the tools they handed down to me for the pursuit of a passion. And this strong taste for ideas had first been instilled in me in 1955, when I read Will Durant's celebrated *Story of Philosophy* which, at that time, had sold more than

1,250,000 copies, spreading around a feeling for what the author called “the joy of understanding”.

My interest in Galilean studies dates from 1963. Alistair Crombie came for a short visit at the “Institut” and I was thus introduced to his *Medieval and early modern science* (1959). Looking for a PhD topic, I was told by a young new teacher in the department of philosophy, who had just finished a dissertation on Whitehead, that he had often read about accounts of how Galileo challenges his Aristotelian contemporaries, but he had yet to hear about a systematic examination of how Galileo proceeded to criticise Aristotle himself. That was the starting point which put me into business. And, as I will try to make clear later, this idea may still have fruits to bear. Also in 1963, Paul Vignaux thought that my project of looking into these matters for a doctoral dissertation made sense and he graciously offered to ask his friend Alexandre Koyré for an advice and maybe a tutorship. As we all know, a year later, Koyré had passed away. In retrospect, I cannot but feel a certain relief. I am not at all sure I could have done the same teething job I did, chewing on his monumental work, if this master mind had been alive and I had been his pupil.

In 1962, I started what was going to be a 35 year commitment to teaching philosophy at undergraduate level. In my spare time, I did my homework on Galileo, guided by the following idea: to look closely into Galileo’s critical treatment of Aristotle’s thinking in physics, as something not to be confused with his quarreling with his Aristotelian contemporaries. I started reading the appropriate texts. And of course the first ones were the *De motu antiquiora*.<sup>1</sup> Israel Edward Drabkin’s partial translation of the Essay had just been published.<sup>2</sup> Following closely in Drabkin’s footsteps, more than thirty years later, I am very glad to publicly announce here today the completion of a double translation, in French and in English, of the totality of the material contained in Galileo’s autograph. My French translation is now under revision and should soon come out at Les Belles-Lettres in Paris. Now, since 1998, the Max-Planck-Institut für Wissenschaftsgeschichte in Berlin has been supporting financially and technically this double translation project. And shortly an On Line version of my English translation with notes and morphological links to the Latin text should become freely available on the Max-Planck web site.

*De motu antiquiora*, *Older Writings on Motion*, such is the title Galileo eventually gave to his Pisan autograph. But, back in the middle sixties, doing my homework, I was confronted with a major problem. I was facing more than 200 years of discussion pursued by the most celebrated scholars

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<sup>1</sup> Galilei, Galileo. 1890-1909. *Le opere di Galileo Galilei*. Edizione nazionale. Firenze: Barbèra. See, vol. I (1890), EN I, 251-419.

<sup>2</sup> Galilei, Galileo. 1960. “On Motion”. In *Galilei, Galileo: On motion and on mechanics*, edited by M. Clagett. Madison: The University of Wisconsin Press, 3-131.

about this autograph, –from Viviani<sup>3</sup> in 1674 and then Nelli<sup>4</sup> in 1793 who had first publicly revealed its existence, right down to Ed Grant who then was publishing some very remarkable articles<sup>5</sup> on its contents, with, in between, the expertise of people like Guillaume Libri,<sup>6</sup> Ernst Mach,<sup>7</sup> Pierre Duhem,<sup>8</sup> Emil Wohlwill,<sup>9</sup> Leonardo Olschki<sup>10</sup> – and there still was no agreement as to exactly when and in what order these writings had been done. The only thing on which there was total unanimity concerned a single fact: these writings were said to have been left incomplete. However, no one clearly said anything about why or at what point their production was abandoned by Galileo. This matter had to be looked into. To do so, if you allow me the metaphor, I needed to have a real taste of this autograph and savour its accompanying archives. I thus had to go to Florence. I arrived in *Firenze La Bella* early in May of 1967, six months after the dreadful flood disaster of November 4 1966. La Professoressa Maria-Luisa Bonelli, who nearly drowned that evening in saving Galileo's telescopes from destruction, remembered having received a good word of recommendation from her friend Raymond Klibansky. She literally took me under her wing, and handed to me a freshly dried copy of Tom Settle's PhD dissertation.<sup>11</sup> Two years

<sup>3</sup> Viviani, V. (1674). *Quinto libro degli elementi d' Euclide: ovvero scienza universale delle proporzioni spiegata colla dottrina del Galileo Enth.: Vincentii Viviani... enodatio problematum universis geometris propositorum a clarissimo ac reverendissimo d. Claudio Comiers... : praemissis horum occasione tentamentis variis ad solutionem illustris veterum problematis de anguli trisectione*. Firenze, Condotta. See 104-105.

<sup>4</sup> Nelli, G. B. C. d. (1793). *Vita e commercio letterario di Galileo Galilei: nobile e patrio fiorentino, mattematico e filosofo sopraordinario de Gran Duchi di Toscana Cosimo e Ferdinando II*. Losanna, [s.n.]. See 759.

<sup>5</sup> Grant, Edward. 1965a. "Aristotle, Philoponus, Avempace, and Galileo's Pisan Dynamics". *Centaurus* 11: 79-95. Grant, Edward. 1965b. "Bradwardine and Galileo: Equality of Velocities in the Void". *Archive for History of Exact Sciences* 2: 344-364. These analysis are still as refreshing to read as they were when they appeared.

<sup>6</sup> Libri, G. (1838-1841). *Histoire des sciences mathématiques en Italie: depuis la renaissance des lettres jusqu'à la fin du dix-septieme siècle*. Paris, J. Renouardi. See vol. vol. 4, 179.

<sup>7</sup> Mach, E. (1960). *The science of mechanics: a critical and historical account of its development*. LaSalle, Illinois [u.a.], Open Court Pub. Co., 151-155.

