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RESEARCH, TEACHING AND SCIENCE POPULARIZATION IN THE XVII CENTURY: AN ANALYSIS OF THE CORRESPONDENCE OF JACOPO BELGRADO WITH GIOVANNI POLENI

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“Vorrei tornare indietro

per rivedere il passato,

per comprendere meglio

quello che abbiamo perduto”

Passacaglia, Franco Battiato

Abstract

Europoleni is a project promoted by the Centre for Correspondence and Diary Studies (CECJI) of the University of Brest, France. Its purpose is to digitalize the correspondence of the physicist Giovanni Poleni (1683-1761), the first professor of experimental physics at the Physics Cabinet of Padova. The letters he exchanged with Jacopo Belgrado (1704-1789), mathematics and physics professor, Jesuit abbot and founder of the astronomical observatory of Parma, have been transcribed and analyzed for this thesis. They will be then encoded to be available online, completed with a report of their scientific contents. Thanks to this work, it has been possible, besides widening the knowledge about Poleni, to bring back to light the figure of Belgrado. Not so many sources are available about this fascinating character, tirelessly busy on the spiritual and scientific fronts. Careful research allowed me to study his life, works and experiments, and to contextualize them in the Enlightenment movement of the eighteenth century. Through this thesis, guided by his letter exchange with his colleague and friend Giovanni Poleni, we will discover the main steps of Belgrado's lifeworks.

Contents

Introduction

In this thesis, the correspondence between two eighteenth-century Italian scientists, Giovanni Poleni and Jacopo Belgrado, will be analyzed. The research is framed within the international project Europoleni, promoted by the Centre for Correspondence and Diary Studies (CECJI) of the University of Brest, France, which aims at analyzing the correspondence of the Paduan professor Giovanni Poleni. In fact, Poleni was a central figure of eighteenth-century European culture. As for physics, he was the first to hold the chair of experimental physics in Padua, instituted in 1739 by the Venetian Republic. The project was labelled by the *Maison des sciences de l'Homme de Bretagne* (2019-2020).

The Europoleni Project

The purpose of the project Europoleni is the digitalization and translation of the the correspondence of Poleni, the encoding in XML-TEI, and the critical analysis of the contents, thus allowing the dissemination of knowledge as well as further deep research in several fields, such as the history of science in the Enlightenment.

In particular, from the beginning of the eighteenth century, after the Scientific Revolution, physics teaching underwent radical changes which saw the role of instruments and experiments as central. Besides setting up a suitable space for attending such kind of lessons at the *Palazzo del Bo* of Padua, Poleni purchased several instruments for the Cabinet of Physics, initiating the rich collection that is now kept at the Museum of the History of Physics of the University of Padua, now Giovanni Poleni Museum.

Poleni was in touch with several scientists of his time, from all over Europe, with whom he exchanged information about the research and scientific themes of his time, but also about scientific literature and experimental results. Most of the letters are kept in Italian archives, such as the Biblioteca Marciana of Venice, Biblioteca Civica of Verona, and the archives of the University of Padua.

Minor personalities emerge from the project: the case of Jacopo Belgrado

The long list of characters with whom Poleni was in contact, amongst notorious figures, includes "minor" personalities about whom too little has been written, despite their life and research would deserve a thorough analysis.

For this thesis, I studied Father Jacopo Belgrado from Udine.

Thanks to the possibility of working with primary sources, the letters that Belgrado exchanged with Poleni from 1742 to 1761 (i.e., until the death of Poleni), it was possible to reconstruct some steps of the life of this enterprising character.

The first step of my work was the transcription of the original, hand-written letters, that had been previously scanned within the Europoleni project. Then I looked for papers about the two characters, focusing on the figure of Jacopo Belgrado, whose work has been poorly studied in the last two centuries. This is partly due to the fact that, because of a series of events that had forced Belgrado to move more than once from the cities where he was working and to leave all his belongings behind, a lot of sources were lost. Nevertheless, from an in-depth research on his life and his publications, the complexity and versatility of his teaching and research projects emerged. I found, read and analysed one of his publications, about which he discussed largely in his correspondence with Poleni. I also collected information about the astronomical observatory of Parma, that he founded in 1757,. Thanks to these works, besides bringing back to the surface the works of this Enlightenment scientist, it was possible to contextualize them in the intense research and science communication work in which scientists from all over Europe were engaged during the eighteenth century.

Jacopo Belgrado, who had held the chair of mathematics and physics at the *Studium Parmense,* founded the astronomical observatory of Parma, the third in Italy. Belgrado had himself attempted to introduce in his didactic work the demonstration of experiments, added to theoretical explanations, but he did not create something like the Cabinet of Physics of Padua, partly because the environment in Parma was perhaps not as predisposed, and partly because his teaching activities ceased in 1750, when he became court mathematician to Duke Filippo di Borbone. Belgrado published many treatises on scientific topics that were the object of his research, as well as theological treatises, being a Jesuit member of the so called *Compagnia di Gesù)*.

Within this thesis, the correspondence between the two scientists will be analyzed, focusing on some of the most relevant topics about which they talked about. First, I will present an overview of their lives (Chapters 2 and 3), then, a report on the letters that were transcribed and studied (Chapter 4), and finally a focus on the three most important themes that emerged from them.

Poleni and Belgrado used to exchange information about instruments and the experiments that they carried out; from the letters and the information found by studying the catalog of the instruments belonged to Poleni at the

Museum of Padua, we will see that Poleni acquired some of his instruments and books through Belgrado.

From 1755, a long letter exchange between the two men discusses two dissertations that Belgrado had written and asked Poleni to review, asking him also to mediate with the director of the printing house of the Seminar of Padua for their publication. A copy of the book *"On the action of chance in inventions and On the influence of stars in terrestrial bodies"*[1], which contains the two dissertations and dates to 1757, the year of the first publication, was found in the Historical Library "Guido Horn D'Arturo'' of the Department of Physics and Astronomy of the University of Bologna. The availability of the book, together with the detailed information that has been found in the letters, allowed to reconstruct the phases of the publications, to see some of the drafts that Belgrado wrote before, and how he corrected them under advice provided by Poleni himself (Chapter 6). The content of the dissertations is also worthy of attention, because they contain many reflections of the scientist that purely reflects the Enlightenment thought. Moreover, the second dissertation, "*On the influence of stars in terrestrial bodies"*, falls within the context of a new movement of scientific communication that interested scientists from the whole of Europe.

Finally, in Chapter 7, we will talk about the astronomical observatory of Parma that Belgrado founded, about which he talked with Poleni in some letters, updating him with the instruments he settled and his observation of astronomical phenomena.

The need to contextualize the contents emerged from the analysis of the correspondence will bring into light the character of Jacopo Belgrado and

1 Original title in Italian *"Dell'azione del caso nelle invenzioni e Dell'influsso degli astri ne' corpi terrestri"*, Jacopo Belgrado, 1757, Stamperia del Seminario, Padua

his polyhedric activities, mostly in the time frame that starts from 1742 and ends in 1761. Belgrado constitutes a clear example of the typical work of a natural philosopher, the precursor of what we now call physicist, and teacher of the eighteenth century. In a little city such as Parma, in fact, Belgrado managed to conduct research and communication activities of the same kind as his European colleagues, such as Jean Antoine Nollet, Willem ‘s Gravesande and Poleni himself, besides improving the quality of didactics at the *Collegio di San Rocco,* introducing new topics to the mathematics teaching and publishing mathematics treatises for which he received compliments by D’Alembert and Lalande.

Chapter 2

Jacopo Belgrado - Biography

The life of Father Jacopo Belgrado was bustling and characterized by many intentional and unintentional moves in northern Italy.

He was born on the 16th of November 1704. After studying Greek and Latin literature in Padua, he moved to Bologna to study philosophy and mathematics, and then went to Venice to teach literature. After that, around 1735, he moved to Parma, where he studied theology. His first intention was to pursue a literary career.

In 1723, Belgrado had joined the *Compagnia di Gesù*, The *Compagnia di Gesù*, which had been founded in Paris in 1540, had sent a congregation in Parma in 1564, and the latter was assigned the management of the church of San Rocco and three adjoining houses. From that moment, the Jesuits started collaborating with the *Studium Parmense* for didactic activities, besides having their own schools at the *Collegio di San Rocco*. This was the place where Belgrado resided during his years in Parma. In 1601, a part of the college was fully dedicated to the instruction of noble students and was called *Collegio dei Nobili*. The boarders included some of the major Italian noble families such as the Caracciolo, Doria, Gonzaga, Pallavicino, Sanvitale, Simonetta, Spada, Spinola and Visconti families, and some important personalities of the academic world, such as Scipione Maffei, Cesare Beccaria and Pietro Verri, who had been a student of Jacopo Belgrado himself.

The construction of the entire building, which is now a University of Parma location, lasted from 1659 to 1730.

When he moved to Parma, thanks to his friendship with Father Vincenzo Riccati, Belgrado got a room in the Collegio di San Rocco, the Jesuit college of the city. There, besides carrying on his theological studies, he also had the occasion to dedicate himself to mathematics, which was his other passion. This occasion allowed him "to put his genius to good use, the first studies he had already made in Bologna, the new stimuli, the favourable conjunction of his excellent fellow student and friend, in order to become an illustrious Mathematician."[2]

In 1738, shortly after celebrating his first Mass, Belgrado was assigned to the chair of mathematics at the *Studium Parmense*, precursor of the University of Parma. That was not in use in the Jesuit college, in which Theology studies were followed by the novitiate and profession of vows. Belgrado, instead, carried on his spiritual exercises and professed the vows immediately, teaching and directing the Congregation of Public Study, without novitiate.

When assigned to the mathematics chair, Belgrado managed to improve the level of those subjects. The teaching at the College was, in fact, quite limited if compared to university lectures: the institute was not a university yet, so students were younger, and subjects less technical. Belgrado purchased a collection of the best mathematics and physics treatises, and introduced in the mathematics program equations, analytical geometry of plan figures, and some analysis elements. As for the physics lectures, he managed to make them comparable with the ones attended in universities, introducing scientific instruments and experiments, the first of which was a telescope that seems to have been used for didactic, as well as for

2 Belgrado, Carlo. *Commentario della vita e delle opere dell'Abate Conte Jacopo Belgrado*. Dalla Reale tipografia parmense, 1795 ("ch'anzi tutto pose a profitto il suo genio, I primi studj già fatti in Bologna, I nuovi eccitamenti, la favorevole congiuntura dell'eccellente condiscepolo e amico a divenir Matematico illustre.")

research. From the notes of his students, it is clear that Blegrado's teaching had a clear Newtonian footprint.[3]

Not satisfied by the instruments he bought, Belgrado wanted to have his own for this reason, he started a collaboration with the two artisans Stefano Droghi, a Patrician from Parma, and Pietro Ballerini. They were skilled in manufacturing works, but they did not have physics and mathematics training: Belgrado himself took care of this, in order to make them competent enough to understand the functioning and purposes of the machines they had to build. Their combined efforts successfully led them to the creation of a collection of excellent machines for the study of Static, Hydrostatics, Hydraulics, Optics, Dioptrics, Catadioptrics and Astronomy. Having at his disposal such a rich instrumentation, Belgrado started giving public lectures of experimental physics, a subject that in that century saw its first popularization, as we will see in the following chapters. iHs lectures involved "*people of every kind, and even of the first ranks, and these then went everywhere preaching the knowledge and skill of the young Professor, and the method he used, demonstrating and teaching; a method that was easy and simple, and appropriate to everyone's intelligence."*[4]

The news of his talent soon arrived soon to e His Royal Highness Don Filippo di Borbone Infante di Spagna, who hurried to attend the lectures held by Professor Belgrado.

3 Annali di Storia delle Università Italiane, CLUEB, Bologna, 2005, pp. 82-89

4 Belgrado, Carlo. *Commentario della vita e delle opere dell'Abate Conte Jacopo Belgrado*. Dalla Reale tipografia parmense, 1795 ("Concorreano in folla a' nuovi sperimenti le persone d'ogni genere, ed anche de' primi ranghi, e queste poscia andavano per ogni dove predicando il sapere e l'abilità del giovane Professore, e 'l metodo, di cui usava e dimostrando e ammaestrando; metodo facile e piano, e appropriato all'intelligenza di tutti.")

During his years of teaching, Belgrado published scientific essays and dissertations on various topics, such as elasticity[5], electricity[6] and fluid dynamics[7], in Latin and in Italian. One particular essay deal with a series of experiments that Belgrado discussed with Poleni in some letters of the correspondence and will be treated in Chapter 4. From the analysis of the correspondence between him and Giovanni Poleni, it is clear that he never failed to send his dissertations to his Paduan colleague, asking for an opinion.

Besides Poleni, Belgrado held correspondences with several important personalities of scientific community, such as D'Alembert, LeSage, Keralio, le Roy, Lalande, Clairant, La Condamine, Mairan, Boscovich, Roberti, Zanotti, Toaldo, Congolato and others.

Belgrado was also dedicated to his literary activity, which, in the period of Parma, mostly consisted of writing poems and in cultural exchange with other poets. He was a founder of the Parma Arcadia, following the example of the Roman Arcadia, a literary circle that met in the theatre provided by Count Sanvitali. In that circle, Belgrado was known by the nickname *Damageto Cripteo*. The Parma Arcadia was attended by famous Italian poets, such as Frugoni, Sanvitali, Landi, Scutellari and Bernieri.

Belgrado left the teaching activity at the college when, in 1750, he was appointed mathematician of the court of the duke Filippo di Borbone and the duchess Elisabetta di Borbone-Francia, as well as their spiritual guide. His prestige grew to such an extent that, whoever came to Italy, especially from France, would not only have considered a dishonor not to homage

5 Belgrado, Jacopo. *De corporibus elasticis disquisitio physico-mathematica,* 1747

6 Belgrado, Jacopo. *I Fenomeni elettrici con i corollarj da lor dedotti*. G. Rosati, 1749.

7 Belgrado, Jacopo. *Della riflessione de' corpi dall'acqua*, Parma, Monti, 1753.

the Royal couple, but did ot fail to be presented to Belgrado as well. The only didactic activity that he carried out in those years was the instruction of the son of the duke, Ferdinando.

That position turned out to be advantageous for Belgrado, who had more time forhis scientific research. While being a court mathematician, he managed to launch the project of Parma astronomical observatory, that was achieved in 1757[8], and he published two writings: "*Observatio defectus Lu nae habitae Parmae in novo observatorio patrum Societatis Iesu die 30 iulii 1757*", about a Lunar eclipse happened on that year, and "*Dell'azione del caso nelle invenzioni e Dell'influsso degli astri ne' corpi terrestri*"[9]. Chapter 5 of this thesis is dedicated to the latter volume, about which detailed discussions with Poleni were found in their correspondence.

During those years, Belgrado also obtained academic awards: he joined the Academy of Sciences of Paris in 1762 thanks to the success of the treatise "*De utriusque analyseos usu in re physica*"[10], for which he was complimented by important mathematicians such as D'Alembert and Lalande. besides joining other Italian academic institutes in Bologna, Padua, Siena, Cortona, Ravenna and Udine.

His career at the court of Filippo di Borbone ended abruptly in 1768. From 1762, an anti-Jesuitical movement had started spreading in Parma, guided by the minister of the dukedom of Parma and Piacenza Léon Guillaume du Tillot. His relationship with Belgrado had already soured years before, in 1758, when the latter hindered the promulgation of a law that the Minister

8 Chapter 7

9 Belgrado, Jacopo. *Dell'azione del caso nelle invenzioni e Dell'influsso degli astri ne' corpi terrestri,* Stamperia del Seminario, Padova, 1757.

10 Belgrado, Jacopo, Benigno Bossi, and Giuseppe Patrini. *De utriusque analyseos usu in re physica volumina duo: 2: De analyseos infinitorum usu in re physica volumen secundum*. excudebant haeredes Monti, 1761.

proposed. The law would have imposed a tax that could seriously damage the citizens of the dukedom, as well as commerce. Belgrado wrote a letter to the duke Filippo in which he explained the possible adverse consequences, convincing him not to approve the law.

On the 20th of November 1763, a letter of du Tillot arrived to Belgrado, in which he found out to be "dispensed for the future from the care of the management of his conscience". His dismissal represented a shock for all those who knew Belgrado and appreciated his work. But it was not over: five years later, Ferdinando di Borbone, who had meanwhile become duke, banned the Jesuits from his dukedom, as it already happened in Portugal, France, Spain and in Naples. In the night of the 8th of February 1768, all the Jesuits that lived in the Parma were awakened by the police, charged into coaches and brought to the Vatican. They were also deprived of their belongings, which were seized by the police, so that Belgrado was forced to leave in his room all his writings and instruments.

