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Introduction. 1564-2014. Homage to Galileo Galilei

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1 The *Iuvenilia*–Early Galilean works

When Galileo Galilei (1564-1642) published the *Sidereus Nuncius* in 1610 [Galilei 1890-1909, III, pt. I, 51–96], he was a famous enough scientist, who was not young: for, he was 46. Nevertheless, this little book represented the fundamental turning point in Galileo's life and scientific production. The *Sidereus Nuncius* was very successful and gave rise to numerous discussions. Some scholars defended Galileo—the most important was Kepler—, many others, with a series of different arguments, criticized the content of the *Sidereus*. Galileo became the most famous and discussed European scientist. All his most important contributions, among them we remind the reader *Il Saggiatore* [Galilei 1623], the *Dialogo* [Galilei 1632] and the *Discorsi e dimostrazioni* [Galilei 1638], appeared after the *Sidereus Nuncius*. All these works are contributions which aim at reaching theoretical conclusions, although the experimental method plays a fundamental role to reach such conclusions. While, if we go back to Galileo's production before 1610, three facts are surprising, enough: a) the relatively scarce amount of written and published works; b) most part of these works have a practical approach, that is, they are dedicated to the military operations or military fortifications or to instruments usable in a military context; c) some contributions are commentaries to important works of ancient authors, above all Archimedes. There are also some more theoretical contributions, like those relating to the new star appeared in

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1604 [Galilei 1890-1909, II, 267-306]. However, they are a minority. On the other hand, it is known that Galileo claimed more than once that the years he spent in Padua, working for Venetia Republic, were his most happy and fruitful period, from a scientific as well as a personal standpoint. It seems therefore only natural that he developed many of the ideas explained from 1610 forward in the period spent in Padua. Hence, the reason of interest connected to Galileo's production preceding 1610 is twofold:

1. The specific content of Galileo's writings.
2. The attempt to understand which ideas he had developed in that period, but clearly expounded after 1610.

Usually the word *Iuvenilia* is reserved for Galileo's works reported in the initial pages of the first volume of Favaro's National Edition [Galilei 1890-1909, I, 7–178, hereafter EN]. According to the outlined panorama, we propose to extend the word *Iuvenilia* to the whole production of Galileo published before the *Sidereus Nuncius*. Thus, we refer to the content of the first two volumes of the Galilean National Edition. We consider all these contributions as *Iuvenilia*, identifying the separation line with the fact that, before the publication of *Sidereus Nuncius*, Galileo published, in substance, no theoretical work, though his theoretical activity had already been rather profound, as is well known. Here we report the content of the first two volumes of the National Edition:

> *Iuvenilia. – Theoremata circa centrum gravitatis solidorum. – La bilancetta. – Tavola delle proporzioni della gravità in specie de i metalli e delle gioie pesate in aria e in acqua. – Postille ai libri de sphaera et cylindro di Archimede. – De motu.* [Galilei 1890-1909, I]

> *Breve instruzione all'architettura militare. – Trattato di fortificazione. – Le mecaniche. – Lettera a Iacopo Mazzoni (30 maggio 1597). – Trattato della sfera ovvero cosmografia. – De motu accelerato. – La nuova stella dell'ottobre 1604. – Frammenti di lezioni e di studi sulla nuova stella dell'ottobre 1604. – Considerazione astronomica circa la stella nova dell'anno 1604 di Baldesar Capra, con postille di Galileo. – Dialogo de Cecco di Ronchitti da Bruzene in perpuosito de la stella nuova. – Il compasso geometrico e militare. – Del compasso geometrico e militare, saggio delle scritture antecedenti alla stampa. – Le operazioni del compasso geometrico e militare. – Usus et fabrica circini cuiusdam proportionis, opera et studio Balthesaris Caprae, con postille di Galileo. – Difesa contro alle calunnie et imposture di Baldessar Capra. – Le matematiche nell'arte militare.* [Galilei 1890-1909, II]

The Galilean literature is wide, so that it is impossible to list all references.[1] In the secondary literature one can read reflections, which are sometimes interesting, but not always historically proved such as clear hypotheses, reasoning and assumptions. In general, Galileo's adolescent life and scientific activity are not explored and known, enough [Heilbron 2010]; i.e., it seems that his father also proposed, or simply had in mind, a sort of experimental method for his musical instruments [Cohen 2010, 85 sq.]. Other probably alleged—or not—stories concern his father Vincenzo who would give Galileo the idea of joining the *Camaldolese order*, though this story does not look accurate because the religious order, at that time, did not accept young boys. Some authors pointed out Vincenzo's opposition to his son's mathematical studies. There is also a debate on Galileo's home-birthplace in Pisa. Furthermore, a new edition of Galileo's *Opere* (such as also Torricelli's) works seems to be necessary.