<sup>8</sup> Duhem, Pierre. 1991. *The origins of statics: the sources of physical theory*. Translated by Leneaux, Grant F. Vagliente, Victor N. Wagnere, Guy H. Vol. 123, *Boston studies in the philosophy of science*. Dordrecht Boston, Mass. London: Kluwer. See 166-183. Duhem, Pierre Maurice Marie. 1905-1906. *Les origines de la statique*. Paris: A. Hermann.

<sup>9</sup> Wohlwill, E. (1993). *Galilei und sein Kampf für die Copernicanische Lehre: 1. Bis zur Verurteilung der Copernicanischen Lehre durch die römischen Kongregationen, 2. Nach der Verurteilung der Copernicanischen Lehre durch das Dekret von 1616*. Vaduz/Liechtenstein, Sändig. See vol. 1, 80-118.

<sup>10</sup> Olschki, L. (1965). *Geschichte der neusprachlichen wissenschaftlichen Literatur Bd. 3: Galilei und seine Zeit*. Vaduz, Kraus Reprint. See section entitled Galilei als Forscher und Lehrer, 198-226.

<sup>11</sup> Settle, T. B. (1966). *Galilean science: essays in the mechanics and dynamics of the Discorsi*. Ithaca, NY, Cornell: VII, 280 S. This seminal work, ever since, has guided and deeply

latter, in 1969, I handed in my own PhD dissertation,<sup>12</sup> which I defended in front of a panel on which sat Stillman Drake and William Shea.

Before inviting you to plunge with me into the multitude of problems which Galileo's *De motu antiquiora* autograph has been causing to historical scholarship, I owe the special audience you are a brief word as to my main purpose here. This lecture should be heard essentially as an invitation to work, to verify for yourself back home whatever I may happen to think true to say on Galileo's *De motu antiquiora*. Having just finished my double translation of these texts, of course I consider myself a privileged reader, but don't ever take my words for cash! And, please, don't ever just pick up passages here and there anymore, take the resolution to read the DMA, at least once, in its entirety. If there is one thing I would like this lecture to achieve, it is to convince you to do just that. Do not read these texts piecemeal but as a whole. You will then realize that the DMA is a work in progress, as complete as it could ever have been, a work Galileo kept in his files and never discarded, a work containing ideas which accompanied him throughout his whole career, a work still to be reckoned with when, after the disaster of the 1632 *Dialogo*, he prepared the final version for his famous 1638 *Discorsi*.

OK, now let's come to the autograph<sup>13</sup> of the *De motu antiquiora*. Facing the unanimous opinion that Galileo's *Older Works on Motion* were left incomplete, my attention was attracted by a passage in Favaro's preface in volume I of the Edizione Nazionale. Favaro, referring to no less than 35 chapters of an Essay On Motion, tells the reader (EN I, 246-7), that he had first thought of distributing the material in several books, according to which "we would have tried, by entering into the intention of the Author, in so far as it would be permitted to guess it, *di dar forma organica a quello che apparentemente ha soltanto un aspetto frammentario* (to give organic form to what apparently had only a fragmentary aspect)". *Apparentemente!* Could it be that the supposed incompleteness of the DMA was only an appearance? What was this organic form of the Essay Favaro had at first thought of restituting in his edition of the DMA? Now, of course, every one of you does realize that to seriously try to answer such a question of "organic form", in other words, to find out the organizing structure of the texts, one has to embrace the work both as a whole and through its every details. This meant many months of reading and rereading. And to guide me

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inspired my reading of Galileo's thought. Cf. <http://www.mpiwg-berlin.mpg.de/litserv/diss/settle/html/Page001.htm>

<sup>12</sup> Fredette, Raymond. 1969. *Les De Motu 'plus anciens' de Galileo Galilei: prolégomènes*. PhD Institut d'Études Médiévales, Faculté de Philosophie, Université de Montréal, Montréal. Cf. [http://www.mpiwg-berlin.mpg.de/litserv/diss/fred\\_2/html/Page001.htm](http://www.mpiwg-berlin.mpg.de/litserv/diss/fred_2/html/Page001.htm)

<sup>13</sup> Procissi, A. (1959/ 1985). *La Collezione Galileiana della Biblioteca Nazionale di Firenze Vol. 1: "Anteriori"- "Galileo"*. Roma, Ist. Poligrafico e Zecca dello Stato. Cf. mss Gal 71 and Gal 46.

in making a thorough job, I undertook a French translation of these texts. I soon realized that I had to postpone my intention to study directly the criticisms of Aristotle's physics in Galileo's *Older Works on Motion*. Some preliminary studies had first to be done. Imagine, even though we scholars had at our disposal Favaro's edition of all the pertinent material involved from the mss Gal. 46 and Gal. 71 since 1890, two questions had yet to be settled: when exactly and in what order had the material been written? Dealing essentially with these two questions, I entitled my 1969 dissertation "*Pro-légomènes*". And what I had to say in there clashed enough with the then accepted views of Koyré<sup>14</sup> and later of Drake<sup>15</sup> that it took more than twenty years for my views to come to the fore,<sup>16</sup> become the object of critical testing,<sup>17</sup> and obtain some recognition as seriously defensible.<sup>18</sup>

I am inviting you today to a special guided tour of how some scholars reacted when involved with Galileo's *De motu antiquiora*. But first, here is the one and only explicit statement we have, made by Galileo himself, concerning the DMA. It is found as a memorandum he wrote among 8 pages (cf. EN I, 409-417) of other memoranda which span the whole period of production of the DMA material. In this memo, Galileo says:

There will be many who, after they have read my writings, will turn their mind, not to consider whether the things I have said are true, but only to seek in what way, whether rightly or wrongly, they could undermine my opinions. (412.19-22, my translation)

This may be read as implying an intention to publish. But, not only did Galileo not publish his DMA but he never seems to even have privately alluded to them. And when Viviani finds them among his master's papers, here is the first public account we obtain. In 1674, Viviani reveals the existence of a manuscript written on many small 5 leaf pads –quinternetti in-

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<sup>14</sup> Koyré, A. (1939). *Histoire de la pensée: T. 1, Etudes Galiléennes T. 1: A l'aube de la science classique*. Paris, Hermann. Koyré, Alexandre. 1937. "Galilée et l'expérience de Pise: à propos d'une légende". *Annales de l'Université de Paris* 12: 441-453. Koyré, Alexandre. 1959. "Jean Baptiste Benedetti, critique d'Aristote". In *Mélanges offerts à Etienne Gilson*. Toronto-Paris: Pontifical Institute of Mediaeval Studies.

<sup>15</sup> Drake, Stillman. 1976. "Galileo Gleanings XXIV, The evolution of De Motu". *Isis* 67: 239-250. Drake, Stillman. 1979. "Galileo's notes on motion: arranged in probable order of composition and presented in reduced facsimile", in *Supplementa agli Annali dell'Istituto e Museo di Storia della Scienza. Fascicolo 2, Monografia N. 3*. Firenze. Drake, Stillman. 1986. "Galileo's Pre-Paduan Writings: Years, Sources, Motivations". *Studies in History and Philosophy of Science* 17 (4): 429-448.

<sup>16</sup> Galluzzi, P. (1979). *Momento: Studi galileiani*. Roma, Ed. dell'Ateneo & Bizzari.

<sup>17</sup> Wisan, W. L. (1984). "On the Chronology of Galileo's Writings". *Annali dell'Istituto e Museo di Storia della Scienza di Firenze* IX(2): 85-88.

<sup>18</sup> Camerota, M. (1992). *Gli scritti "De motu antiquiora" di Galileo Galilei: il Ms. Gal 71: un'analisi storico-critica*. Cagliari, CUEC. See also Wallace, W. A. (1993). "Review of Camerota's *Gli scritti De motu antiquiora di G.G. ...*" *Isis* 84: 797.

octavo—. This manuscript, he says, has a front title page (now lost) on which he read DE MOTU ANTIQUIORA. Viviani then goes on to say that we find there

...dei primi giovenili studi di lui, e per i quali nondimeno si vede, che fin da quel tempo non sapev'egli accomodare 'l libero 'ntelletto suo all'obligato filosofare della comune delle scuole. Quello però di piu singolare, che è sparso in tal manoscritto, tutto, come si vede, l'inscastrò poi egli stesso opportunamente, a' suo' luoghi, nell'opere che egli stampò.<sup>19</sup>

Let us take a moment to look at these two statements.

First, Viviani says that in these first youthful studies it is nevertheless clear that Galileo, already then, was not able to accommodate his free mind to philosophize along the compulsory ways of the schools. OK, let us consider as a fact that Galileo's mind is, from the start, free from submission to scholastic Aristotelianism. Second, Viviani says "What is most curious is that is dispersed in this manuscript, all that, as one can see, he later inserted himself opportunely, in its place, in the works which he printed". There is an ambiguity here which had consequences we are going to examine below. Does Viviani mean to say that *all the interesting things* found in the DMA find themselves in their due place in the published work? Or, rather, which is very different, does he mean to say that *all that Galileo published on motion*, already finds itself, if only in germ, in these youthful works? I think I can show that the first meaning is the correct one, but, as we shall see in a moment, scholars in the XVIIIth and XIXth Centuries including Favaro let themselves be fascinated by the second.

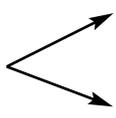
We are all familiar here with how, after his death, Galileo's papers, notwithstanding the care he had given them during his lifetime, became lost and dispersed.<sup>20</sup> We historians exercise a trade which is totally dependent on the happenchance existence of archives whose survival is indeed very fortuitous and uncertain. This is our daily bread. Now, in the case of the DMA, some time after Viviani's death in 1703, the autograph disappeared with other manuscripts. And there is a beautiful legend according to which, in 1750, Giovanni Batista Clemente de' Nelli is said to have recognized Galileo's handwriting on a piece of paper which his butcher had used to wrap some mortadella, some cold cuts of baloney, before having it delivered to him. Thus Nelli tracked down the source of the butcher's wrapping paper. They came from a "buca da grano", a grain bin, containing what was left of Viviani's collection of Galileo's manuscripts. Nelli bought them for 88 scudi.<sup>21</sup> Knowing

<sup>19</sup> Cf. supra, note 3.

<sup>20</sup> Favaro, A. (1886). "Intorno ad alcuni Documenti Galileiani recentemente scoperti nella Biblioteca Nazionale di Firenze". *Bullettino di Bibliografia e di Storia delle Scienze Matematiche e Fisiche* Tomo XIX.

<sup>21</sup> Cf. supra, note 4.

this, I also did my own archive tracking to try to reconstitute as clear a picture as the data will permit of what could have been the state in which Viviani did find Galileo's early papers.<sup>22</sup> The result may be grasped through some comments I now propose to give you of a reconstruction which yields the following list of documents.