Jacopo Belgrado moved to another Jesuitic college in Bologna and became its director in 1769. But the papal state was determined to complete the job and disband the *Compagnia di Gesù*, so that, only four years later, Belgrado had to face the cardinal Malvezzi, Archbishop of Bologna, who was organising the closure of Jesuitic structures. Belgrado, together with the Father rector of the College, opposed the initiative, but unsuccessfully. Belgrado was arrested on the 5th of June 1773, and, when exiled and brought to the board of the dukedom, found a brief asylum in Modena, where the Prince and Princesses, the nobles and the prelate greeted him with reverence. Unluckily, he was forced to leave that city too after the official suppression of the *Compagnia di Gesù*, emitted by Pope Clemente XIV. The duke of Modena Francesco III, not willing to lose him, assigned him the chair of physics at the University of Modena on the 25th of August 1777, but Belgrado kindly refused because of his age.

Instead, he reached his brother Alfonso in Udine on the 22nd of April 1774, where he kept on working on his scientific and theological writings and dedicated himself to the education of his nephews. *"Mr. Abbot Belgrado"* wrote the mathematician Lalande *"occupies the idleness of his old age by writing works that always announce a distinguished scholar."*[11] Most of the dissertations on which he worked in that period remained unpublished.

Jacopo Belgrado died, after a long and incurable fever lasting five months, on 26th of March 1789, at the age of eighty-four years. Several important figures of the time could boast of having been instructed by him, such as the philosopher, historian and economist Pietro Verri, student of the *Collegio de' Nobili*, the bishop Adeodato Turchi and the artist Pietro Antonio Martini.

11 Belgrado, Carlo. *Commentario della vita e delle opere dell'Abate Conte Jacopo Belgrado*. Dalla Reale tipografia parmense, 1795 (citation of Jerome Lalande: "Il signor Abbate Belgrado occupa gli ozj della sua vecchiezza scrivendo Opere, che annunziano sempre un Dotto distinto")

Chapter 3

Giovanni Poleni - Biography

Giovanni Poleni was born in Venice on 23rd of August 1683. After attending juridical and classical studies, he started studying mathematics and natural philosophy, and he became an experimental physics enthusiast.

On 26th of February 1710, he was assigned by the Senate of the Republic of Venice the chair of *Astronomia e Meteore* at the University of Padua, where he moved with his wife and sons. Five years later, he was assigned the chair of *Philosophia ordinaria in secundo loco.* In 1719, he was transferred to the chair of Mathematics, right after Nicolaus I Bernoulli left it.

Poleni received various prestigious awards during his brilliant career. One of the most remarkable of them was the appointment as a fellow of the Royal Society of London, which happened on the 30th of November 1710, as proposed by Sir Isaac Newton. He also was a member of the Ricovrati Academy of Padua, of the Institute of Science of Bologna, and of the Imperial Academy of St. Petersburg. He was in touch with leading figures from the scientific community, such as Euler, Morgagni, Newton, Maupertious, Nollet, Joann I, Daniel I and Nicolaus I Bernoulli, Leibniz, Boscovich, Clausius, ‘s Gravesande and Musschenbroek.

On 27th of November 1738, in Padua, a chair of experimental physics was created by the Venetian Senate. This event took place in the context of the revolution that was transforming the teaching of natural philosophy in the whole of Europe. Under the influence of Sir Isaac Newton, president of the Royal Society from 1703, in universities, but also in public contexts, new lectures of experimental physics were introduced. While until those times the teaching of natural philosophy was purely theoretical, in those new lectures, instruments and experiments played a central role, and teaching no longer dealt with all aspects of nature but was limited to what we now call physics.

Poleni was involved in this new form of teaching from the first years of 1700, when, with instruments of his property, he had started giving experimental physics demonstrations in his house in Venice. He was in contact with other scientists, such as the Viennese mathematician and astronomer Guglielmo Marinoni, and with several scientific instrument makers of the Veneto region. It was probably because he was already an expert in that field that, in 1738, Giovanni Francesco Morosini wrote to Poleni, asking him about "a valuable person to honorably give a course of Experimental Philosophy"[12]. Morosini was one of the *Riformatori allo Studio di Padova*, an elite group of Venetian patricians, who was at the guide of the University of Padua. Poleni himself was chosen for that role, because he fitted into all the requirements that were essential for such teaching: experience in practicing with instruments, practical ingenuity, and good theoretical bases[13].

It must be remarked that, in spite of all these prerequisites, before being assigned to the chair, Poleni was subjected to a strict examination by Giovanni Francesco Pivati, one of the Venetian *Riformatori*, who had written the proposal for the introduction of the chair of experimental physics.

12 Morosini to Poleni, 13 November 1738: Venice, Biblioteca Marciana, (BMVe), ms. It., IV, 592, (=5555), c. 229 ("soggetto valevole a sostenere onorevolmente la lezione di Fisica Sperimentale")

13 Talas, Sofia. *"New Light on the Cabinet of Physics of Padua."* (2013).

On 12th of February 1739, the chair was officially assigned to Poleni. To accomplish this important task, Poleni managed, first, to find someone to help him in the preparation of instruments and experiments, a suitable place for lectures and funds for an adequate set of instruments. His requests were quickly accomplished by the Venetian authorities: as an assistant, they provided him with Giovanni Antonio Dalla Bella. Also, the funds were provided from the Republic.

As for the place for the lectures, Poleni and Morgagni worked on the appropriate design of a theater at the *Palazzo del Bo,* one of the historical buildings of the University of Padua. That structure was purposely planned with a limited number of seats, in order to ensure that all the members of the audience had an appropriate view of the experiments and were able to hear the explanations.

Lectures planned and carried on by Poleni were of the same kind as the ones performed by the Newtonians of England and Netherland.

For the experiments, Poleni provided the Cabinet of Physics with an increasing number of instruments, starting with some of his own property and some bought from Cristiano Marinelli. The collection increased over the years: Poleni needed instruments for didactics, but also for his own research. Some of the ones he acquired belonged to other scientists before, some were acquired from other parts of Europe, while some were built on the requirement of Poleni by local craftsmen, on the Dutch model, taking inspiration from ‘s Gravesande and Musschenbroek. Most of the instruments acquired for the Cabinet of Physics of Padua are kept at Giovanni Poleni Museum of History of Physics of the University in Padua.

In 1755, Poleni was also assigned the chair of Nautica e Costruzioni Navali at the University of Padua. He wrote about that to Belgrado in a letter of the 12th of November 1757[14].

Besides his didactics and research activity at the University, Poleni collaborated on several projects, to the point of being granted citizenship of Padua and admission to the Noble council.

He was engaged in 1729 by the prosecutor Pietro Foscarini for the analysis of the structure of the Dome of the San Marco Basilica, in Venice, that was at risk of collapse, and he also was involved in the works and restorations on the Sant'Antonio Basilica of Padua.

Between 1742 and 1748, he was involved in the restoration of the St. Peter's Dome in Rome. This task was assigned to him by Pope Benedetto XIV. In those years, he directed the works on the Dome together with the architect Luigi Vantivelli. A report of the works was published by him in 1748.

Architecture was actually one of the other main interests of Poleni, besides natural philosophy. Between 1739 and 1741, he published a commentary of Vitruvius' *de Architectura,* in three volumes, titled *Exercitationes Vitruvianae*[15]. From his correspondence with Belgrado, we see that his research on antique architecture continued in the following years. Within several letters, some hints on the subject appear, and Poleni complains that his institutional obligations do not leave him time enough to complete the work. Belgrado tried to encourage him, exhor

14 Poleni to Belgrado, 12 November 1757, Venice, Biblioteca Marciana, It.X,135 (=6713) f° 242

15 Poleni, Giovanni. *Exercitationes Vitruvianae primae [-tertiae]. Hoc est: Ioannis Poleni commentarius criticus de M. Vitruvii Pollionis architecti. 10. librorum editionibus, necnon de eorundem editoribus, atque de aliis, qui Vitruvium quocumque modo explicarunt, aut illustrarunt*. typis Seminarii, Padova, 1739.

ting Poleni to dedicate himself to the job, but also to take the necessary time.

Poleni's opera about Vitruvio was completed after his death, with a fourth volume, by his student Simone Stratico, and Giovanni Battista Stratico, Simone's nephew, finally published it in Udine between 1825 and 1830[16].

Giovanni Poleni died on 15th of November 1761, after years of chronic migraines and tertian fevers. In his letters to Belgrado, he often complained of tertian fevers that tormented him, and which he was trying to cure with bloodletting and a medicine called *china-china,* today's quinine. The autopsy, executed by his friend and colleague Giambattista Morgagni, revealed that a rupture of the aorta was the cause of the death.

Poleni left a rich heritage to the University of Padua, first, by taking care of the building of the Theatre and Cabinet of Physics, and by starting the instrument collection that is now kept in the Museum of History of Physics, but also working on the library and the rebuilding of other structures.

He was also a reference figure for a lot of students that carried on his work, and for his colleagues. One of them, as we will see in the following chapters, was Father Jacopo Belgrado himself, to whom Poleni provided precious advice and concrete help. This help, however, was not one directional: in fact, besides encouraging words about the treatise on Vitruvio, Belgrado also shared experimental results with Poleni, and seems, from what emerges from their correspondence, to have collaborated on the construction of some instruments Poleni bought from him.

16 Poleni, Giovanni, Stratico, Simone. *M. Vitruvii Pollionis Architectura: textu et recensione codicum emendato cum exercitationibus notisque novissimis Joannis Poleni et commentariis variorum, additis nunc primum studiis simonis stratico*. Vol. 1. Apud fratres Mattiuzzi, 1825

Chapter 4

An analysis of the correspondence between Jacopo Belgrado and Giovanni Poleni

The collection of letters exchanged by Giovanni Poleni and Jacopo Belgrado covers a time frame of almost twenty years, starting from the 18th of December 1742 and ending on the 1st of December 1761, with a letter addressed to the son of Giovanni Poleni, in which Belgrado expresses his condolences for the death of the scientist. Those letters are kept at the Biblioteca Marciana of Venice and at the Biblioteca Civica of Verona. After the transcription, they will be digitalized and encoded in XML-TEI and made available online on the website of the project Europoleni, completed with the analysis of the content. This chapter focuses on this analysis.

The first letter is dated 18th of December 1742[17], sent by Belgrado to Poleni. From its content, it is clear that the correspondence had already started before.

Within 1742 and 1761, there are some time frames in which no letters have been found though, from the content of the following ones, it can be deduced that other letters were exchanged by the two scientists, or other forms of communication occurred. From the 1st of August 1743 to the 19th of January 1745, for example, we found no letters, but the first one after this period, contains a drawing of an instrument made by Belgrado, and starts with the sentence "The content of the instruction sent to you last

17 Belgrado to Poleni, letter sent on the 18 December 1742. Venice, Biblioteca Marciana, It, X,324(=6666) f° 31

fall consisted mainly of teaching you how to open the cylindrical middle piece of the machine."[18]

Other time frames in which no letters have been found are between the 29th of May 1745 and the 8th of December 1747, and from the 22nd of July 1747 to the 12th of August 1749.

From the 1st of October 1756 and the 6th of July 1760, the only available letters are the draft copies of the ones sent by Poleni, that he preserved, while the letters he received from Belgrado are missing. Luckily, thes copies contain some brief summaries of the contents of his correspondent's letters, so the main sense of the conversations can be reconstructed.

A great number of topics are tackled in the correspondence of the two scientists. Besides personal communication about health, movements and news from their cities and workplaces, Belgrado and Poleni had the habit to share with each other "*literary news,"* i.e., the scientific books and treatises they read, and the news about the other scientists with whom they were in touch. But, most important, they used to communicate to each other the instruments they bought, some of which were found similar in the collection of the Museum of History of Physics inf Padua, while some others can be contextualized in a bigger research field. Also, they used to read each other's writings and give opinions, advice and compliments.

The topics can be summarized into three main categories: the instruments and experiments on which they were working on, the characters they were

18 Belgrado to Poleni, letter sent on the 19 January 1745. Verona, Biblioteca Civica, It.X,324 (=6666) f° 117 ("Il contenuto dell'istruzione speditavi nell'autunno scorso consisteva principalmente nell'insegnarvi il modo d'aprire il pezzo di mezzo, cilindrico, della macchina")

in touch with, the writings they sent each other and the books they bought and discussed. To those categories will be dedicated the following sections.

Instruments and Experiments

In this subchapter, we will have an overview of the instruments and experiments that were mentioned in the letters between Belgrado and Poleni. The most significant of them will be discussed in a more complete way in Chapters 5 and 6.

In the first two letters of the collection, sent on the 18th of December 1742 and on the 8th of January 1743[19], an experiment is described in detail by Belgrado. He describes the manufacture, to which he himself assisted, of a particular type of glass vials. The experiment consisted of inserting those objects in a vacuum bell and dropping a flintstone in them. The experiment could be repeated in the presence or absence of air, or other unspecified fluids, and with flintstones or graves of different materials. When the experiment was made in the vacuum, a Boyle machine, i.e., a vacuum pump, was used. The scientists were interested in observing if the vial was broken by the impact with the grave, if it produced a sound and if sparkles appeared. In the second letter, besides a picture of the experiment (Fig. X), Belgrado reported the data he collected. From in-depth research, it emerged that the objects in questions were the so-called "batavic vials", that, like the "batavic drops", were made of a specially worked glass, that showed unexpected and contradictory resistance properties. This subject will be treated in Chapter 5.

19 Belgrado to Poleni on the 18th of December 1742 and on the 8th of January 1743, Venice, Biblioteca Marciana, It.X,324 (=6666) f° 30, 31

Belgrado talks about another instrument in his letter of the 19th of January 1745[20], in which he reports an image and an explanation of a way to *open the cylindrical piece*. Unfortunately, since the previous letter is missing, the nature of that instrument is not clear, nor its use. From the picture, it seems to be a part of a vacuum pump.

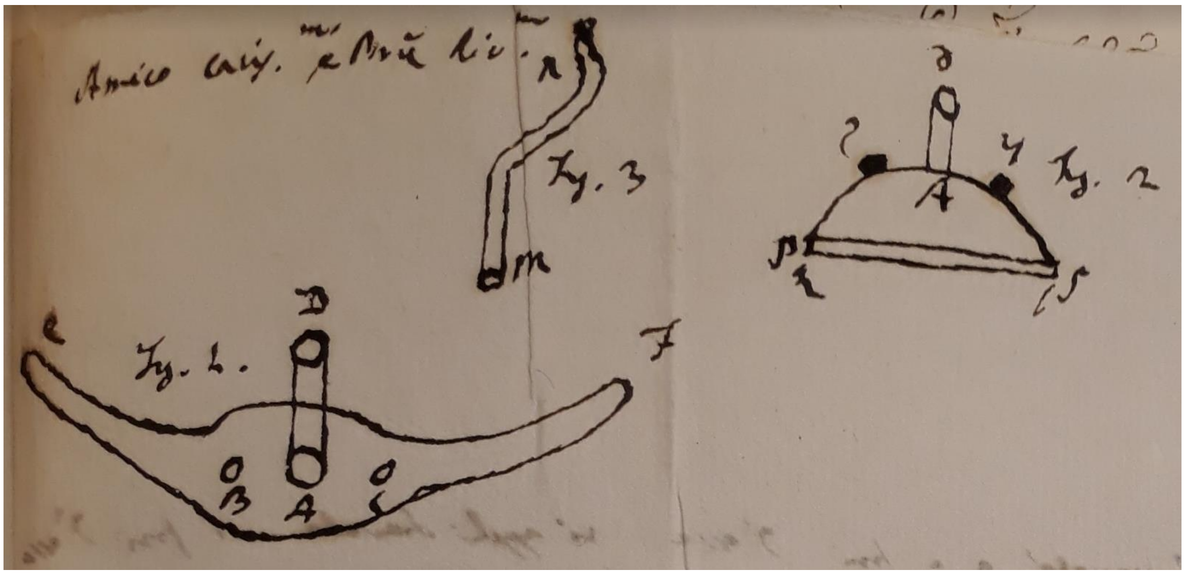


Fig. 1: drawing made by Belgrado in the letter of the 19th of January 1745[21]

Other instruments that the two scientists had built or bought are mentioned in the letters, but without technical details about, or experiments in which they were used.