Therefore, there are several unsolved aspects and historical problems as to Galileo's young life. We hope that this special issue offers to the historians, philosophers and scientists a right provocation, an intellectual stimulus and a sufficient grit to face again Galilean studies in the 21st century.

2 On the special issue

The early Galilean works [Galilei 1890-1909, I–II] are historically crucial to better understand both philological aspects and early foundational Galilean convictions-doubts-methods before his definitive study on parabolic trajectories (1608-1609) and his mechanics. A cautious attitude sometimes shines, in some circumstances Galileo appears not completely confident with physical subjects, as it is the case, e.g., in some parts of the *Trattato di Fortificazione* [*Ivi*, II; see also Pisano & Bussotti 2015, and below Pisano's works on the subject], where there are pictures which show rectilinear trajectories for the projectiles. The influence of the studies developed in this period clearly appears in conspicuous parts of later Galileo's production: for example, when Galileo addressed technical subjects as the strength of materials in the *Discorsi e dimostrazioni matematiche*, he also faced architecture and fortresses. He conceived these parts not only as researches for military expert architects, but also as lectures for students: i.e., two speeches on *fortifications* stem from teaching speeches collected by his pupils on indications of Galileo himself. In this sense, the experience he had made in the period spent in Venice Republic, as a professor at Padova university and as an expert, who worked for the Republic, was fundamental. The relatively limited amount of secondary literature (on mechanics correlated to fortifications) is a matter of fact, testifying the modest interest in these topics with respect to (the more relevant) Galileo's

1. In the References, we mention a selected list of the primary and secondary sources connected to the content of our Introduction.

researches on mechanics, instead largely commented by many scholars. This is why we propose a special issue that, starting from the period in which Galileo produced his works on fortifications and military architecture, is the occasion to rethink, more profoundly, of the whole production by Galileo preceding his discoveries of the law of uniformly accelerated motion (1608-1609) and the publication of *Sidereus Nuncius* in 1610.

3 The papers

All of the papers in this special issue have been independently blinded refereed. We have respected different individual ideas, historical, philosophical and epistemological accounts from each of the authors. The authors' contributions appear in alphabetical order. Each of the authors is responsible for his or her own opinions, which should be regarded as a personal point of view based on his scientific background.

Crapanzano (Italy) analyses Galileo's dialogue *De motu* and related contributions under a particular perspective: the reading offered by Raffaello Caverni (1837-1900) of these Galilean works. The author reminds us that Caverni wrote, at the end of the 19th century, the monumental work *Storia del metodo sperimentale in Italia*, a text, which, although imprecise for many aspects, continues to represent an important source. After that, Crapanzano summarizes the history of *De motu* and its relations with *De motu antiquiora*. The author points out that Caverni played an important role in establishing the text of *De motu* for Galileo's National Edition. He actively collaborated with Antonio Favaro (1847-1922), though Caverni is not mentioned in the Edition. The section 2 is an interesting and successful attempt to frame Caverni's *Storia del metodo sperimentale in Italia* within the context in which this work was conceived. Finally, the author faces the difficult problem to catch the role of *De motu* within history of mechanics.

In his paper, Drago (Italy) deals with a broad problem: what was the role of Galileo in the birth of modern science. To face the question, Drago first presents the most accredited positions in the literature as to this subject. Following his line of reasoning, the author identifies three dialectic dichotomies, which allow us to enter the problem: 1) experiment/ mathematical hypotheses; 2) potential infinity/ actual infinity; 3) axiomatic organization/ problem-based organization. As to this third aspect, the dialectic classical logic/ non-classical logic, identified by Drago, also plays a fundamental role. With regard to the birth of science, the author first analyses the interplay of these three aspects in their general form. Afterwards (8th and final section) the role of Galileo is analysed in the light of the explained dichotomies.

Fredette (Canada) analyses *De motu antiquiora* published in the first volume of Galileo's EN. The author traces a continuous line between this early work and the most mature and important contributions given by Galileo

to science: the *Dialogo sopra i due massimi sistemi del mondo* and *Discorsi e dimostrazioni matematiche intorno a due nuove scienze*. Fredette precisely identifies eight issues developed in details by Galileo in the *Dialogo* and in the *Discorsi*, which were already present in *De motu antiquiora*. The author, given any single issue he has posed, refers to the solution offered by Galileo in *De motu* and to the corresponding idea fully developed in the *Dialogo* and in the *Discorsi*. In this manner, a useful lens, by which to look at the whole of Galileo's production is offered starting from one of his initial contributions to physics.