<p><i>Dialettica</i> EN I, XIX, 30 Cf. Edwards, 1988, Wallace, 1992</p>	VIVIANI XV		<p>Gal.27</p> <p>Gal.46</p>
<p><i>Juvenilia</i> EN I, 15-177 Cf. Wallace, 1977</p>			
<p><i>De motu antiquiora</i> EN I, 251-419</p>	VIVIANI XVI		<p>Gal.71</p>
<p><b>Memoranda for a work on motion</b> EN I, 409-417 including the memo of the <i>Dialogus</i> EN I, 375-378</p>			
<p><b>Program of a work on motion</b> EN I, 418-419</p>			
<p><b>Dialogue on motion</b> EN I, 367-408 without its memos and left unfinished</p>			
<p><b>Excerpt from the 1638 <i>Discorsi</i></b> 'Liber secundus in quo agitur de motu accelerato' EN II, 261-266 = EN VIII, 197-198</p>			
<p><b>10 chapter reworking of Book I of the Essay</b> EN I, 344-366</p>			
<p><b>Essay on motion</b> EN I, 251-340</p>			
<p><b>Rewriting of chapter 1 and 2 of the Essay</b> EN I, 341-343</p>			
<p><b>Excerpt from the 1612 <i>Discorso</i></b> 'Aggiunte all Trattato delle Gallegianti' EN IV, ??? -----&gt;</p>			
			<p>Gal.42</p>

The key to this reconstruction comes from Nelli's catalogue. Nelli took note of Viviani's numbering of Galileo's collection of autographs. Thus we

<sup>22</sup> Cf. supra, note 12; see 6-17.

learn that Viviani had given the two files containing Galileo's early writings the numbers XV and XVI. To the right, you find the numbers by which the different manuscripts are known today in the Biblioteca Nazionale of Florence, according to the Procissi catalogue. We will come back later to number XV. Let's first look at XVI.

Now, the DMA proper are constituted of 6 of the 8 items listed here in bold. They are listed in the order in which Viviani and Nelli found them in the autograph. Under each item is Favaro's pagination. Let us first identify these 6 items. My time being counted, permit me to do so by briefing you with the latest results concerning the order of composition of each one of these 6 items. When I say the latest, I mean 1998. Enrico Giusti published in *Nuncius* his "Elements for the relative chronology of Galilei's *De Motu Antiquiora*".<sup>23</sup> These results confirm those I had established back in 1969.<sup>24</sup> At that time my results, through a detailed analysis of an hypothesis first expounded in 1960 by Drabkin,<sup>25</sup> relied on a methodology that made use of the alleged intellectual evolution of Galileo's thought. Thus my idiosyncracies<sup>26</sup> then just clashed with those of Drake's analysis of watermarks<sup>27</sup> and Hooper's<sup>28</sup> observations of the colors of inks. But Giusti's arguments are formally independent of interpretations or conjectures concerning what Galileo could plausibly do or say. Giusti, through a colossal work implying a word for word comparison of the autograph with Favaro's edition, was able to analyse systematically the passages appearing with minor changes in two or more of the items which I will now name.

First Galileo jotted down his **Program of a work on motion**: it holds on one face of a single folio (3v) and lists 24 subjects on motion that he obviously plans to develop.

The second item written was the **Dialogue on motion**, 34 folios in length: I propose we call it the *Dialogus*, since this latin text cannot be confused with its well kown later Italian offsprings, the *Discorso*, the *Dialogo* or the *Discorsi*. A certain Domenico is briskly walking along the seashore near Pisa, on a chilly winter morning. He is caught up by an out of breath Alessandro, running to catch up with him who says "Where [are you going] on such a swift foot, dearest Domenico?" To which the latter replies, "Ah, greetings, dear master!" They decide to go on a walk on the outskirts of the city and Domenico submits to Alessandro 6 questions or problems on which he wants to hear the master. Only three of the questions are in fact

<sup>23</sup> Cf. Anno XIII, fasc.2: 429-460.

<sup>24</sup> Cf. supra, note 12; see 164-282.

<sup>25</sup> Drabkin, I. E. (1960). "A Note on Galileo's *De motu*". *Isis* 51: 271-277.

<sup>26</sup> Cf. supra, note 12; see 164-282: Chapitre quatrième: ordre vraisemblable de composition.

<sup>27</sup> Cf. supra, note 15.

<sup>28</sup> Hooper, W. E. (1992). Galileo and the problems of motion: VIII, 399 S. Cf. <http://www2.mpiwg-berlin.mpg.de/litserv/diss/hooper/html/Page001.htm>

treated. Now, since there exists no traces whatsoever indicating that some part of this *Dialogus* could have been lost, we can pretty safely affirm that Galileo may never have completed it. Moreover, Drabkin<sup>29</sup> in 1960 was the first scholar to challenge the long accepted opinion, according to which this *Dialogus* was written after the Essay. Endorsed by Favaro in 1890, it was then critically defended by Wohlwill<sup>30</sup> in 1909, Olschki<sup>31</sup> in 1927, down to Giacomelli<sup>32</sup> in 1949. It was this opinion which was responsible for the total unanimity of scholars according to whom the whole Pisan project of Galileo on motion had been left incomplete.

Then Galileo wrote the **Essay on motion**, covering over 60 folios in length. For more than forty years now scholars have familiarized themselves with the content of its 23 chapters through Drabkin's translation. This is a complete work, in two books, ch. 1-13 and then ch. 14-23. It stands by itself and it treats of all the material found in the *Dialogus* and much more. Now the autograph of this Essay contains a great many traces of having been reread by its author who introduced numerous marginal notes and corrections. In fact his rereading prompted him in reworking some entire chapters of the first Book.

This is where the next item comes in order of composition; in the list here it is next to the last item. We have here Galileo's first reworking, a simple **rewriting of chapters 1 and 2 of the original Essay**, with small changes in vocabulary where words like *levis*, *light*, are dropped and replaced by *minus gravis*, *less heavy*. This covers less than 2 folios.