In the letter of the 18th of December 1742, Belgrado talks about a fire extinguishing machine and a pyrometer, specifying he is assisting in its

20 Belgrado to Poleni, letter of the 8 January 1743, Venice, Biblioteca Marciana, It.X,324 (=6666) f° 30

21 Belgrado to Poleni, letter of the 8 January 1743, Venice, Biblioteca Marciana, It.X,324 (=6666) f° 30

construction, and prisms “made in the English way” are mentioned too. Similar instruments were found in the catalog *“Indice delle macchine”*[22], drawn up by Poleni between 1740 and 1761. Other instruments that have been found in that catalog are artificial magnets, about which Poleni talked enthusiastically in the letter he sent to Belgrado on the 16th of August 1749: in that letter, he says that Bernardino Vandelli updated him with the invention, happened in England, of “an artificial magnet, which is able to attract an iron piece equal to its own weight. But what is marvelous, they say, is that needles that are magnetized with this artificial magnet do not undergo declination”[23]. Those instruments will be discussed in Chapter 4.

Moreover, As Belgrado was setting up the Astronomical Observatory, he reported to Poleni the instruments that he acquired such as sundials, wall dials, astrolabes, an astronomy seconds clock, telescopes and binoculars. This topic will be discussed in Chapter 7.

Belgrado also discussed about scientific instruments with the duke Filippo: in the letter sent on the 19th of June 1753[24], he mentioned a box belonging to him containing a thermometer, a hygrometer and an *artifice with a sail.* This is interesting because, in a letter he sent to Poleni only six months before, on the 1st of January, he asked to be updated about the studies and

22 Poleni, Giovanni, *Indice delle Macchine*, Biblioteca Marciana di Venice , mss.it., cl III, 54-55 = 4969-4870, cl. IV, 626 = 5497

23 Poleni to Belgrado, letter of the 16 August 1749, Venice, Biblioteca Marciana, It.X,295 (=6587) f° 43 (“un Inglese a trovato il modo di fare una sorta di Calamita artifiziale, la qual tira tanto peso di ferro, quanto è il suo proprio peso. Ma ciò, ch’è il maraviglioso, dicono, che gli Aghi calamitati con questa calamita artifiziale non patiscono Declinazione.”)

24 Belgrado to Poleni, letter of the 22 July 1753, Verona, Biblioteca Civica, 3096P f° not numbered

the machines with which he was working, because *"the court does not love such things, so it is better to research them through you"*[25].

Essays and Dissertations

The two scientists also sent each other essays and dissertations they wrote, and shared comments and advice on them.

In the letter that Poleni sent to Belgrado on the 29th of May 1745[26] he speaks about a book written by Belgrado that he intends to present to "S. Eminenza" and publish. We found no letters from Belgrado in which he talks about the book mentioned. However, in the same year, Jacopo Belgrado's book *"De vita beati Torelli Puppiensis commentarius"*[27] was published at the Seminary of Padua printing house. The book is written in Latin and deals with the life of Torello da Poppi, a Christian monk and hermit, who was beatified by Pope Benedetto XIV. It is possible that Poleni took care of the edition of that book, mediating between Belgrado and the printing house.

In the letter sent on the 22nd of July 1747, Poleni announces the reception of a dissertation written by Belgrado, that he is very interested in. From his comment "*The subject is very interesting, and one can no longer be a Philosopher or a Mathematician if one does not have electricity in view, which has now become the lovable object of those who contemplate*

25 Belgrado to Poleni, letter of the 1 January 1753, Venice, Biblioteca Marciana, It.X,284 (=6576) f° 158 ("La corte non ama di tali cose: conviene ricercarle costà da voi."
26 Poleni to Belgrado, letter of the 29 May 1745, Venice, Biblioteca Marciana, It.IV,335 (=6666) f° 12

27 Belgrado, Jacopo. *De vita beati Torelli Puppensis commentarius,* typis Seminarii, Patavi, 1745

Nature"[28], it can be deduced that it refers to the dissertation "*I fenomeni elettrici*"[29] ("The electrical phenomena") that was published by Belgrado two years later in Parma, and the first work that he dedicated to the duke Filippo di Borbone. That dissertation deals with the nature of the "electric spirit", which was seen by Belgrado as an elastic, subtle fluid, similar to light and fire. Belgrado does not come to conclusions, but prefers to analyze the observed phenomenon, and foresees the effort that will be required from scientists in order to explain such a complex topic. Because of the lack of knowledge available at that time, Belgrado considered the hasty theories that were being formulated at the time, such as those of Nollet and D'Alembert, to be nonsensical.[30] In the *Memoire pour l'Historie des Sciences et Beaux-Arts*, the work was commented as follows: "The brevity, simplicity and cleanliness are the qualities of this work, in which the author shows himself to be a worthy philosopher, and one who cares about the true spirit and the straightforward nature of excellent philosophy."[31]

28 Poleni to Belgrado, letter of the 22 July 1748, Venice, Biblioteca Marciana, It.XI,222 (=6976) f° 170 ("La materia è interessantissima, e non si può più essere ò Filosofi ò Matematici se non si abbia in vista l'elettricità, che è divenuta ora l'oggetto amabile di quelli che contemplano la Natura. Il libro dell'Abbate Nollet non lo ho ancora veduto.")

29 Belgrado, Jacopo, *I fenomeni elettrici*, Stamperia di Giuseppe Rosati, Parma, 1749

30 Belgrado, Carlo. *Commentario della vita e delle opere dell'Abate Conte Jacopo Belgrado*. Dalla Reale tipografia parmense, 1795.

31 Unknown author, *Memoires pour L'Histoire des Sciences et des Beaux Arts*. de l'Imprimerie de SAS, unknown year ("la brevità, la semplicità, la pulitezza costituiscono i pregi di quest'Operetta, nella quale l'Autore si dimostra in ogni parte degno filosofo, e tale, a cui sia a cuore il vero spirito, e la schietta indole dell'ottimo filosofare."), Paris, unknown year, cited in Belgrado, Carlo. *Commentario della vita e delle opere dell'Abate Conte Jacopo Belgrado*. Dalla Reale tipografia parmense, 1795

On the letter sent to Belgrado on the 25th of May 1754[32], Poleni commented on another dissertation whose expedition had been announced on the 15th of January of the same year[33]. Poleni says that he appreciated the content of the dissertation, because it aims to explain a phenomenon that emerges from vulgar experiences, instead of being forced by an artificial intervention. About that, he cited the experience of Giovannetti, described as follows:

"Pebbles vibrate obliquely against the water, from which they rise with a reflex motion. This experience is well known; but to find a convenient reason for it was very difficult. And, indeed, if water is a fluid, and a fluid is that body whose parts yield to any force made against it, and by yielding easily move among themselves, how can it be conceived, at first sight, that reflection arises, when this seems to come only from solid and elastic bodies? But you, having set forth the true data, with your veils of water (so ingeniously imagined) and with the consideration of the various degrees of speed and force in the collisions, and with the explanation of the various degrees of the yielding of water, you have clearly and duly made known how, according to the laws of Mechanics, the thing cannot go except as the vulgar Experience makes us see it."[34]

32 Poleni to Belgrado, letter of the 25 May 1754, Verona, Biblioteca Civica, 3096P f° not numbered

33 Belgrado to Poleni, letter of the 15 January 1754, Verona, Biblioteca Civica, 3096P f° not numbered

34 Poleni to Belgrado, letter of the 25 May 1754, Verona, Biblioteca Civica, 3096P f° not numbered (“Ella è una Esperienza volgare quella dei Giovannetti, che vibrano obbliquamente i sassolini contro l’acqua, da cui risalgono con un moto riflesso. Tale Esperienza è trita; ma il trovarne la conveniente ragione era ben difficile. E di vero, se l’acqua è un Fluido, ed il Fluido è quel Corpo, le di cui parti cedono a qualunque forza, che contro di lui sia fatta, e cedendo facilmente si muovano tra di loro; come mai a prima vista si può concepire, che nasca riflessione, quando questa pare, che da soli Corpi solidi ed elastici provenir possa? Ma Voi, premessi li veri Dati, con que’ vostri veli d’acqua (sì ingegnosamente immaginati) e colla considerazione dei varj gradi di velocità, e di forza

The dissertation is not attached to the letter, but, as it deals with the motion of water and the ability of current water to drag small stones, a subject that can be useful for the scientific study of streams and rivers, it can be deducted that it was *"On the reflections of bodies in water"*[35], published by Belgrado the year before.

A more detailed series of letters deal with two dissertations that were published by Belgrado in 1757. The writings in question were published together in one book, whose title is *"On the action of chance in inventions and On the influence of stars in terrestrial bodies"*[36], i.e., the names of the two dissertations.

The first one was mentioned by Belgrado in the letter of the 16th of April 1754[37], when he still was working on it. On the 27th of May 1755[38], Belgrado asked Poleni the favor to recommend him to the director of the printing house of the Seminary of Padua, in order to publish the book. From 1756, a whole set of letters is almost entirely dedicated to the agreements between Belgrado and Dr. Carli, director of the printing house, again mediated by Poleni. After sending in Padua a copy of the manuscript via P. Rauli, the scientists exchange agreements about the price of the printing, the number of copies and the editing style, as well as the members of the

negli urti, e colla spiegazione de' varj gradi de' cedimenti dell'acqua, avete chiaramente e dottamente fatto conoscere come, secondo le leggi della Meccanica, la cosa non possa andare, se non se come la volgare Esperienza cela fa vedere.")

35 Belgrado, Jacopo, *Della riflessione de' corpi dall'acqua*, Monti, Parma, 1753

36 Belgrado, Jacopo, *Dell'azione del caso nelle invenzione e Dell'influsso degli astri ne' corpi terrestri*, Stamperia del Seminario, Padova, 1757

37 Belgrado to Poleni, letter of the 16 April 1754, Biblioteca Civica, Verona, 3096P f° not numbered

38 Belgrado to Poleni, letter of the 27 May 1755, Biblioteca Civica, Verona, 3096P f° not numbered

scientific and intellectual community to whom they are willing to send those copies. Via Poleni, the book gained the license by the revisor of the Doge of Venice, the Riformatori, and the Inquisitor.

Besides contractual agreements, Poleni makes some corrections and gives advice on some topics that are treated in the dissertations. Those specific topics, together with the content of the dissertations and their historical contextualization will be treated in Chapter 5.

Two copies of the book were found in the historical archives of the library "Guido Horn D'Arturo" of the Department of Physics and Astronomy of the University of Bologna, so it was possible to consult it.

Belgrado and Poleni's colleagues of: other scientists mentioned in the correspondence

In the correspondence between Belgrado and Poleni, we find other scientists, exponents of eighteenth-century Enlightenment, with whom they corresponded or that they met over the years. Some of them, besides being interesting characters and their friends, collaborated with them in experiments and projects.

One of the most quoted and relevant was Jean Antoine Nollet.

Born in November 1700, Nollet is known for his discovery of the phenomenon of osmosis. Shortly after completing his master's degree in theology at the University of Paris, he abandoned his clerical career of deacon and dedicated himself to scientific studies. He was particularly interested in electrical phenomena, as well as in anatomy, thermometry, pneumatics, phosphorescence and magnetism. In 1734, he became a member of the Royal Society of London, and in 1762 he was elected director of Paris Royal Academy of Sciences. While he was a professor of Experimental Physics at the Collège de Navarre, he engaged in preparing physics lessons addressed to a public wider than the one represented by academics and university students, in order to make science a public domain. This kind of lectures and activities, which actually mark the birth of science popularization, started a few years before with the lectures of Desaguliers and other English lecture-demonstrators. Other important names are Peter von Musschenbroek and Willem 's Gravesande. The lectures held by Nollet, that took place in French salons, were characterized by the introduction of several experiments, supported by a real collection of instruments that Nollet created almost entirely by himself, with the support of workers he guided, for it was hard, in France, to find specialized artisans and too expensive to buy them from abroad. The purpose was not only to explain theoretically, but to show the effects of the physical principles that he was explaining, so as to stimulate curiosity and critical spirit in his public. A revolutionary characteristic of his approach was that his lessons were also open to women and children. Demonstrations were often spectacular, but, as Nollet cared to specify, "Even if you are allowed to fix the attention of your listeners by phenomena which surprise them, it is not worthy of a physicist to leave them ignorant of their causes, when they can be made known to them."[39]

Between 1743 and 1748, Nollet published a six-volume treatise titled "*Leçons de physique expérimentale"*[40] ("Experimental Physics Lectures"), in which he exposes in a rigorous way the structure of his lectures, not based on a formal reading of handouts, but on practical demonstrations that would not bore the audience. The structure of the book is very precise:

39 Nollet, Jean Antoine. L'art des expériences", 3 vol. (Durand, Paris) 1770.

40 Nollet, Jean Antoine. *Lezioni di fisica sperimentale* . Six Volumes. Durand, 1743 - 1748.

every lecture starts with the preparation of the experiment, then follows the observed effects, the explanation of the phenomenon and the possible applications. The book is completed by drawings of the experimental apparatus.

The particular attention to the explanation of the cause of phenomena was a characteristic of the Enlightenment, and it was the same reason for which Nollet was also engaged in disprove the "fake news" that were proliferating. In their physics lectures, he and other physicists such as John Theophilus Desaguliers, presented phenomena that were passed off like magic, complete with the scientific explanation of what happened.

For instance, in 1749, Nollet travelled through Italy in order to see a lecture of Giovanni Francesco Pivati, a member of the Riformatori and promoter of the foundation of the chair of experimental physics, and also superintendent of Prints at the Studio of Padua, who had announced that he had infused medicines through electrical discharges. After attending the lecture, Nollet demonstrated that there was no scientific evidence of what Pivati was declaring.

On that occasion, Nollet met Poleni. In two letters of 1749, in fact, Belgrado and Poleni talked about him: first, in the letter of the 12th of August 1749[41] Belgrado told Poleni that he the saw him "*showing Nollet his machines*"[42], without specifying where that meeting took place, and asks him to give

41 Belgrado to Poleni, letter of the 12 August 1749, Biblioteca Marciana, Venice , It.X,295 (=6587) f° 42

42 Belgrado to Poleni, letter of the 12 August 1749, Biblioteca Marciana, Venice , It.X,295 (=6587) f° 42 ("Parmi di vedervi al fianco dell'Ab. Nollet, (che dovia a quest'ora esser certamente giunto costui), e mostrargli le vostre macchine, e usargli di quelle pulite, e gentili maniere, che sono a voi sì porglivi.")

him his greetings. In the following letter, of the 16th of August 1749[43] Poleni told Belgrado that Nollet went to Padua “on St. Anne’s day” together with Father Garo, expert of mechanical arts and professor of Experimental Physics at the University of Turin, and that he showed them his machines and books. “They wanted to go to Venice,” writes Poleni, “to see Mr. Pivati's Experiences: but I don't know if all of them will be successful”[44].

Nollet is mentioned again in 1759, when Poleni asks Belgrado to send him, if he finds it, the fifth volume of the *Leçons de physique expérimentale.*

In the same letter where Nollet is mentioned for the first time, Poleni also talks about a visit he received from Bernardino Vandelli, in which he had spoken about an English physicist that invented “a kind of artificial magnet, which pulls as much iron weight as its own weight. But what is wonderful, they say, is that the needles magnetized with this artificial magnet do not suffer Declination.”[45]

Bernardino Vandelli was a physician from Modena, brother of Domenico and Francesco Vandelli, who both covered the role of Mathematics professors. The chair that was assigned to Domenico, at the court of Rinaldo I, was the first chair of that discipline in the history of the city. In London, Domenico Vandelli had met important personalities of the

43 Poleni to Belgrado, letter of the 16 August 1749, Biblioteca Marciana, Venice , It.X,295 (=6587) f° 43

44 Poleni to Belgrado, letter of the 16 August 1749, Biblioteca Marciana, Venice , It.X,295 (=6587) f° 43 (“Volevano andare a Venice , per vedere le Esperienze del Sig. Pivati: ma non so se tutte saranno riuscite.”)

45 Poleni to Belgrado, letter of the 16 August 1749, Biblioteca Marciana, Venice , It.X,295 (=6587) f° 43 (“un Inglese a trovato il modo di fare una sorta di Calamita artifiziale, la qual tira tanto peso di ferro, quanto è il suo proprio peso. Ma ciò, ch’è il maraviglioso, dicono, che gli Aghi calamitati con questa calamita artifiziale non patiscono Declinazione.”)

scientific community of that time, from Jean Theophilus Desaguliers to Isaac Newton himself, and he attended astronomical observations conducted by Edmund Halley. In the letter, Poleni refers to Bernardino as "brother of our dear professor", so it can be supposed that he refers to Domenico.