In his contribution, Gatto (Italy) interprets *Le mecaniche* by Galileo as a conceptual bridge between the old science of weights and the modern statics. The author traces an ideal itinerary to explain the novelties of Galileo's text relying upon what he calls "the comprehension principle", namely the notion "according to which force, resistance, time, space, speed, continuously compensate each other: if the power increases, the speed decreases because, in moving the resistance through a given space, in the same time the force crosses a space longer than it". In modern terms: work cannot be created *ex nihilo*, but only transformed; the nature cannot be deceived. Gatto faces such an important problem in this early work by Galileo offering a profound picture both from a philological-historical and conceptual standpoint.

Gorelik (USA) deals with an extended form of the so-called Needham Question, that is: what prevented Greco-Roman and medieval civilizations from developing science following the line indicated by Archimedes and what prevented the Eastern civilizations from giving significant contributions to physics for centuries after Galileo (Needham's questions were restricted to the Eastern civilizations)? Along his itinerary to find an answer, the author points out the mathematical and experimental method of modern physics and tries to identify a line of separation between Galileo's and Archimedes' approach. He then identifies an optimistic feeling in the regularity of nature and in our capability to penetrate such regularity. After that, the possible role of Christian religion is also taken into consideration.

Lévy-Leblond (France) addresses a particular subject within Galileo's production: the *Due lezioni all'Accademia Fiorentina circa la figura, sito e grandezza dell'Inferno di Dante* (1588). The author explains that Galileo entered into two different interpretations of Dante's Inferno, the one by Manetti and the other by Vellutello. Galileo's lectures, in which he also exploited his mathematical knowledge to interpret some passages of the Inferno, fully succeeded and contributed to make Galileo famous in the academic environment. Probably these lessons played a role when Galileo became professor in Pisa university (1589). Beyond specifying all these aspects in details, the author also frames the *Due lezioni* in the context of Galileo's early scientific production. However, a great part of this paper is dedicated to the specification of Galileo's arguments developed in the *Due lezioni*. This allows the reader to fully appreciate Galileo's pedagogical and argumentative capabilities, which characterize the whole of his production.

Martins & Cardoso (Brazil) present Galileo's *Trattato della Sfera ovvero Cosmografia*, a treatise of geocentric astronomy, probably written in 1600 or few years earlier, as a textbook. The author compares Galileo's *Trattato* with the text which was a reference point for this kind of books: the *Sphaera* by Sacrobosco. The similarities and differences are pointed out both as far as the conceptual and the stylistic-methodological aspects are concerned. The authors also look for the sources of Galileo, thus mentioning Peuerbach's *Theorica Planetarum* and above all a series of vernacular treatises on the sphaera written in the second half of the 16th century. In this context, Galileo's annotations of Piccolomini's *Sfera del mondo* appear particularly significant. Other sources are mentioned, too, although Piccolomini's work seems the most important one. The two authors also offer profound insights on the literature concerning Galileo's *Trattato della Sfera*.

Massai's (Italy) contribution represents an ideal chronological conclusion of this special issue because the author analyses the *Sidereus Nuncius*, work which we assumed as the conclusion of the *Iuvenilia* and the beginning of Galileo's mature phase. Massai intends to point out the importance of the instruments, the observations and the experiments in Galileo's scientific praxis. The author underlines that Galileo was an expert instrument-maker. This was fundamental for him to realize the telescope could have an astronomical utilization. Furthermore, Massai enters the logic of many argumentations developed by Galileo in the *Sidereus Nuncius*, showing that Galileo reaches the right conclusion as he excludes a series of hypotheses because they are not consistent with the observations. Therefore, Massai's is both a descriptive and a methodological paper.

Mottana (Italy) examines Galileo's treatise *La bilancetta*, taking into account the first draft of this work and the successive additions. The thesis of the author is clear: experiments guided the whole of Galileo's production and scientific procedures. Thus, Mottana presents early Galileo's studies from the very beginning of his scientific activity. After having described the environment in which *La bilancetta* was conceived, the author enters into an analytical and exhaustive examination of the subjects dealt with in the first draft, describing in detail all the operations carried out by Galileo with the instrument. The same approach is used to describe the additions. Here the figure of Guidobaldo dal Monte plays an important role. The whole paper is enriched by numerous and perspicuous references to primary and secondary sources.

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