The fifth item in the list comes next. Galileo decides that the small changes in vocabulary are not enough. He starts over again and this time we have the **10 chapter reworking of Book I of the Essay**. We have here 4 brand new chapters and the original chapters 1-5 and 12 have been entirely rewritten and in the process, chapter 6, "in which is explained the correspondence that natural mobiles have with the weights of a balance" is simply dropped. This reworking covers 17 folios. These have yet to appear in any translation in their entirety.

The last item of the DMA to be identified is on the top of the list here. It contains the so-called **Memoranda**. They are a series of notes accumulated during production for further development. And most of them find their place in the core of the main texts. The first three concern the *Dialogus* and the third, a quite lengthy one, Favaro decided to publish in the place Galileo indicated for it. All the following memos concern the Essay, first chapter 12 and others from both Books, and then, in that order, the first and the second reworkings.

<sup>29</sup> Drabkin, I. E. (1960). "A Note on Galileo's De motu." *Isis* 51: 271-277. Cf. supra, note 25.

<sup>30</sup> Cf. supra, note 9.

<sup>31</sup> Cf. supra, note 10.

<sup>32</sup> Giacomelli, R. (1949). *Galileo Galilei giovane e il suo DE MOTU*. Pisa, Domus Galilaeana.

Now, I would like you to pay attention to the order in which Favaro edited these elements:

- 251-340, he first put the original complete *Essay* in 23 chapters;
- 341-343, then the first 2 chapter reworking which was abandoned;
- 344-366, then the much more elaborated 10 chapter reworking; then,
- 367-408, the *Dialogus*
- 409-417, the *Memos*
- 418-419, the *Program*

Thus Favaro's pagination reveal three important editorial opinions:

- 1) the chronological reading order of the 3 *Essay* items: v.1, v.2, v.3;
- 2) the anteriority of the *Essay* vs the unfinished *Dialogue*;
- 3) the *Memos*, which span the whole production, were put in annex, ending the edition with the *Program* of 24 topics with which Galileo had initiated and launched his research on local motion.

We now come to the other two items of the list. In addition to its specific DMA material, the ms originally contained two other items, obviously belonging to published material: one from the Third Day of the 1638 *Discorsi*; and another concerned with the 1612 *Discorso* on Floating Bodies.

The *Discorsi* excerpt, 4 full folios in the hand of Galileo, is a near verbatim copy, of the Liber secundus of the *De motu locali*, this famous Latin text read and submitted for discussion by Salviati in the Third Day. In this Liber secundus is explained how “post diuturnas mentis agitationes”, the Author established the correct definition of naturally accelerated motion. This text is still bound to ms Gal. 71.

The second excerpt is no more bound with Gal. 71. At the end of Viviani's item number XVI, Nelli's catalogue also mentions the presence of some “Aggiunte all Trattato delle Gallegianti”; unfortunately, neither I, nor Michele Camerota<sup>33</sup> who looked into the matter closely, have yet been able to identify them with precision. We presume that it was Antinori who may be responsible (but then maybe not) for placing them (if they are) with others now in Gal. 42. More work on the secondary archives may yield their identity. It would be very interesting indeed to know what they were. One thing is sure, some passages from the debate on floating bodies were inserted by Galileo in the original file of his *De motu antiquiora*.

This question of manuscripts brings us now to Viviani's number XV. Those of you who have looked closely into the DMA know that, today, all the DMA material belongs to ms Gal. 71, except for the Memoranda. The 8 folios (102r-110r) containing these memos now find themselves bound with the 100 folios containing the *Juvenilia* in ms Gal. 46. As is easily conjectured with this reconstruction, an accident in handling these archives may well

<sup>33</sup> Cf. supra, note 18; see ch. V, “Le misteriose Aggiunte al Trattato delle Gallegianti”.

have been responsible for this fact. This reconstruction of ours permits us to conjecture that originally Galileo had put together, in one file to which Viviani gave the number XV, the contents of today's Gal. 27 and Gal. 46 minus the memos, and that he had put in another file, numbered XVI by Viviani, the contents of Gal. 71 including its memos on top of the file.

If this reconstruction is valid, Viviani's remark quoted above, concerning the DMA file, makes perfect sense. The obviously antiaristotelian tone of this Essay and of its accompanying *Dialogus*, both concerned with totally congruent ideas on motion, together with the fact that both these literary genres were already being brought closely together as they will be later, added to the presence of famous published material, one of which is one of the most important passage from the 1638 *Discorsi*, the correct definition of naturally accelerated motion, others concerned with the 1612 *Discorso* on Floating Bodies, all in Galileo's hand, it is no wonder that Viviani, notwithstanding his surprise, feels authorized to say "... is dispersed in this manuscript, all that, as one can see, he later inserted himself opportunely, in its place, in the works he printed".

Now, if already in the XVIIth Century Galileo was a great hero, in the XVIIIth and the XIXth he became a mythical giant. The climax of this came with Albèri's *Le Opere di Galileo Galilei, prima edizione completa condotta sugli autentici manoscritti palatini*. In 1854 comes out the *Sermones de motu gravium*.<sup>34</sup> The editor wants to demonstrate, and here permit me to quote myself from above "that *all* that Galileo published on motion, already finds itself, if only in germ, in these youthful works". For an enterprise in marketing if not in delusion, it was quite something. Albèri first publishes the *Dialogus*, saying, at its abrupt interruption, that he could not establish whether material had been lost or that the task had been left incomplete.<sup>35</sup> Then follows a highly sophisticated choice of excerpts from the Essay. Of course, we find the chapter on incline planes (Drabkin's ch. 14), which proves that Galileo was using this experimental tool back in Pisa around 1590. Then come two chapters (Drabkin's ch. 15-16) which show Galileo attacking basic principle's of Aristotle on motion: rectilinear and circular motions have a ratio to each other, and concerning circular motion whether it is natural or forced, arguing that some motions could be mixed, others neither natural nor forced. The fourth excerpt is Drabkin's ch. 21, "in which it is proved against Aristotle that, if natural motion could be extended without end, it would not become faster without end". Albèri uses it to convey to the reader that long before Newton and Leibniz, Galileo was on his way to invent the calculus<sup>36</sup> and already in possession of the princi-

<sup>34</sup> Galilei, Galileo, and Eugenio (Hrsg.) [u.a.] Albèri. 1854. *Le opere: prima edizione completa, condotta sugli autentici manoscritti Palatini*, Tomo 11: [Opere fisico-matematiche]. Firenze: Soc. Ed. Fiorentina. See 9-80.