Another character that is often mentioned in Belgrado and Poleni's letters is Count Francesco Algarotti, a venetian writer and philosopher and important promoter of Newtonianism and Enlightenment. Algarotti dedicated himself to science popularization and he is well known for his book *"Newtonianesimo per le dame"*[46] ("Newtonianism for Ladies"), published in 1737, with the purpose of making science available also for a non-academic audience.

Algarotti was a member of the Royal Society of London, he spent a part of his life between England and Prussia, and, in 1753, he came back to Italy, working in Venice, Bologna and Pisa. As well as a promoter of Newtonianism, he was also a diplomat and art dealer.

In a letter written by Poleni to Belgrado in 1754[47] Poleni specifies that Algarotti has delivered him the book with the two dissertations that Belgrado sent him.

Belgrado and Poleni also used to exchange scientific information with Count Algarotti. In a letter written by Belgrado on the 23rd of June 1754[48] Belgrado attaches an explanation about a picture of "the one-wheel clock",

46 Algarotti, Francesco. *Il Newtonianismo per le Dame: ovvero Dialoghi sopra la luce, i colori e l'attrazione*. 1746.

47 Poleni to Belgrado, letter of the 25 May 1754, Biblioteca Civica, Verona, 3096P f° not numbered

48 Belgrado to Poleni, letter of the 23 June 1754, Biblioteca Civica, Verona, 3096P f° not numbered

an instrument about which he had received a representation and instructions in French. In that letter, he asks Poleni to communicate to Algarotti the information about the clock, as he had promised him. Poleni replies that Algarotti lives permanently in Venice and, since he is already planning to meet him in order to discuss several topics with him, he will also show him the picture of the clock and the instructions.

In the letter of the 21st of December 1751[49]Belgrado spoke about the "one-wheel clock"that the prince had shown him, and that was in the Cabinet of the king of Ventimiglia.

In the previous year, Belgrado had actually become court theologian and confessor of Ferdinando di Borbone, as well as mathematician of the Royal house. From that moment, as we said, he left his mathematics chair at the *Studium Parmense*, and started the project of the astronomical observatory in the Jesuitic College of Parma, which was later converted into a Meteorological Observatory and is now an Institute of the University. Belgrado discusses with Poleni about the construction and setting up of the project in his letters, starting from 1750.

As we already said, the astronomical instruments for the observatory were mostly built by Pietro Ballarini and Stefano Droghi. Ballarini is mentioned in the letter sent by Belgrado on the 19th of January 1745[50]: it seems that he was impatient to talk to Poleni about some essays he read, but it is not clear the topic they dealt with.

49 Belgrado to Poleni, letter of the 21 December 1751, Biblioteca Civica, Verona, It.X,284 (=6576) f° 156 (ex 20)

50 Belgrado to Poleni, letter of the 19 January 1745, Biblioteca Marciana, Venice, It.X,324 (=6666) f° 117

Belgrado also spoke, in the letter of the 21st of December 1751[51], about fathers Boscovich and Mayre, who were working on the setting up of the astronomical observatory of Brera, and providing the building with astronomical instruments, such as a sundial "according to the length of the Ecclesiastical state", in Poleni's words. Poleni comments that "Such a work will be profitable for Astronomy and Geography; and all the more so, since it will be carried out by those two most skillful Subjects, it will be true; and it will be one of those which the Sun is pleased to find when it is at the highest point of the Earth."[52] which indicates the great esteem that the Paduan physicist had towards Boscovich and Mayre.

Ruđer Josip Bošković (mother-tongue name of Roger Joseph Boscovich), was a Croatian born Jesuitic that dedicated himself to physics, astronomy, mathematics studies, as well as to poetry and diplomacy. He was one of the first Europeans to accept Isaac Newton's theories and published several works about a theory he elaborated about the laws of forces of nature, that found a complete description in his *Philosophiae naturalis theoria*, published in 1758. Moreover, he published over seventy essays about optics, astronomy, gravitation, meteorology and trigonometry. It must be pointed out that Boscovich was also in strict correspondence with Giovanni Poleni, and their letters are in the archive of the project Europoleni.

Boscovich is often mentioned in Belgrado's letters, together with Father Mayre, of whom, instead, it is not easy to find historical traces.

51 Belgrado to Poleni, letter of the 21 December 1751, Biblioteca Civica, Verona, It.X,284 (=6576) f° 156 (ex 20)

52 Poleni to Belgrado, letter of the 8 January 1752, Biblioteca Marciana, Venice , It.X,284 (=6576) f° 157 ("Una tal opera riuscirà proficua all'Astronomia, ed alla Geografia; e tanto più, quanto che, eseguita essendo da quei due valentissimi Soggetti, sarà vera; e sarà una di quelle, che il Sole si compiacia di ritrovare, quando è nel più alto Punto.")

Another collaboration that emerges from the letters was the one with Antonio Vallisneri junior, son of the homonym professor of Theoretical and Experimental Medicine at the University of Padua, who became himself a naturalist and biologist, besides reorganizing his father's works and donating to the University of Padua his naturalistic, archeological and artistic collections.

In the letter of the 9th of June 1753[53]Poleni asks Belgrado to talk with him or with Count Antonio dal Bono, in order to receive a clutch machine that had been recently invented. Poleni's request is the following: if Belgrado gets a clutch machine built, he would like to have one built for him too.

In the letter of 18th of May 1755[54], Belgrado tells that Charles Marie de la Condamine went to visit him, and that he is now going to Padua and is willing to meet Poleni. In the following letters, it turns out that La Condamine remained in Padua for a long time and had several occasions to talk with Poleni, before going back to France.

De la Condamine was a French explorer, geographer and mathematician. He was a member of the *Académie des Sciences* of Paris, where he covered the role of Assistant Chemist. One of his most important works was his measure of the length of a degree of latitude at the equator, that he made during an expedition with the French Geodesic Mission in Ecuador, with the aim of confirming Isaac Newton's hypothesis that the Earth is not a perfect sphere. The travel started in 1735 and was presented to the *Académie des Sciences* in 1751. In 1745, he also published a map of the

53 Poleni to Belgrado, letter of the 9 June 1753, Biblioteca Civica, Verona, 3096P f° 2

54 Belgrado to Poleni, letter of the 18 May 1755, Biblioteca Civica, Verona, 3096P f° not numbered

Amazon, made thanks to astrogeodetic observations, that was the first map of that zone.

In 1755, when he traveled along Italy and met Belgrado and Poleni, as well as he traveled to Rome and took measurements of ancient buildings in order to determine the length of a Roman foot, de la Condamine had recently published a "*small book on smallpox inoculation*"[55], that Belgrado mentions. It was a theme de la Condamine cared a lot about and kept on defending, going so far as to publish several works about it at the *Académie des Sciences,* the most important of which was the *Histoire de l'inoculation de la petite vérole*[56], in 1773. In those treatises, he collected proofs of the efficacy of the vaccine and found out that the negative outcomes of that practice were often due to medical mistakes.

Besides that, he also wrote three tomes about the figure of the Earth, *Mesure des trois premiers degrés du méridien dans l'hémisphère australe*[57]*,* published in 1751, regarding the mission in Ecuador in which he took part. Jacopo Belgrado speaks about that book in a letter that he sent to Poleni in 1755.

Finally, Poleni mentions the abbot Nicholas Louise de Lacaille, that gave him as a gift a copy of his book *Astronomiae Fundamenta*[58]*,* and asks Belgrado to entrust his reply letter to someone who can meet Lacaille in

55 Belgrado to Poleni, letter of the 18 May 1755, Biblioteca Civica, Verona, 3096P f° not numbered ("un piccolo libro sopra l'inoculazione del vajolo")

56 de La Condamine, Charles-Marie. *Historie de l'inoculation de la petite vérole, ou recueil de mèmoires, Lettres, Extraits et autres Écrits, sur la petite Vérole artificielle: Tome premier, premiere partie*. Vol. 1. par la Société typographique, Amsterdam, 1773.

57 de La Condamine, Charles-Marie. *Mesure des trois premiers degrés du méridien dans l'hémisphère australe* . Volo. 10. dell'Imprimerie Royale, Paris, 1751.

58 de Lacaille, Nicolas Louis. *Astronomiae fundamenta, novissimis SOLIS et Stellarum Observationibus. Paris: JJ St. Collombat* (1757).

Paris. Lacaille was a French astronomer, who published an astronomical catalog with constellations he had introduced himself. He worked with Jacques Cassini at the determination of the length of the meridian arc in France and in an expedition in South Africa where he measured the lunar and solar parallax, the south African meridian arc and observed a lot of stars that were only visible from this Emisphere.

He had already returned to France and worked at the astronomical observatory of the Collège Mazarin when he published the *Astronomiae Fundamenta*, in 1757.

In the collection of letters I studied, there is a letter that Poleni wrote to Lacaille, in Latin, in which he thanks for the book and speaks about astronomical instruments.

Literary novelties

Belgrado and Poleni also used to exchange *"literary novelties"*, updating each other about scientific books they read, and sometimes sending copies of them. Belgrado was in contact with a French bookseller merchant, whose name is, unluckily, never reported, and several times he turned to him to procure some books that Poleni had asked for.

The first books mentioned are found in the letter of the 19th of January 1745. They consisted in some scripts of Isaac Newton that had just been found in Losanna and Vienna, and "*Astronomia Nautica* by Magellano, and the annals by Edmund Halley"[59], about which there is no additional

59 Belgrado to Poleni, letter of the 19 January 1745, Biblioteca Civica, Verona, It.X,324 (=6666) f° 117 ("Mi son giunti i 3 tomi degli apparecchi di Newton ritrovati in Vienna, e in Losanna. L'edizione è bella, e v'è dentro qualche cosa, che non avea veduto. M'è altresì giunta l'ottica degli annali di Halley. È anche un'astronomia nautica di Maugellais")

information. In 1749, Poleni talks about the new publication by d'Alembert's on the precession of équinoxes, that is probably "*Recherches sur la précession des équinoxes, et sur la mutation de l'axe de la terre, dans le systême newtonien*"[60], that he is willing to read.

An important treatise, that is mentioned in the letter of the 21st of December 1751 by Belgrado, is the translation of "the two physics tomes by Desaguliers"[61]. It refers to the two volumes of "*A course of experimental philosophy*" [62] that were published in 1734 and 1744 respectively, that aimed at presenting Newtonian physics through the presentation of experiments. Belgrado said that he received it from his bookseller in Paris. Poleni received that book too, in addition to the *Filosofie Esperimentali* by Willem's Gravesande, professor of physics and mathematics at the University of Leiden, supporter of Galilei and Newton's theories. He surely referred to the "*Mathematical Elements of Natural Philosophy, Confirmed by Experiments: or, An introduction to Sir Isaac Newton's philosophy*"[63], published in London in 1747, but it had several editions in various languages.

In 1757, Poleni asked Belgrado to send him the title of the book about conical sections written by Symson, and, in 1758, and, to send him also a

60 D'Alembert, Jean Baptiste, *Recherches sur la précession des équinoxes, et sur la mutation de l'axe de la terre, dans le systême newtonien,* chez David l'aine, libraire, rue S. Jacques, à la Plume d'or, Paris, 1749

61 Belgrado to Poleni, letter of the 21 December 1751, Biblioteca Civica, Verona, It.X,284 (=6576) f° 156 (ex 20) ("I due tomi di fisica di Desaguliers")

62 Desaguliers, John Theophilus. *A course of experimental philosophy*. W. Innys, London, 1734 – 1744

63 's Gravesande, Willem, *Mathematical Elements of Natural Philosophy, Confirm'd by Experiments: or, An introduction to Sir Isaac Newton's philosophy*, W. Innys, London, 1747

list of mathematics books that the French bookseller could buy, but unfortunately the list is not attached to the letter.

In the letter of the 7th of July 1759[64] Poleni sends Belgrado a dissertation written by the mathematician Jacopo Riccati, found in the fifth volume of the *Supplement of Italian Journal.*

In the letter of the 23rd of February 1760, Poleni says that he is willing to send to Belgrado two opusculo written by himself, titled *Motu aguae mixto*[65]*,* and *de Castellis* [66]*,* because it is no longer possible to find them through the librarians. In the following letter, he also informs Belgrado that the translation of the *Transazioni Anglicane*[67]*,* probably referring to the *Philosophical Transactions* published by the Royal Society, was continuing. Regarding these translations, more research would be needed.

Finally, the two scientists mentioned documents that do not directly deal with physics or mathematics, such as the *Tabula Itineraria Peutingeriana*, mentioned by Poleni in the letter of the 6th of April 1754[68], that he is willing to acquire. It consisted in a topological cartographic representation of military streets of the Roman Empire. Another one, mentioned in the letter of the 19th of May 1759[69]was the *Observations sur les Antiguites*

64 Poleni to Belgrado, letter of the 7 July 1759, Biblioteca Marciana, Venice , It.X,136 (=6714) f° 30

65 Poleni, Giovanni. "*De Motu Aquae mixto, libri DUO.*" *Padova: G. Comini; VII* (1717).

66 Poleni, Giovanni. *De Castellis per quae derivantur fluviorum aquae habentibus latera convergentia liber*. Typis Iosephi Comini, 1718.

67 , 1675–1975, 1675–1975

68 Poleni to Belgrado, letter of the 6 April 1754, Biblioteca Civica, Verona, 3096P f° not numbered

69 Poleni to Belgrado, letter of the 19 May 1759, Biblioteca Marciana, Venice , It.X,136 (=6714) f° 20

d'Hermlaneum"[70] written by Cochin and Bellicard, a book about sculpture that Poleni wanted to acquire in Paris.

This is coherent with the interest that Poleni had in architecture. As mentioned in his biography[71], he published three volumes of the *Exercitationes Vitruviae*[72], a critical edition of Vitruvius' *de Architectura*[73], between 1739 and 1741. Anyway, it is clear that his interest in the topic continued after the publication, because from 1745 to 1757 he spoke to Belgrado about his ongoing studies about Vitruvian works, and in other books that he was writing.

Additional information

Beside experimental physics teaching and researching, Poleni was engaged in other kinds of work. In some letters, on 4th of September 1756[74], the 30th

70 Cochin, Charles Nicolas. *Observations sur les antiquités d'Herculanum; avec quelques réflexions sur la peinture et la sculpture des anciens; & une courte description de plusieurs antiquités des environs de Naples. Par MM. Cochin & Bellicard*. chez Ch. Ant. Jombert, imprimeur-libraire du Roi en son Artillerie, rue Dauphine, 1755.

71 Chapter 3

72 Poleni, Giovanni. *Exercitationes Vitruvianae primae [-tertiae]. Hoc est: Ioannis Poleni commentarius criticus de M. Vitruvii Pollionis architecti. 10. librorum editionibus, necnon de eorundem editoribus, atque de aliis, qui Vitruvium quocumque modo explicarunt, aut illustrarunt*. typis Seminarii, 1739.

73 Marco Vitruvio Pollione, *de Architectura*, Eucharius Silber, Rome, 1486-87

74 Poleni to Belgrado, letter of the 4 September 1756, Biblioteca Civica, Verona, 3096P fà not numbered

of June 1759[75] and 30th of November 1759[76], he talks about having been involved in some works in Polesine, a region in the north-east of Italy together with the mathematician Antonio Rossi,

On the 31st of December 1755[77] Belgrado announced to Poleni the arrival in Padua of his nephew, who was also called Jacopo; he was willing to follow the Experimental Physics lectures and was also recommended to Professor Antonio Terzi. Poleni will update Belgrado with his nephew's progress in studies for the next three years, until he receives his doctoral degree.

75 Poleni to Belgrado, letter of the 30 June 1759, Biblioteca Marciana, Venice , It.X,136 (=6714) f° 30

76 Poleni to Belgrado, letter of the 30 November 1759, Biblioteca Marciana, Venice , It.X,136 (=6714) f° 76

77 Poleni to Belgrado, letter of the 31 December 1755, Biblioteca Civica, Verona, 3096P f° not numbered

Chapter 5

Experiments and Instruments

In this chapter, the experiments and the instruments of which Belgrado and Poleni talk about in their correspondence will be discussed. In those conversations, a lot of instruments used for didactic, or research are mentioned, but often, except for the mention itself, there are no discussions or descriptions about them. The two scientists used to communicate with each other the instruments they bought, built or received. For example, as mentioned above, when Belgrado was setting up the astronomical observatory, he spoke about a clock, a telescope and a pendulum he acquired, and Poleni replied complimenting about the choice of the instruments and the crafstman who made them.