<sup>35</sup> *Ibid.*, p. 55.

<sup>36</sup> See Albèri's note to a passage of the *Sermones*, p. 39.

ple of inertia. Here however, the editor omits to include the last paragraph which explicitly refers to the subject of the following chapter,<sup>37</sup> Drabkin's ch. 22. Its inclusion would have revealed itself totally incompatible with the thesis, and deprived it of the following final punch. Indeed, last comes the *Discorsi* excerpt, presented as belonging to the same early period of production. QED. Quod erat demonstrandum.

Let us go back to my reconstruction of Galileo's file. Today we scholars have learned what Galileo always knew. Back between 1589 and 1592, when he was lecturing as Matematico of the Studio di Pisa, he was not in possession of the correct definition of naturally accelerated motion. At that time he was even of the opinion that acceleration of falling bodies was somehow an accidental phenomena. It took a lot of work, both in the lab and at his working table, to recognize acceleration as a natural necessary feature of free fall. Now, permit me here to recall again, lest you still hesitate on how this first attempt at a new science of motion should be called, that this file was given a private name by Galileo: *Older Works On Motion*. When did he do so? When could these works be labelled older? Well, if my reconstruction is valid, imagine yourself, looking over Galileo's shoulder, in his house in Arcetri, at some time, say in late 1633 or early 1634, shuffling around his notes, in preparation for the *Discorsi on Two New Sciences*, putting is older papers in order. And now, let's read this transparency once more. On top of the pile comes the **Memoranda**, spanning the whole Pisan production, followed by its **Program** in 24 topics. Next comes the *Dialogus*, for which he had written a very important memo –the equivalent for the Dialogue of some of the material in the 10 chapter reworkings of the Essay–, but this first *Dialogus* had been left unfinished at the time. Why? Well, the first results of a search for the ratios, *proportiones*, of heavy bodies in motion were not quite satisfactory. Back in 1972, in my *Physis* article,<sup>38</sup> and again recently in Liège<sup>39</sup> in 1997, I still stood by an explanation given in the '69 dissertation<sup>40</sup> for Galileo's total silence on his DMA. I was still convinced that the reworkings on the Essay had revealed to our young *filosofo-geometra* a hidden con-

<sup>37</sup> In which Galileo announces: "...at the beginning of their motion they are not moved in accordance with their heaviness, because they are impeded by a contrary force, it will surely not be astonishing if the swiftesses do not observe the ratios of the heavinesses; on the contrary, and this surely seems remarkable, lighter things go down more swiftly than heavier ones at the beginning. Others, too, have tried to assign a cause for this remarkable effect; since they have not been successful, we will in the next chapter refute them and endeavor to bring forth the true cause". EN I, 333.3-13, my translation.

<sup>38</sup> Fredette, R. (1972). "Galileo's De Motu Antiquiora". *Physis, Rivista Internazionale di Storia della Scienza*. Anno XIV (Fasc.4 - 1972): 321-348.

<sup>39</sup> Fredette, Raymond. 1997. "Notes pour une traduction *intégrale* du Traité contenu dans les *De motu antiquiora* de Galilée". Paper read at the *XXème Congrès international d'histoire des sciences 20-26 juillet 1997*, Liège, Belgique. The Symposium #40: les traditions classiques et médiévales et la renaissance des sciences physico-mathématiques au XVIe siècle, in the midst of which this paper was presented, is due to be published in the course of 2001.

<sup>40</sup> Cf. *supra*, note 12, see 284-295.

tradition in defining the concept of *virtus impressa* as lightness. I now find that this accusation is not valid. I now think that the discrepancies between theory and experimental results amply suffice to have commanded prudence before making these results public. He had written a full Essay, in two books, he even had completely rewritten the first book, but to no avail. The discrepancies were still there. Notice here, in the final ordering of his DMA file, how he puts the elaborate reworking first; then comes the original complete version of the Essay; and at the end is found the discarded reworking. More than fifty years later, the master, “post diuturnas mentis agitationes” had indeed made some progress and he was now ready to commit publicly what could be saved of his work in mechanics, cinematics and dynamics. And so, before he puts away these Older Writings, Galileo inserts autograph copies of the excerpts Viviani and Nelli found, as if to make a comment to himself on his Pisan dynamics. He now is in possession of some truths concerning certain errors he had made in the beginning.