The clock with one wheel

Another example is the clock with one wheel, built by Lepaute, of which Belgrado talks for the first time in the letter of the 1st of January 1753. The brothers Jean-Andrè and Jean-Baptiste Lepaute were two French clock-makers, living in Paris, who introduced numerous innovations to watchmaking. The older brother, Jean-Andrè, held the brevet of *Horologers du Roi* (watchmaker of the King).

Building clocks with only one wheel was a technical and intellectual challenge that clockmakers were joining in that century, perhaps in the attempt to simplify their manufacturing. The first clock with one wheel was built by Jean-Andrè Lepaute in collaboration with Pierre Le Roy, another clockmaker, who had worked on techniques for ensuring isochronism. The clock, shown in Fig. 2, was presented to King Luigi XV in May 1751[78].

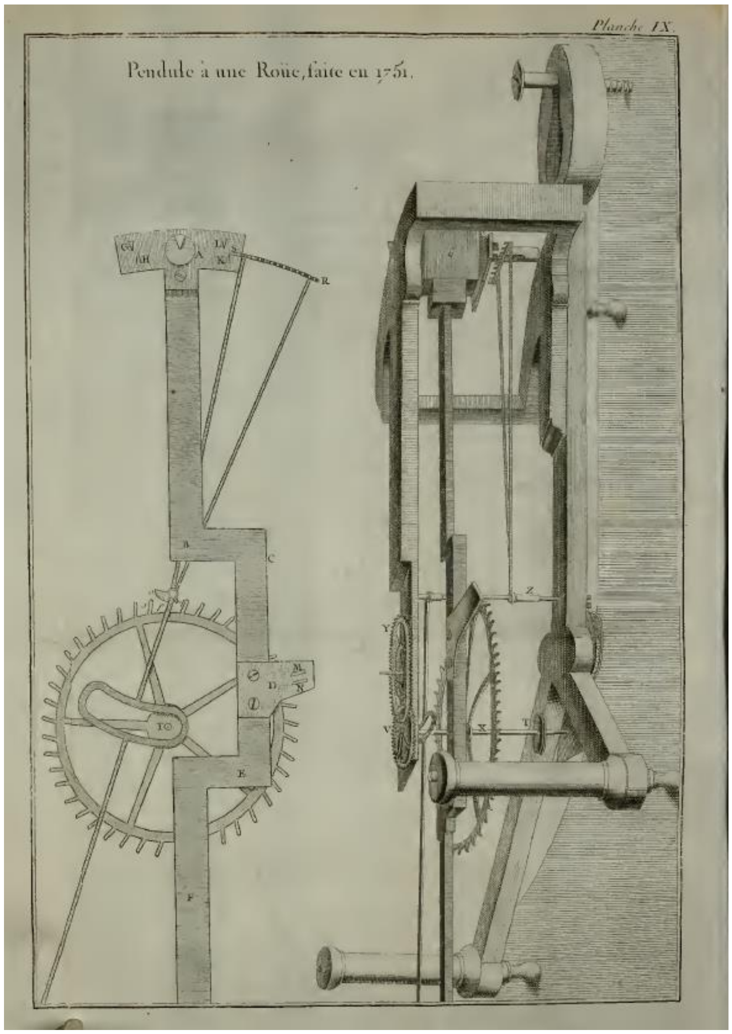


Fig. 2: Clock with one wheel of Jean-Andrè Lepaute[79]

78 *Gli orologi con una ruota*, orologiko.it, unknown author

79 Jean André Lepaute, *Traité d'horlogerie*, A Paris, Jean-Jacques Samson, 1767

The second invention was, instead, carried out by the younger brother Jean-Baptiste in 1754, and it is represented in Fig. 3.

Those two inventions are reported in the book *Traité d'horlogerie,* written by Jean-Andrè and published in Paris in 1755, 1760 and 1767[80].

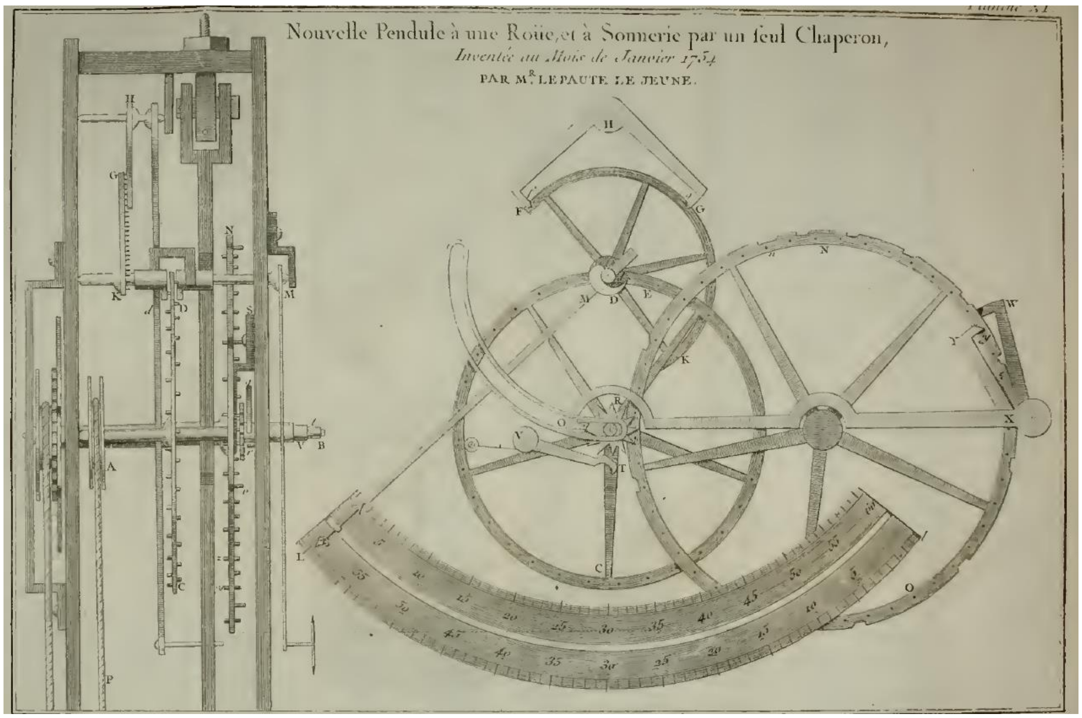


Fig. 3: Clock with one wheel by Jean-Baptiste Lepaute[81]

From that information, it can be deduced that the clock which Belgrado talks about is the first one, built by Lepaute and Le Roy, because he talks about it one year before the invention of the second one. Belgrado writes:

“I do not know whether you have seen Mr. Le Paute's newly invented pendulum clock, which has only one wheel, and is therefore very simple and very well designed. I have sent one for the Prince, and it is now in one

80 Jean André Lepaute, *Traité d'horlogerie*, A Paris, Jean-Jacques Samson, 1767

81 Jean André Lepaute, *Traité d'horlogerie*, A Paris, Jean-Jacques Samson, 1767

of his rooms, and is working very well. I have the drawing with the description written in pen."[82]

From that sentence, it seems that Prince Filippo di Borbone possessed one of these clocks, and it was functioning well.

Poleni seemed particularly interested in that instrument, so that he asked with a certain insistence Belgrado to send him the drawing and the description of the clock. The description of the clock arrived to Poleni only in 1754, a year in which, in the letter of the 6th of July, he thanked Belgrado for the information. The description is not included in the catalogue, so it cannot be said if it was taken from the book *Traité d'horlogerie.*

The description reported in Chapter IX of the book says that the purpose of building a clock with one wheel was to simplify the clockwork machines, but it was not possible to find a simpler way than the one with three wheels for a pendulum that signs hours, minutes and seconds. Different trials had been done in this sense in that technical field. The one that Lepaute and the sons of Julien Le Roy presented to the king involved a complex mechanism through which a cogwheel transferred the movement to a system consisting of a lever, a balance and a pendulum[83].

The entire mechanism is described, at the end of the chapter, as extremely defective and inaccurate by Lepaute himself, who remarks that he and Le Roy have no intention of claiming this invention, even though it was presented to the King. This may sound in contradiction with the emphasis

82 Belgrado to Poleni, 1 January 1753, Biblioteca Marciana, Venice, It.X,284 (=6576) f° 158 ("Non so se abbiate veduto l'orologio a pendolo del Sig. Le Paute di nuova invenzione, che ha una sola ruota, ed è perciò semplicissimo, e ottimamente immaginato. Il Sig. Infante l'ho fatto venire, ed ora è in una delle sue camere, e va molto bene. Io ho il disegno colla descrizione scritta a penna."

83 Jean-André Lepaute, *Traité d'horlogerie,* Pag. 129, Chap IX, A Paris, Jean-Jacques Samson, 1767.

with which Belgrado describes the object, and with the deep interest that Poleni shows in it. But, indeed, Lepaute, at the end of the chapter dedicated to the clock, remarks that *"This pendulum is the most difficult clock that I know"*[84], so, the interest of the two scientists may have focused on the technical aspects.

Philosophic vials and Prince Rupert's drops

As for the experiments, the one that Belgrado and Poleni discuss more widely consists in dropping flintstones into a glass flask placed into a vacuum bell. In the first two letters of the collection examined for this thesis, sent by Belgrado on the 18th of December 1742 and on the 8th of January 1743[85], those experiments are described in detail as for the execution and the materials, but no details are given about the purpose.

From the description of the experiment, we see that the flasks should have a particular oval shape, with the glass thicker at the bottom, and with a short neck[86]. Into that kind of flask, a small piece of flintstone was dropped in. The experiments were reiterated with flintstones of different weights and materials, and in different conditions: in presence of air, in the vacuum or in presence of differently dense fluids. Belgrado also says that the bottle

84 Jean-André Lepaute, *Traité d'horlogerie,* Pag. 135, Chap IX, A Paris, Jean-Jacques Samson, 1767 ("Au reste, cette Pendule est l'ouvrage d'Horlogerie le plus difficile que je connoissie.")

85 Belgrado to Poleni, letter of the 18 December 1742, Biblioteca Marciana, Venice, It,X,324(=6666) f° 31

86 Belgrado to Poleni, letter of the18 December 1742, Biblioteca Marciana, Venice, It,X,324(=6666) f° 31 ("alcune boccette di vetro a v. degnissima assai ben note, di figura ovale, di doga assai grossa massimamente verso il fondo, fornite d'un collo anzi corto, che lungo")

should be well known by Poleni, so it is possible that he was also engaged with experiments on that topic.

The observed result was that the glass was quickly broken by the impact with the flintstone, while the same did not happen if, instead of a flintstone, a piece of metal, such as brass, stain, lead and mercury was dropped in.

In the following letter, Belgrado attaches a picture of the experimental apparatus, reported in Fig. 4.

The tripod that held the flask was placed into the bell of a Boyle machine, in which a good level of vacuum could be reached. On the top of the flask, a small piece of paper that held the flintstone was fixed. By rotating the screw on the top of the vacuum bell connected to a small hook, it was possible to turn the paper and drop the flintstone into the flask. Belgrado observed the same results in absence or presence of vacuum, i.e., the breaking of the flask, except for the fact that, when the experiment was made in the vacuum, no sound was perceived.

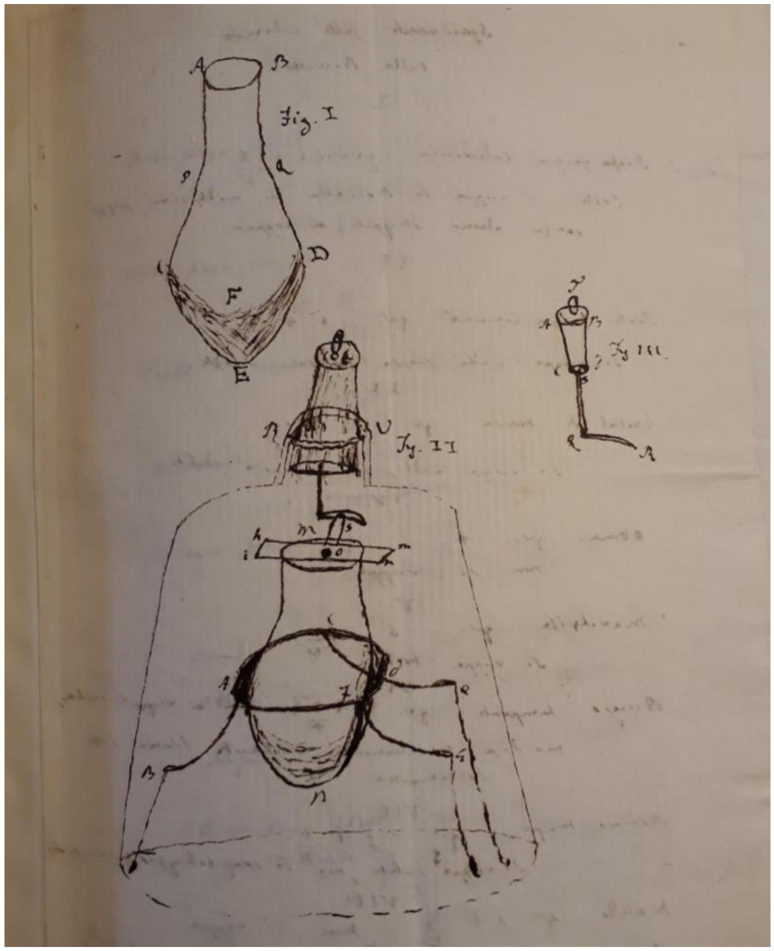
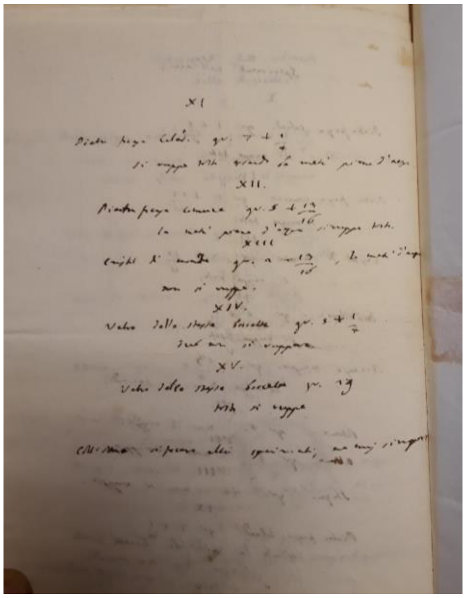
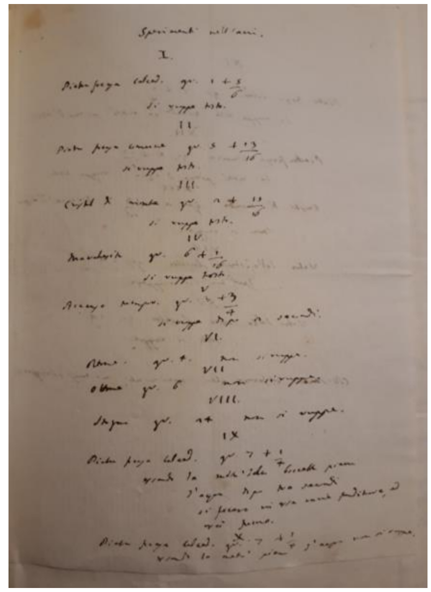


Fig. 4: representation of the experimental apparatus for the experiment on flasks[87]

The results of the experiments were reported below: they are divided into those carried out in the vacuum and those carried out in the air. The material of which the flintstone or the metal were made, and its weight, are noted. Lastly, Belgrado annotates whether the flask breaks or not, and in how much time.

87 Belgrado to Poleni, letter of the 8 January 1743, Biblioteca Marciana, Venice, It,X,324(=6666) f° 31





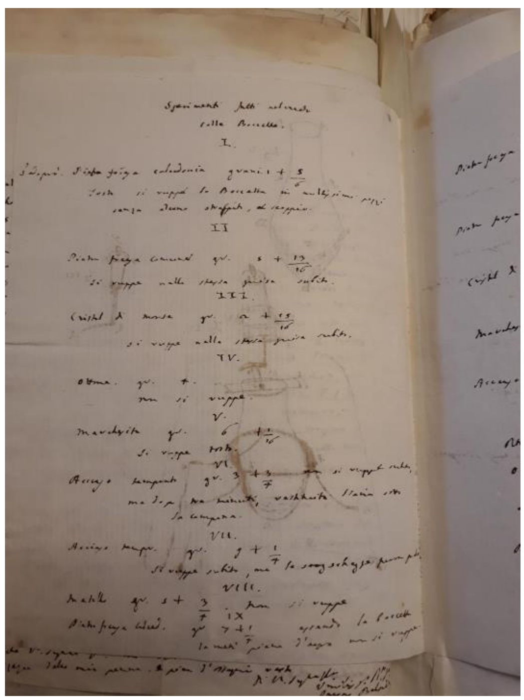


Fig. 5-6-7: experimental results about the vials[88]

88 Belgrado to Poleni, letter of the 8 January 1743, Biblioteca Marciana, Venice, It,X,324(=6666) f° 31

This kind of experiment can be re-conducted to the studies about the "philosophic vials" or "vials of Bologna", which were part of a series of experiments on the resistance of glass to impacts and its dependence on the way it had been worked. Their peculiarity was the fact that, through an annealing of the material, it became harder and more fragile, and less dense[89]. That way, if the glass was hit by a smooth object, such as a metal sphere, it was able to resist even if the weight of the object increased, while, if hit by a sharp object, such as a flintstone, it was quickly broken, sometimes with an explosion. Belgrado also observed that, if the vial was hand-held, with the flintstone on its neck, and slowly inclined in order to make the stone gradually reach its bottom, then it did not break or explode.

Fig. 8: vials of Bologna

89 A. Daguin, *Traité élémentaire de physique théorique et expérimentale Vol. 1*, 1855, Paris

Furthermore, Belgrado described in the letter the manufacturing process of the vials to which he assisted: the glass was inserted into an oval oven that did not have a uniform temperature, but a gradually increasing temperature with a maximum in the place where the glass was placed. The glass was left for a short time in the oven, and then extracted with a hook, through which it was passed to all the different temperature zones of the oven. The artisan, says Belgrado, noticed that, in winter, all the windows should have been closed, because, if exposed to a cold temperature when extracted from the oven, they quickly exploded. If the vials were put into a bracket, they became so resistant that they never exploded.

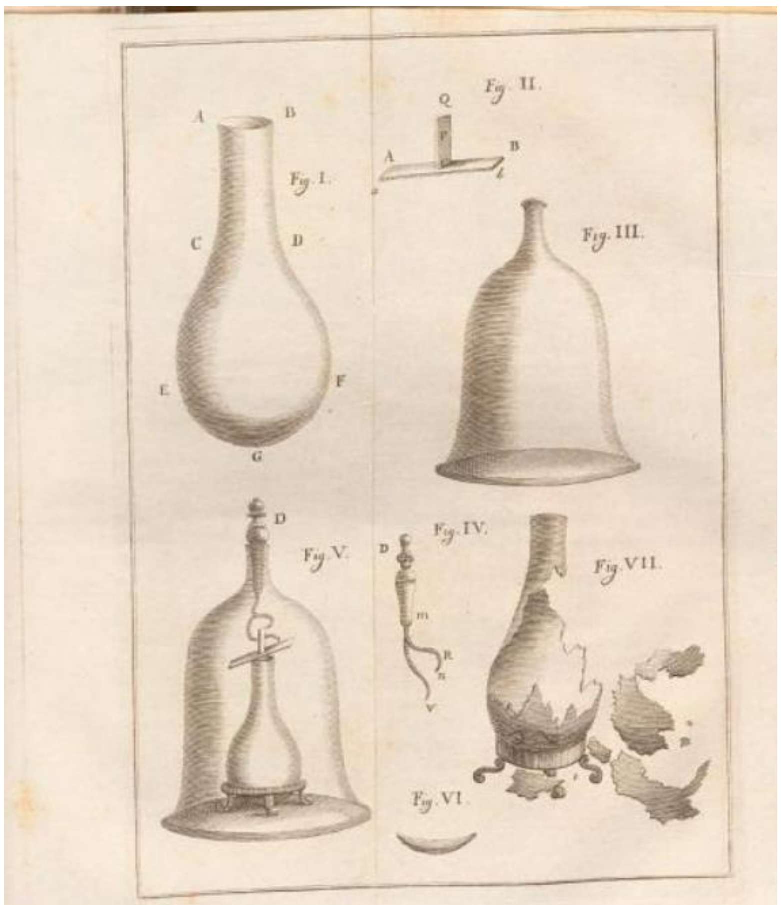
About that topic, Belgrado published in 1743 a short dissertation, in Latin, titled "*De Phialis vitreis ex minimi silicis casu dissilientibus*"[90], where an illustration of the experiment is reported. The dissertation was published at the print house of the Seminary of Padua, the same to which Belgrado decided to commission the publication of his book containing the two dissertation "*Dell'azione del caso nelle invenzioni*" and "*Dell'influsso degli astri ne' corpi terrestri*" in 1757. On that occasion, the communication between him and the director of the print house, as emerged from the correspondence, was mediated by Poleni. As they also discussed, at the beginning of 1743, about the vials of Bologna, it is possible that the same happened for this dissertation. Unluckily, no other letters exchanged in that year are present in the collection.

In the "*Commentary of the life and work of the Abbot Count Jacopo Belgrado*"[91], published by his nephew Carlo in 1795, I found a partial

90 Belgrado, Jacopo. *De Phialis vitreis ex minimi silicis casu dissilientibus,* Stamperia del Seminario, Padova, 1743.

91 Belgrado, Carlo. *Commentario della vita e delle opere dell'Abate Conte Jacopo Belgrado*. Dalla Reale tipografia parmense, 1795.

analysis of this work. According to his nephew, in the dissertation "*De Phialis vitreis ex minimi silicis casu dissilientibus*"[92], Belgrado did not give an explanation of the phenomenon, but, without assuming any hypothesis, he discussed the mechanical principles, according to the experimental results. In a letter sent afterwards, in 1746, to Scipione Maffei, he showed a disagreement about the cause of the phenomenon with Gian-Lodovico Bianconi, a member of the Science Institute of Bologna, who attributed the cause to the compressed air inside the glass.



92 Belgrado, Jacopo. *De phialis vitreis ex minimi silicis casu dissilientibus acroasis experimentis, et animadversionibus illustrata*. 1743.

Fig. 9: vials illustration on *De Phialis vitreis ex minimi silicis casu dissilientibus"*[93]

The explanation of Belgrado is not reported, and that letter was not found, but it is worth, again, that he was not satisfied with the most accepted explanations but was keen to investigate in detail each phenomenon he studied.

Another manufacturing, concerning a similar kind of experiment, to which Belgrado recounts having witnessed, is the fabrication of *philosophic drops*, also known as *"Prince Rupert's Drops"*. Those objects were first introduced to the Royal Society on 4th of March 1660-61, arousing strong interest among scientists. The first public demonstrations and publications about that subject go back to 1656.

The drops were created by dripping molten glass into cold water: the result was a tear-drop shaped glass bead, ending with a fine tail. Those drops have peculiar resistance characteristics, that still interest scientists of nowadays: while the head can resist to strong efforts, such as a hammer blow, the squeeze of a vice, or a bullet impact, the tail is so fragile that it is sufficient to exerting pressure with fingers on it to make the entire drop explode into powder. Those contradictory resistance properties have a similar nature to the ones of the philosophic vials.

93 Belgrado, Jacopo. *De phialis vitreis ex minimi silicis casu dissilientibus acroasis experimentis, et animadversionibus illustrata*. 1743.

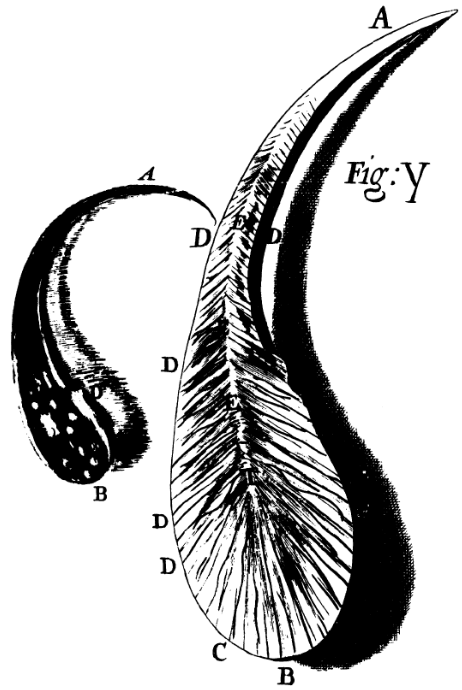


Fig. 10. "Prince Rupert's Drops" shown in Hooke's *Micrographia*[94]

In 1665, Robert Hook published an explanation on the phenomena in his book *Micrographia*[95], according to which, when, with a quick cooling, molten glass passes from a state of viscous fluid to a hard elastic solid, it hardens first in the external part; near the centre of the drop, instead, the fluid contracts by expanding one or a few vacuoles, and its contraction brings the outer layers into a state of compression that makes the object extremely resistant against stresses. It is sufficient to break the tail, to make air fill the vacuoles and this causes the explosion of the drop.

94 Hooke, Robert. '*Observation vii. of some Phaenomena of Glass Drops'*. In *Micrographia* or *Some Physiologial Descriptions of Minute Bodies made by Magnifying Glasses with Observations and Inquiries thereupon* (London, I665), pp. 33-44.

95 *Micrographia* or *Some Physiologial Descriptions of Minute Bodies made by Magnifying Glasses with Observations and Inquiries thereupon* (London, I665)

In 1671, Geminiano Montanari[96] carried out experiments about these drops in Murano, Venice, and added to them the production of another object of that kind, that he called "vermicelli". They consisted in long glass wires with an irregular helical curvature, that, if broken at some point, showed a propagation of a disintegration "wave" that left a pattern of multiple inner fracture in the glass, that divided the material into needle-like splinters, as seen in Fig. 8[97].

Studies on those objects were carried on by physicists of all Europe in the following years, and some traces of them can be found in experimental physics books published in the eighteenth century.

The French natural philosopher Philippe Vayringe (1684-1747), for instance, professor of experimental physics at the Academy of Lunéville and supporter of newtonian mechanics, in his "*Cours de philosophie mecanique et experimentale, par lequel sans être versé dans les mathematiques, on peut comprendre presque tous les phénomenes de la nature, qui ont été découverts par principes geometriques",* 1732,[98] reports about various experiments, one about Prince Rupert's Drops.

96 Montanari, Geminiano. *Speculazione Fisiche,* Bologna, 1671

97 Brodsley, Laurel, et al. "Prince Rupert's Drops." *Notes and Records of the Royal Society of London*, vol. 41, no. 1, The Royal Society, 1986, pp. 1–26, http://www.jstor.org/stable/531493.

98 Vayringe, Phylippe. *Cours de philosophie mecanique et experimentale,* Nicolas Galland, Imprimeur-Libraire de Son Altesse Royale, Paris 1732.

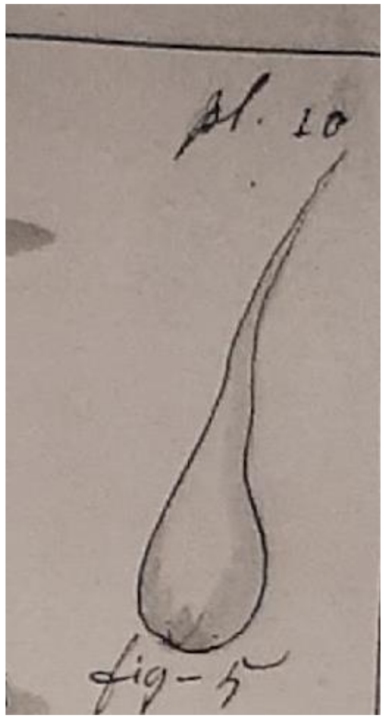


Fig. 11: Prince Rupert's Dorp drawing from *Cours de philosophie mecanique et experimentale*[99], *P.Vayringe*

The description he gives of the mechanism to which the properties of resistance and fragility of the drops are due is the same given by Hooke.

That theme, anyway, was still in discussion in those years. Belgrado, in his letter, actually tells Poleni that he disagrees with the explanation of the phenomena given by Mariotte and Stevin, that involves the dryness of water, while he agrees with Jean Antoine Nollet. Unluckily, that explanation is not reported in the letter, nor was it found in his *Leçons de physique expérimentale*[100].

99 Vayringe, Phylippe. *Cours de philosophie mecanique et experimentale,*Nicolas Galland, Imprimeur-Libraire de Son Altesse Royale, Paris 1732.

100 Nollet, Jean-Antoine. *Leçons de physique expérimentale* (6 vols.).
Du fonds de H.L Guerin & L.F. Delatour. Chez Durand, neveu, libraire , rue S. Jacques, à la Sagesse, Paris 1743-1764

A more modern study is due to A. A. Griffith, who, in 1920, gave a mathematical formulation of the strengthening effect of compressive stress. According to his theory, what causes the fracture of a fragile substance is the extraction of elastic energy initiated from pre-existing microcracks, which can grow larger. The energy is enough to pay for the energy of the increased area of free surface only if the stress around them is tensile and the product of the stress and the square root of the crack diameter exceeds a critical value that depends on the properties of the material. In the interior of a stressed material there are places of greatest weakness, due to the irregular arrangement of atoms, but these are equivalent only to exceedingly small microcracks, so that the glass in the interior of the drop can sustain an extremely high tensile stress. The tail has a cylindrical symmetry, similar to the one of the "vermicelli" that Montanari studied, and its fracture causes a crack that penetrates the interior tensile. The vacuoles, instead, do not have sharp edges, so they cannot cause serious crack initiators.[101]

The last argumentation could also explain the reason why Belgrado did not observe the breaking of his vials when he dropped metal balls on them: not having sharp edges, they did not cause tensile cracks. Belgrado and Poleni, together with other personalities such as Nollet, were working on an extremely complex subject that interested scientists for centuries, involving properties of glass-like materials that were not out of reach with the knowledge of their times.

101 Brodsley, Laurel, et al. "Prince Rupert's Drops." *Notes and Records of the Royal Society of London*, vol. 41, no. 1, The Royal Society, 1986, pp. 1–26, http://www.jstor.org/stable/531493.

Instruments found in the catalogue "Indice delle Macchine", compiled by Giovanni Poleni

Other instruments that the two scientists had built or bought are mentioned in the letters, but without technical details or description of the experiments in which they were used.

In the letter written by Belgrado on the 18th of December 1742, after talking about the experiments on the vials, he also mentions other instruments that were under construction: a fire extinguishing machine, a pyrometer and prisms.

At first, he talks about the *"brass peaks fire extinguishing machine, with two valves"*[102], which is only half built. In Poleni's catalogue of the instruments he acquired for his Cabinet of Physics, at number 173, a similar instrument is found, described as:

"A large machine with three turned and machined cast metal tubes, in two of which act two emboli, and which communicate with each other through metal channels, and there are other parts of wood and iron to make the machine work. All the parts are in a wooden case with many carvings, two and a half feet long, one foot and eight inches wide and one foot and two inches high. There is also a gut for directing the movement of the water to various sites, if desired. It is used for experiments to show the movement of

102 Belgrado to G. Poleni, letter of the 18 December 1742, Biblioteca Marciana, Venice, It,X,324(=6666) f° 31 ("una macchina in picchi d'ottone per estinguere gli incendj, a due valvole, in cui si dovrà intravedere anche l'azione della compressione dell'aria; ed ella è eseguita per la metà")

water under pressure, for demonstrating the artifice of machines for extinguishing fires, and for other purposes."[103]

That machine was acquired by Poleni between the 4th of September 1743 and the 2nd of February 1745 from Belgrado himself: it could be the same instrument that Belgrado was talking about, or a copy that Poleni required.

The pyrometer was also under construction, following the model proposed byMusschenbroek. Belgrado asked Poleni to clarify the functioning of the spring that maintains the parallelepipeds at the same height, which he found not clear in the explanation provided by Musschenbroek.

In his catalog, Poleni mentions, as number 49, "a Pyrometer, i.e., a machine for knowing and measuring the elongation in metals caused by heat. It is made of brass with sprockets, a slider with teeth, and its graduated dial. There are also twelve parallelepiped rods made of various metals, each with a double pivot, for use in experiments. There is a wooden foot with a screw and other parts made of brass, and, moreover, there are the lamps needed to produce various degrees of heat."