Before concluding, I now come to a quite exciting moment in this exercise of reconstruction of Galileo's early writings. Absorbed as I was with the DMA, I had never bothered seriously with the *Juvenilia*, which Favaro had dated 1584, much less with the *Dialettica*, which Favaro had not even considered fit for full publication. Well, I was wrong. Preparing the present lecture gave me the opportunity to catch up on some reading I should have done long ago. And for me the impact is as surprising as it is gratifying. Remember what I said at the beginning of this lecture as to what was my point of departure in Galilean studies: look into Galileo's criticisms of Aristotle's thinking on motion as opposed to his making fun of his Aristotelian contemporaries. Well you will easily imagine the pleasure I had in finding out about the *Dialettica* and the *Juvenilia*. These are not the notes of a Vallombrosa school boy, nor are they the notes of a senior college student getting instructed in standard scholastic philosophy. No! These notes are those of a young man who has abandoned medicine to study mathematics, a field which feeds his imagination to concoct a very ambitious project: establish with theoretical rigour and experimental precision that Aristotle's basic principles in natural philosophy cannot be held true anymore. Read those notes! You will find out that they are the result of Galileo's copying and abridging manuscripts written by the then most recent competent Jesuits Aristotelian teachers, those of the Collegio Romano. Bill Wallace,<sup>41</sup> since

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<sup>41</sup> Galilei, Galileo. 1992. *Galileo's logical treatises: a translation, with notes and commentary, of his appropriated Latin questions on Aristotle's posterior analytics*. Translated by Wallace, A. William. Vol. 138, *Boston studies in the philosophy of science*. Dordrecht: Kluwer. Galilei, Galileo, William A. Wallace, William F. Edwards, and Biblioteca nazionale centrale di Firenze. 1988. *Tractatio de praecognitionibus et praecognitis; and, Tractatio de demonstratione, Saggi e testi*; 22. Padova: Editrice Antenore. Galilei, Galileo Wallace, William A. (Hrsg.). 1977. *Galileo's early notebooks: the physical questions; a translation from the Latin, with historical and paleographical commentary*. Notre Dame London: Univ. of Notre Dame Press.

1967, working independently of Alistair Crombie and Adriano Carugo<sup>42</sup> who also have contributed to this breakthrough, has been working at trying to identify these teachers. And his outstanding scholarship in digging them out of Italian libraries must be saluted as a very beautiful contribution to Galilean studies in the last 25 years. These notes of Galileo constitute a highly sophisticated sort of writing. Do not look for Galileo's explicite thoughts and comments here. What Galileo is doing is his homework on Aristotle and he proceeds very seriously, with care and great competence. He obviously has read Aristotle's texts in logic and natural philosophy. And if you browse through these notes you will notice that Galileo is very selective on the questions and subjects he wants to be briefed on. First comes the *Dialettica*, in Gal. 27, which deals with basic questions on the nature of what is a true science. Here Galileo reads some *reportationes* written by his Jesuit sources, that is their lecture notes to Aristotle's *Posterior Analytics*. And what Galileo does is to jot down passages of his choice, copying some, summarizing others, in general, gathering the information he wants. In Gal. 46 we have basic questions concerning the constitution of the universe and the motions of the spheres, where Galileo summarizes *reportationes* concerned with some parts of the *De caelo* and also on questions concerning problems of alterative motion and the nature of the elements, delving this time with issues from the *De generatione et corruptione*. We now should take these notes seriously and read them as a preamble work to his ambitious project of a new mathematically oriented science of motion. Before embarking on his ambitious project of criticising Aristotle, Galileo makes sure he knows and understands his target as well as he possibly can. And the job will eventually serve him very well. This job, *in fine*, has always appeared to me as being Galileo's most important contribution. Galileo thinks again Aristotle, one last time, in such a way, that, after him, not being able or not having to think Aristotle anymore, is not only possible but necessary for the advancement of learning. This ambitious project will take nothing less than a lifetime and be a decisive success. With the publication of the *Discorsi* in 1638, the new science of motion does rest on new foundations, in replacement of the venerable science of Aristotle which had guided our understanding of the universe so well during 1800 years.

Time now for my concluding remarks. I have chosen to end these *Notes for a reappraisal* by risking a brief reflexion on our trade as historians of the ideas of and around Galileo. And I will do so through what is for me a rather sensitive subject, namely what I would call the outrageously well known and extremely often repeated opinion according to which Galileo in his early *De motu* is following Benedetti. The next time any of you is tempted to say so, especially if you intend to drape yourself in the authoritative

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<sup>42</sup> Carugo, A. and A. C. Crombie (1983). "The Jesuits and Galileo's Ideas of Science and Nature". *Annali dell'Istituto e Museo di Storia della Scienza di Firenze*. Anno VIII (Fascicolo 2): 3-68.

mantle of Alexandre Koyré, may I suggest you take a deep breath and instead of saying so, take the resolution to go back to the texts and check, both in Koyré and in Benedetti. You may be in for some surprise. For instance, in his 1959 article for the *Mélanges offerts à Etienne Gilson*, Koyré has this opening paragraph:

Jean-Baptiste Benedetti est, très certainement, le physicien italien le plus intéressant du XVI<sup>e</sup> siècle; il est aussi celui dont le rôle historique fut le plus important: en effet, son influence sur le jeune Galilée qui, dans son traité de Motu, le suit pas à pas, est indéniable et profonde.<sup>43</sup>

Somehow, Koyré here seems to let himself be carried away. He seems to have become totally oblivious of the fact that twenty years before, he had written a comment on Mach and Wohlwill, who, says Koyré, had asserted that

at Pisa, Galileo did no more than repeat without acknowledgment what has been taught by G. B. Benedetti. This judgment, ... , is not entirely fair; while he does follow Benedetti (which, moreover, is explained by the fact the Benedetti's thought, like that of the young Galileo, is a strange mixture of Parisian empiricism and Archimedean mathematicism) he does diverge from him on occasion, and when he does he is always right to do so. At such points, we would say, he shows himself to be more profoundly both empiricist and Archimedean than Benedetti. It is this that makes a study of Galileo so instructive.<sup>44</sup>

Strangely enough, instead of studying Galileo's text, we scholars took the master's word that, anyway, here in the *De motu*, Galileo is mainly following Benedetti. With the result that we dispensed ourselves from really reading Galileo's Pisan dynamics with attention. Now, if you start closely comparing texts looking for precise traces of a dependence of Galileo on Benedetti, you will not find a single one which could be shown as an indication in that direction. For sure, they are both resolutely against Aristotle's opinion on many common subjects, for instance the instantaneity of motion in the void. And, if Galileo follows someone "pas à pas" it is not Benedetti but their common masters Euclid and Archimedes. Both Benedetti and Galileo make use of the *De insidentibus in humidum* as a mathematical tool to argue against Aristotelian opinions on motion. And, as Koyré suspected it, this is enough to explain their closeness. If you read Benedetti-

<sup>43</sup> Koyré, A. (1959). "Jean Baptiste Benedetti, critique d'Aristote" *Mélanges offerts à Etienne Gilson*. Toronto-Paris, Pontifical Institute of Mediaeval Studies: 351-372. See 351.