That pyrometer was acquired from Casati and was used by Poleni in the restoration of St Peter Dome, in Rome, required by Pope Benedetto XIV, to which Poleni took part.

103 Poleni, Giovanni, *Indice delle Macchine*, Biblioteca Marciana di Venice , mss.it., cl III, 54-55 = 4969-4870, cl. IV, 626 = 5497 ("Una machina grande con tre tubi di metallo di getto torniti e lavorati: in due de' quali agiscono due emboli: e communicano dessi tubi tra di loro per canali di metallo: e vi sono altre parti di legno e di ferro per fare agire essa macchina. Tutto poi e` in un riservatoio di legno lavorato e con molti intagli, lungo piedi due e mezzo, largo piedi uno e pollici otto, alto piedi uno e pollici due. Vi ci e` inoltre un budello per diriger, quando si voglia, a vari siti il moto dell'acqua. Serve per gli esperimenti da far vedere li moti dell'acqua per pressione, per far vedere l'artifizio delle macchine da estinguere gl'incendi, e per altro.")

Fig. 12-13-14: Pyrometer by Giovanni Poleni

tFinally, Belgrado asked Poleni to have glass prisms worked for him too, in the English way, because the ones he commissioned from England were late in arriving. In Poleni's catalog, three prisms are mentioned with catalog numbers 18, acquired from Jan van Musschenbroek, and one with catalog number 343, was acquired from Castelnuovo: they were used for experiments about the diffraction of sunlight.

Another instrument that is mentioned by Poleni in his catalog "Indice delle Macchine" was the clutch machine that Poleni asked Belgrado to discuss with Antonio del Bono, to whom he had required to build one, in the letter of the 9^{th} of June 1753[104]. Various versions of the machine are present in the catalog, at number 102-103, acquired by Jean Antoine Nollet, and at numbers 113 and 149.

104 Poleni to Belgrado, letter of the 9 June 1753, Biblioteca Civica, Verona, 3096P f° 2

Chapter 6

"Dell'azione del caso nelle invenzioni e Dell'influsso degli astri ne' corpi terrestri"

This chapter concerns the communication between Belgrado and Poleni about the book *On the action of chance in inventions* and *On the influence of stars on terrestrial bodies.*

The book was published in 1757 at the print house of the seminary of Padua. Three years before the publication, Belgrado sent Poleni the two dissertations, asking him for an opinion. In 1755, Belgrado announced his intention to publish them, and asked Poleni to communicate it to the director of the printing house of the seminar, Dr. Carli, and negotiate with him. The letter exchange of that period contains a lot of detailed information about the agreements between Carli and Belgrado, mediated by Poleni. Moreover, Poleni gave appreciation about the topics chosen by Belgrado, and some advice about the content of the dissertations. After the publication, he also arranged for copies of the book to be given to several personalities, besides sending most of them to Belgrado.

The content of the two dissertations shows several examples of the Enlightenment approach that characterized Belgrado.

This chapter will deal with the most important steps that led to the publication and diffusion of the opera, the content of the dissertations and the advice given by Poleni.

Negotiations with the director of the printing house and publication

The first time that Belgrado mentions one of the dissertations is in his letter of the 16th of April 1754[105]. The first title he gave was "*What part does luck and chance play in scientific and literary discoveries*". At the time of the publication, he had shortened the title to *"On the action of chance on the inventions".*

On 27th of May 1755[106] Belgrado asked Poleni to recommend this manuscript to the printing house of the Seminar of Padua, in order to have a correct edition of it, precising that he will cover all the expenses. Poleni replied that he was in contact with the printing house's director, Dr. Carli, who was willing to take care the print, and with a master of Italian language that he knew and would cure the correction and editing.

On 16th of December 1755[107], Belgrado mentions his intention to add another manuscript, second dissertation, titled "*On the influence of the stars in terrestrial bodies".*

The manuscript will arrive in Poleni's hands in October 1756, sent by the rector of the college. Poleni made sure, first, to have the manuscript licensed by "the Father Inquisitor, the Revisor for the Prince of Venice, the Riformatori, and the Bestèmia".

In the following letters, Poleni and Belgrado discussed the formats, the quantity and the prices for the book's printing, in order to reach an agreement with Dr. Carli.

105 Belgrado to Poleni, letter of the 16 April 1754, Biblioteca Civica, Verona, 3096P f° not numbered

106 Belgrado to Poleni, letter of the 27 May 1755, Biblioteca Civica, Verona 3096P f° not numbered

107 Belgrado to Poleni, letter of the 16 December 1755, Biblioteca Civica, Verona 3096P f° not numbered

Before the definitive publication, Poleni also sent to Belgrado a personal revision of some paragraphs that he found inappropriate or incorrect. In the following subchapter, that analyzes the content of the dissertations, the comments made by Poleni will also be treated.

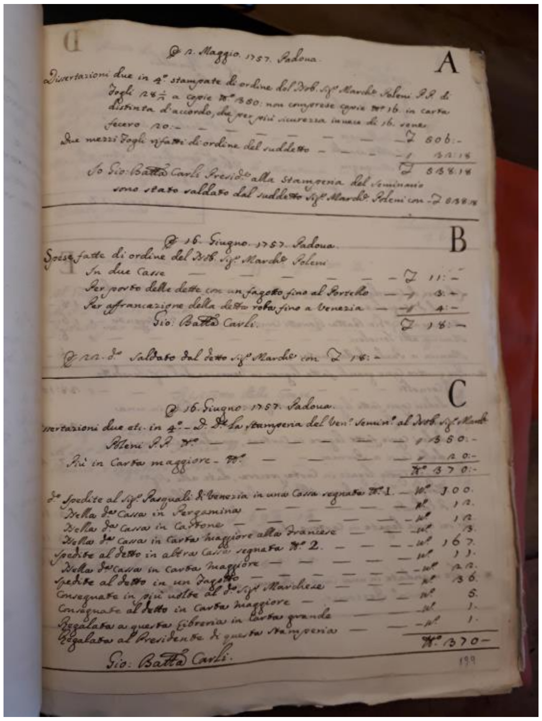
In the letter of the 2nd of July 1757[108], Poleni attached the invoices and policies of the printing house, and the register of expenses and number of copies, that are reported in Fig. 15-16-17.

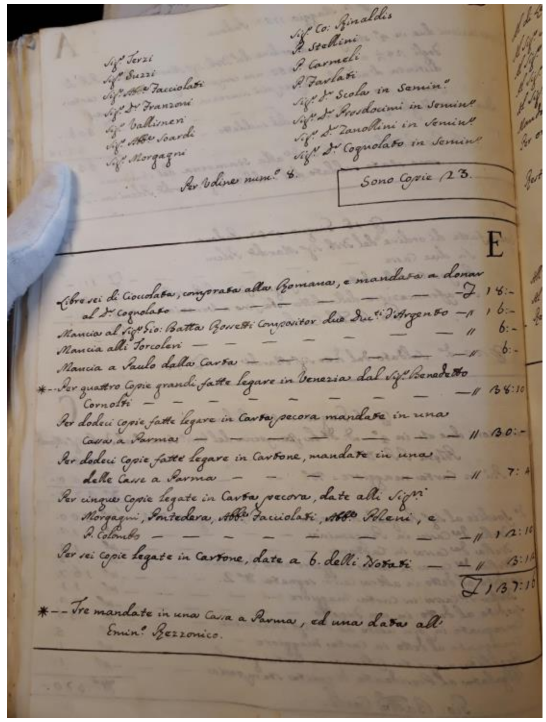
The final agreement was of twelve copies bound in sheepskin paper, twelve in cardboard, four in distinct paper printed in Venice, that were the most sophisticated, and other four-hundred copies.

From the correspondence, we also see that Belgrado, Poleni and Belgrado's nephew were drawing up a list of people to whom they were willing to deliver a copy of the new printed book. When, in June 1757, the printing had been done, eight copies were sent to Belgrado's nephew, who was in Udine at that time, and some others were sent to people he wanted to have it, whose name is not specified.

Belgrado ordered: twenty copies to have in Parma, and three more copies bound in distinct paper, two of them to give as a gift to Father Fantoni, another Jesuit, and one to Cognolato, who was involved in the correction of the orthography at the printing house.

108 Poleni to Belgrado, letter of the 02 July 1757, Biblioteca Marciana, Venice, It.X,135 (=6713) f° 197-200





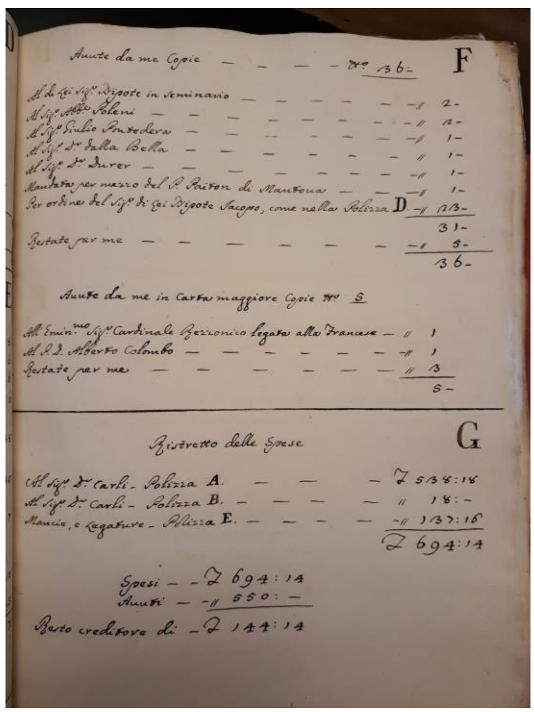


Fig. 15-16-17: policies of the printing house

The last two copies in distinct paper were given by Poleni to Cardenal Rezzonico, and another one to Facciolati.

All those copies were given as a gift to those distinct characters, of whom Poleni notifies the appreciation and gratitude to Belgrado.

Two copies of the book containing the two dissertations are kept in the Historical Library “Guido Horn D’Arturo” of the Department of Physics and Astronomy of the University of Bologna. Those copies have realistically been printed in 1757, in Padua, and are both bound in carton, even if they are in two different editions, and they belonged to a catalogue of the library of Bologna’s Specula.

There probably has not been a second reprint, after the one mediated by Poleni and discussed in the letters.

Fig. 17-18-19: "Dell'azione del caso nelle invenzioni e dell'influsso degli astri ne' corpi terrestri, Historical Library "Guido Horn D'Arturo" of the Department of Physics and Astronomy of the University of Bologna

First Dissertation: On the action of the chance in inventions

The first dissertation deals with an analysis of the notion of "Chance" and "Luck" and what influences they can have on human inventions. It is about two points of that dissertation that Poleni made notes, which Belgrado did not fail to take into account and correct.

The introduction starts with a general analysis of the role attributed to luck as well in science as in art. In antiquity, Belgrado says, every literary, artistic or scientific opera started with an invocation to the muses, or rituals and sacrifices to the gods, in order to conjure good success, and that also the geniality of an inventor was ascribed to luck.

The thesis he defends is that no good success can be regarded as casual, since the mind that creates it has acquired, through long years of studies and research, a series of information and competences that are combined in complicated mechanisms before finally reaching an insight of an invention or discovery. But, citing Musschembroeck's "*Oratio de mente humana semet ignorante"*[109], he affirms that people attribute the merit of inventions to faith or gods because the mind cannot be aware of all the processes that occur inside itself. Man, according to Belgrado, is therefore at least partly the maker of his own fortune.

The concept of "chance" is defined as *"the thing that reason and rationality cannot control"*[110], in agreement with the discussion about the enormous number of connections that happen inside the human mind. Its role, according to Belgrado, can contribute more to the perfection of a new

109 Van Musschenbroek. Peter*, Oratio inauguralis de mente humana semet ignorante*. Vol. 1. Apud Samuelem Luchtmans, 1740.

110 Belgrado, Jacopo. *Del ruolo del caso nelle invenzioni,* Stamperia del Seminario, Padova, 1757.

invention, than its creation, which instead requires intention, knowledge and hard work.

In this sense, some examples of scientific discoveries are brought up. The first one is the discovery of phosphorus, made by Henning Brand in 1669; the German alchemist’s intention was to create artificial gold, but, noticing the formation of an unknown substance with the shining property, even if not exposed to light, he discovered and named a new artificial chemical element. The second regards the Flemish mathematician Grégoire de Saint-Vincent, who was engaged in the research of the squaring of the circle and, even if he did not solve the antique problem, developed calculus methods that were taken up by Leibniz, and were useful for the development of infinitesimal analysis. The third example regards an experiment conducted by Giovanni Poleni himself, to whom Belgrado referred as *“that learned Religious man”*, in which, by combining sulfur, carbon and nitrogen, Poleni casually obtained an explosion that he understood could have a warfare use.

Moreover, the origin of the lyre, of the magnet and of glass are connected to the chance’s action in similar ways. The electric shock that struck Musschenbroek during the Leyden experiment, revealing the power that could be compared to the one of a lightning, was an example of the case that “happily dares to do what neither nature nor art wants to attempt”[111].

That's the role that chance can play in scientific inventions: in this sense, it has more to do with unexpected results of an already prepared analysis, than with an uncontrolled action of mystical forces. The inventor must realize the necessary circumstances so that the chance can act. First of all,

111 Belgrado, Jacopo. *Del ruolo del caso nelle invenzioni,* Stamperia del Seminario, Padova, 1757.

there is the ingenuity of man, and the will to reach a result, even not knowing the way to do it.

The concept of "invention" is defined by Belgrado as the discovery of a new object or phenomenon that has new qualities and uses (or, at least, he specifies, those uses, and qualities seem new to the society to which the invention is presented), and for that reason it arouses admiration. He divides inventions into different categories: the most important distinction is between "similar inventions" and "original inventions". While the first ones are the results of the combination of simpler objects, the second ones are something that did not take place because of another mechanism: these are the ones in which the chance can play a role.

In the fourth chapter, Belgrado discusses the role of art, intended as manufacturing, in inventions. Talking about the continuous perfectioning of the discoveries of laws of nature and art, that owe their progress to a gradual correction of what has been done before, he mentions the discoveries that have been made by one man and improved subsequently by someone else. Here is a paragraph that Poleni corrected to Belgrado in the letter of the 16th of April 1757[112].

Poleni pointed out that some of the affirmations made by Belgrado could be misinterpreted by the members of the Royal Academy of Sciences and those who won the prizes that Belgrado criticized. In his reflections, in fact, he questioned the scientific utility of some discoveries and publications, accusing them of being self-referential and devoid of a real purpose of invention.

112 Poleni to Belgrado, letter of the 16 April 1757, Biblioteca Civica, Verona It.X,135 (=6713) f° 167

Poleni strongly advised Belgrado to give more credit to what the Royal Academy of Sciences approved and pointed out that some affirmations could not look very honorable towards those who wrote those books. In the version that was finally published, those sentences were corrected, in agreement with the advice that Poleni gave, appearing less controversial, but without changing their meaning.

For example, “Five or more volumes of newly invented machines, most of which do not actually contain any intrinsically new invention worthy of applause or use.”[113] was corrected with “Six volumes of newly invented machines have been published. Although they are worthy of much praise for their intrinsic merit and for the approval of such an illustrious Academy, many of them have so far remained without use, either because they are too composed and difficult to execute, or because they are not directed towards objectives that encourage the craftsmen to use them.”[114]

“The most talented Physicists and Mathematicians in Europe took part in the dissolution, awakened by the honor of glory and the hope of a prize.”[115] was corrected with “The most talented Physicists and Mathematicians in

113 Poleni to Belgrado, letter of the 16 April 1757, Biblioteca Civica, Verona It.X,135 (=6713) f° 167 ““Cinque o più volumi di macchine nuovamente inventate, la maggior parte delle quali effettivamente non contiene veruna invenzione intrinsecamente nuova e meritevole d’applauso, e d’uso.”)

114 Belgrado, Jacopo, *Dell’azione del caso nelle invenzioni*, Stamperia del Seminario, Padova, 1757. (“In questo nostro secolo si son pubblicati sei volumi di macchine nuovamente inventate, le quali benchè sien degne di molta lode, e per lo merito loro intrinseco, e per l'approvazione d'un'Accademia sì illustre; per tutto ciò molte fin ora rimaste sono senza uso, o per esser troppo composte, e di malagevole esecuzione, o per non esser dirette a obbietti, che solletichino gli artefici ad adoperarle.”)