<sup>44</sup> Koyré, A. (1939). *Histoire de la pensée: T. 1, Etudes Galiléennes T. 1: A l'aube de la science classique*. Paris, Hermann. See 10, note 3. Translation: John Mepham. Cf. Koyré, A. *Galileo Studies*. New Jersey, Humanities Press. See 40, note 24.

ti you realize that he is an autodidact in mathematics, a pure mathematician with some interest in applied mathematics,<sup>45</sup> notably in music,<sup>46</sup> but no real interest in experimental philosophy. And he will tell you himself that he did not get any official schooling in philosophy.<sup>47</sup> And this certainly shows, if you contrast his demonstrations which are obscure and often logically sloppy,<sup>48</sup> with those very clear, competent and still perfectly adequate criticism written by the young Galileo. Forty years ago Drabkin<sup>49</sup> had already challenged seriously this idea that the young Galileo was following Benedetti. Five years ago, Enrico Giusti<sup>50</sup> published the first analysis of Benedetti's 'De motu' which was not written by looking through what he aptly calls, and I will repeat it in all the four official languages of this Eurosymposium, la lente deformante dell'ottica precursoristica, la lentille déformante de l'optique précurseuriste, la lente deformante de la óptica precursorista, the deforming lens of the precursorist's angle. Prudently Giusti concludes that: "l'influenza di Benedetti su Galileo è tutto da provare". For myself, ever since the middle sixties, I had been pretty well convinced that Galileo had never even read Benedetti. I may be wrong once more. A few weeks ago, I scanned through, for the first time, a paper that was presented at the same Annual Meeting of the History of Science Society, in New-York, late December '71, during which I rendered public some of the results of my PhD research. It is Frederick Purnell's "Jacopo Mazzoni and Galileo".<sup>51</sup> I just learned that the great philosopher Mazzoni, whom I knew was a friend

<sup>45</sup> Field, J. V. (1987). "The Natural Philosopher as Mathematician: Benedetti's Mathematics and the Tradition of *Perspectiva*". *Atti del Convegno Internazionale di Studio: Giovan Battista Benedetti e il suo Tempo*. Istituto Veneto di Scienze. Venezia, Antonio Manno (ed.): 247-270.

<sup>46</sup> Cohen, F. H. (1987). "Benedetti's Views on Musical Science and their Background in Contemporary Venetian Culture". *Atti del Convegno Internazionale di Studio: Giovan Battista Benedetti e il suo Tempo*. Istituto Veneto di Scienze. Venezia, Antonio Manno (ed.): 301-310.

<sup>47</sup> Benedetti, Giovanni Battista. 1553. *Resolutio omnium Euclidis problematum: aliorumque ad hoc necessario inuentorum una tantummodo circini data apertura Resolutio omnium Euclidis problematum*. Venetiis: [Apvd B. Caesatum]. In the preface, see folio 5r, lin. 20-23: "... Scientis eam placuit a teneris unguiculis consecrare, atque hucusque progressus sum (Deo duce) sine monitore praeceptoreque ullo, nullum gymnasium unquam, nullamque scholam frequentavi, neque hoc studui, quod vulgus solet". He will only add, see folio 5v, lin. 2-5, "Caeterum quia cuiusque quod suum est reddi debet, nam & pium, & justum est, Nicolaus Tartalea, mihi quatuor primos libros solos Euclidis legit".

<sup>48</sup> Examples abound, suffice it here that I refer you to one which I consider a model: compare the argumentation in Giovanni B. de (Benedictus, Johann Baptist). 1585. *Diversarum speculationum mathematicarum et physicarum liber*. Tavrini: Beuilaquae. See caput XI, 175, with Galileo's analogous one in the DMA, EN I, 265. For further comments, cf. also, op. cit. supra note 12, see 350-354.

<sup>49</sup> Drabkin, I. E. (1963). "Two versions of G. B. Benedetti's *Demonstratio Proportionum Motuum Localium*." *Isis* 54 (Part 2, N°. 176): 259-262.

<sup>50</sup> Giusti, E. (1997). "Gli scritti 'De motu' di Giovan Battista Benedetti". *Bollettino di Storia delle Scienze Matematiche* XVII (fasc.1): 51-104. See his conclusions 93-96.

<sup>51</sup> Purnell, J. F. (1972). "Jacopo Mazzoni and Galileo." *Physis* (Anno XIV): 273-294.

and tutor to the young Galileo during his tenure in mathematics in Pisa, explicitly follows Benedetti's opinions in discussing the utility of mathematics in physical investigations. But Mazzoni's exposition exhibits points of disagreement with Benedetti's account, and Mazzoni's account is as close as can be to Galileo's in his *De motu antiquiora*. Why? Don't we have here, as Purnell thinks, an indication that, matematico Galileo Galilei, discussing Benedetti with his tutor, was straightening out Mazzoni's reading? –Muchas Gracias!