115 Poleni to Belgrado, letter of the 16 April 1757, Biblioteca Civica, Verona It.X,135 (=6713) f° 167 (“Concorsero allo scioglimento i più valenti Fisici e Matematici dell’Europa, destati dall’onor della gloria, e della speranza del premio.”)

Europe, inspired by the honor of glory and the spirit of emulation, contributed to the dissolution."[116]

"And yet of so many instruments and so many machines proposed, hardly any serve the purpose of the invention."[117] with "With all this, I do not know whether so many instruments and so many machines and inventions and discoveries are in proportion to the advantages and progress of Mechanics and Nautic."[118]

And, finally, "What has been added to the perfection of many other machines is so little and uncertain that it has not even been used, and is only to be admired in the branches well engraved to adorn a book, and to the immortality of the author"[119] is replaced by "It is certain, however, that much has been added to the discoveries of our Majors; and much more perhaps will be added by the valour and ingenuity of the people who will come after us, who, emulating the examples of so many modern valiant men, will enrich experimental physics with new machines, and will stimulate the Crafstmen who are mostly reluctant to put the new inventions to use, to authenticate their merit with experience, and to make

116 Belgrado, Jacopo, *Dell'azione del caso nelle invenzioni*, Stamperia del Seminario, Padova, 1757. ("Concorsero allo scioglimento i più valenti fisici e matematici d'Europa, destati dall'onor della gloria, e dallo spirito d'emulazione.")

117 Poleni to Belgrado, letter of the 16 April 1757, Biblioteca Civica, Verona It.X,135 (=6713) f° 167 ("Con tutto ciò ancora di tanti strumenti, e di sì varie macchinette proposte, appena alcuna serve al fine dell'invenzione") Letter from G. Poleni to Belgrado, Jacopo. 16/04/1757, Biblioteca Marciana, Verona.

118 Belgrado, Jacopo, *Dell'azione del caso nelle invenzioni*, Stamperia del Seminario, Padova, 1757. ("Con tutto ciò non so se di tanti strumenti, e di sì varie macchine e invenzioni, e scoperte siano in proporzione dei vantaggi, e progressi della Meccanica, e Nautica.")

119 Poleni to Belgrado, letter of the 16 April 1757, Biblioteca Civica, Verona It.X,135 (=6713) f° 167 ("Quel che s'è aggiunto alla perfezione di molte altre macchine, è si poco, ed incerto, che neppure fu messo in uso, e soli ammirasi ne' rami bene incisi ad ornamento d'un libro, e all'immortalità dell'autore")

up for the rarity of the transcendent and marvellous inventions that chance sometimes gives us, by copying the trivial inventions of art."[120]

It is easy to notice how Belgrado respected the opinion of Poleni, and followed his advice carefully by correcting his own publication. Moreover, the topicality of the subject and of the discussion amongst the two scientists is interesting. "And as to their use, who knows that they were not once to be reduced to their use? How many speculations are there in Mathematics the use of e does not appear. And the use, which is not there today, may be introduced another day."[121] wrote Poleni in his corrections. This kind of analysis of scientific research is the same argument that nowadays is used by researchers and science communicators about the utility of scientific discoveries, whether theoretical or experimental, in order to let people understand that science progresses through continuous improvements and corrections of mistakes, more than by solving a specific problem at one time.

This topic is taken up again at the end of the chapter, when Belgrado talks about the progress of art, which is slow and adds only little pieces to what existed before. The inventions produced by chance, instead, seem to be simpler and completely new and perfect from the first time.

120 Belgrado, Jacopo, *Dell'azione del caso nelle invenzioni*, Stamperia del Seminario, Padova, 1757. ("Egli è però certo, che molto s'è aggiunto ai ritrovamenti de' nostri Maggiori; e molto più forse s'aggiungerà dal valore ed ingegno de' nostri Posteri, ch'emulando gli esempi di tanti moderni valentuomini arricchiranno di nuove macchine la Fisica sperimentale, e stimoleranno gli Artefici per lo più restii a ridurre ad uso le nuove invenzioni, ad autenticare colla sperienza il lor merito, e a supplire colla copia delle mezzane invenzioni dell'arte alla rarità delle trascendenti, e meravigliose, che qualche volta ci dona il Caso.")

121 Poleni to Belgrado, letter of the 16 April 1757, Biblioteca Civica, Verona It.X,135 (=6713) f° 167 ("E circa l'uso; chi sa, che un tempo non siano per essere ad uso ridotte? Quante speculazioni vi sono nella Matematica, delle quali non ne apparisce l'uso. E l'uso, che non v'è oggi, può esser introdotto un altro giorno.")

In the sixth chapter of this dissertation, Belgrado addresses the theme of the combinatorial calculus developed by Bernoulli, Moivre and Moumart, to conclude that the number of combinations of ideas and information is impossible to calculate. Citing "*Meditatio de cognitione, veritate et ideas*"[122] written by Leibniz, he says that "when a notion is very enveloped, and composed, there is no way to think at one time to all the elements that compose it and form the calculus of their number."[123]

That is declared to be the reason why man cannot do or foresee some inventions with his intellect, but he needs a fortuitous event that creates the occasion. Two examples he brings of those events are the famous apple falling from the tree, that inspired Newton's theory of universal gravitation, and the lamp that Galilei saw oscillating in a church during the religious function and made him think about harmonic motion.

On page 106, at the end of the first dissertation, there is something else that was corrected by Poleni. In the letter of the 23rd of April 1757, he wrote: "In the print I send, p. 106, line 24, we read (as was also in the manuscript) that the crystalline lens is stretched into an ellipse and put back into a sphere. An ellipse, which is a plane figure, does not seem to be able to be put back into a sphere, which is a solid figure."[124]

122 von Leibniz, Gottfried Wilhelm. *Meditatio de cognitione, veritate et ideas*, Typis Marggrafianis, Germany, 1740

123 Belgrado, Jacopo. *Del ruolo del caso nelle invenzioni,* Stamperia del Seminario, Padova, 1757.

124 Poleni to Belgrado, letter of the 23 April 1757, Biblioteca Marciana, Venice, It.X,135 (=6713) f° 176-177 ("Nella stampa che mando, pag. 106. lin. 24. si legge (come pur stava nel MS.o) ad allungare in una elissi, ed a rimettere in una sfera il cristallino. Una elissi, ch'è una figura piana par che non si possa rimettere in una sfera, ch'è una figura solida. Il cristallino negli Uomini non è la figura d'un'intera Sfera, ma piuttosto d'una specie di Lente")

This is followed by a note about the geometric shape of the crystalline, that is shaped as a lens and not as a sphere, and a citation written in Latin from "*Adversaria Anatomica VI*"[125], about the shape and the functioning of the crystallin, written by Gian Battista Morgagni, a friend of Poleni who covered the chair of theoretical medicine at the University of Padua,

In the final book, Belgrado had corrected the sentence in "How many muscles and how many tendons are employed to dilate and shrink the pupil, to decrease and increase the convexity of the crystalline lens, to bring it closer to the retina and to move it further away from it, so that the vision, according to the given circumstances, is perfect!"[126].

It is also interesting to notice that that sentence appears at the same page and the same line that Poleni indicated in his comment: this indicates that the manuscript has not undergone major changes from the draft copy on which Poleni worked on, and the final printing version. In the same letter, in fact, Poleni also talks about other comments and suggestions that he inserted in the copy he sent; from this example, it is clear that Belgrado was willing to accept his advice. In reply, in fact, he sent him a note with the changes and corrections he wanted to be done on the final work.

Another topic that Belgrado uses against chance as a main factor on inventions comes from his natural theology studies. According to this theory, human beings are prior to chance, so that every idea that comes from intelligence and experience permits us to comprehend the laws that rule nature. The chance consists in a combination of phenomena that the

125 Morgagni, Giovanni Battista. *Adversaria anatomica omnia…* Johannes Arnoldus Langerak, 1723.

126 Belgrado, Jacopo. *Del ruolo del caso nelle invenzioni,* Stamperia del Seminario, Padova, 1757. ("Quanti muscoli, e quanti tendini ordinati a dilatare, e a restringere la pupilla, a diminuire e accrescere la convessità del cristallino, ad accostarlo, e ad allontanarlo dalla retina, perchè la visione, secondo le date circostanze, sia perfetta!")

human mind cannot foresee and organize, but they are submitted to mechanical laws.

Belgrado refers to the "continuity law", retrieved by Bernoulli, according to which "nature does not operate by leaps and bounds"[127], citing Boscovich's dissertation *De lege Continuitatis*[128]. According to this treatise, every variable that is present in nature follows this law, so there is no possibility of the chance to act, because it would entail a violation of the mechanical law that the body is submitted to. It is interesting to notice that this argument contains the assumption of the validity of the continuity law. Moreover, even if Belgrado does not use this word, it falls within the concept of determinism, according to which all the bodies of the universe follow in every instant a path that is determined by the laws of physics laws. He says, in fact, that the only reason human minds cannot foresee every effect of the laws is that infinite combinations exist, and human minds cannot understand the infinite. Indeed, it is possible that, among all the possibilities, some of them can be favorable to the scientists that have prepared their culture and experiences enough to understand the possibility of an invention or discovery.

Belgrado concludes that, because of the infinite possibilities that are governed by the mechanical laws, the case should have an infinite power of action to overcome them, and that would be the power of creation, that belongs instead to God.

127 Belgrado, Jacopo. *Del ruolo del caso nelle invenzioni,* Stamperia del Seminario, Padova, 1757. ("La natura non opera a salti")

128 Boscovich, Roger Gregor. *De continuitatis lege et ejus consectariis pertinentibus ad prima materiae elementa eorumque vires dissertatio auctore p. Rogerio Josepho Boscovich…* ex typographia Generosi Salomoni, 1754.

<u>Second Dissertation: On the influence of stars in terrestrial bodies</u>

The second dissertation is an example of the application of the Newtonian scientific method, that Belgrado calls "*Analytical Method*", to the astrological discipline.

In the introduction, he starts by affirming that no proof is sufficient to deny the influences that celestial bodies may have on terrestrial bodies, but, on the other hand, neither to confirm it. His purpose, he says, is to "dispose minds to penetrate reason and obey its dictates precisely"[129]. This is a clear example of Enlightenment thought, according to which people should fully embrace the dictates of reason, to the detriment of the false beliefs to which they hang on in the hope of finding an order that will benefit mankind. This concept is defined by Belgrado as the "Law of mutual trade"[130].

The dissertation is divided into two parts: the first one illustrates the main phenomena whose functioning is commonly linked to astral influences; in the second part researches and discusses the principle on which these beliefs are based, giving the possibility to the reader to analyze their credibility, with the light of reason.

The first influence that is analyzed is the one of the Moon, to which people attributed the motion of tides and winds, as well as the weight of crustaceans, the quality of sawn wood, depending on the Moon phase in

129 Belgrado, Jacopo. *Dell'azione degli astri ne' corpi terrestri,* Stamperia del Seminario, Padova, 1757. ("disporre gli animi a penetrar la ragione, e ad ubbidire precisamente ai suoi dettami")

130 Belgrado, Jacopo. *Del ruolo del caso nelle invenzioni,* Stamperia del Seminario, Padova, 1757. ("Legge del reciproco commercio")

which it has been cut, some illnesses, such as epilepsy and the menstrual period. After the Moon, Belgrado treats the topic of misfortune linked to the passage of a comet, to an eclipse, northern lights and fire globes, and, in the end, he discusses the influences of the planets of the Solar System on Earth.

The only effective influence that, according to the studies of Belgrado, can be attributed to the Moon turns out to be the motion of tides, "because they are supported by countless exquisitely executed observations by expert professors."[131]. Belgrado, in fact, does not only criticize the absence of proof in favor of a thesis, but also the authority of who claims them and the method they follow.

Regarding the observations about the motion of tides, he cites instead the various experiments, such as the one of Mr. Pontchartrain in Dunkerque, the one of the hydrographers Baert and Du Bocage in Haure de Grace, the one made by the mathematicians de la Hire and Picard made in Brest and Bajona, and by Wallis and Sturm in America, Africa, China, Vietnam, and England. Belgrado affirms that these research were made with exact scientific instruments and methods, so the collected data are sufficient proof of the correspondence between tides and moon phases.

About the motion of winds, instead, he cites unfavorable evidence of the influence of the Moon, such as the ones collected by Halley and Musschenbroeck. In the second part of the dissertation, he exposes a study conducted by DanielBernoulli, that explains that the elasticity of the gases that compose the atmosphere makes them less sensitive to the influence

131 Belgrado, Jacopo. *Del ruolo del caso nelle invenzioni,* Stamperia del Seminario, Padova, 1757. ("Accordo la relazione delle maree colle Sigizie. Poichè per esse militano innumerabili osservazioni da spertissimi Professori eseguite squisitamente.")

of the Moon, as opposed to the see, that is made of a liquid, which is not elastic.

The absence of evidence is pointed out as for the weight of crustaceans. Studies about this topic, says Belgrado, made by Aristotle and Plinio, do not report observations made by themselves or by others, nor is an accurate method explained. After an analysis of Aristoteles text, Belgrado concludes that *"this critique teaches us, that the great Philosopher does not always deserve faith"*[132], and *"I ask a wise and discreet judge whether the assertion of a singular, and perhaps previously unheard-of phenomenon, expressed in just two words, without allegation of witnesses, observations, and other evidence in the critical and literary forum, merits belief and faith?"*[133]. About Aristotele, he affirms: *"He trusted too much in his high intellect, allowing him flights too free, and superior to the spirit of a severe Philosopher, more using his mind to imagine nature in his own way, than to discover it with the help of the senses."*[134]

With these affirmations, it is easy to find a clear example of Enlightenment thought. The kind of authority that Belgrado research in authors is not linked to their names or careers, but to their working and communication

132 Belgrado, Jacopo. *Del ruolo del caso nelle invenzioni,* Stamperia del Seminario, Padova, 1757. ("con tutto ciò ella c'insegna, che il gran Filosofo non merita sempre fede")

133 Belgrado, Jacopo. *Del ruolo del caso nelle invenzioni,* Stamperia del Seminario, Padova, 1757. ("Chiedo a un saggio, e discreto giudice, se l'asserzione di un fenomeno singolare, e forse prima inaudito, espresso in sole due parole, senza allegazione di testimoni, d'osservazioni, e di altre pruove nel foro critico, e letterario, meriti credenza, e fede?")

134 Belgrado, Jacopo. *Del ruolo del caso nelle invenzioni,* Stamperia del Seminario, Padova, 1757. ("si fidò ancor troppo dell'alto suo ingegno, permettendogli voli troppo liberi, e superiori allo spirito d'un severo Filosofo, più valendosi della mente a immaginare la natura a suo modo, che a discoprirla coll'ajuto de' sensi.")

methods, that must contain a clear and objective explanation of their experiments and data.

Similar observations are addressed to the writings of Plinio and M. Tullio, who did not take observations themselves or from accredited observers, but from sources that can only be traced back to the “voice of the vulgar, who are always credulous and superstitious”[135].

It is also important to evidence that, besides criticizing authors, Belgrado proposes observation methods, more structured and freer from biases, that can be used to verify or not the correspondence between Moon phases and the phenomenon in analysis.

Similar observations are addressed to the topic of the quality of sawn wood, about which, again, Belgrado affirms that “Those good philosophers either followed the opinions and judgments of the common people, or they made crude observations that were useless for deriving the truth”[136]. He also observes that in more accredited treatises, such as the architecture books written by Vitruvio, or the book written by Mr. Buffon about the use of wood in ship construction, no reference to the correct moon phases in which one should cut the wood is reported.

More interesting is the analysis of the medicine book “*De diebus decretoriis*”[137] written by Galeno, the famous physician who lived in ancient Greek in the second century BCE, in which the influence of celestial bodies is mentioned. According to Belgrado, he “would have composed that book

135 Belgrado, Jacopo. *Del ruolo del caso nelle invenzioni,* Stamperia del Seminario, Padova, 1757. (”si ridurrà la cosa alla voce del volgo, sempre credulo, e superstizioso.”)

136 Belgrado, Jacopo. *Del ruolo del caso nelle invenzioni,* Stamperia del Seminario, Padova, 1757. (”Que’ buoni Filosofi, o seguirono i pareri, ed i giudizj del volgo, o fecero osservazioni grossolane, e inutili a trarre il vero.”)

137 Galeno, *De diebus decretoriis*

annoyed by his friends, in order to reconcile authority, and give credit to their errors with the opinion of such a skillful physician"[138]. This thought is shared with Geminiano Montanari, who is frequently cited from this chapter onwards.

Montanari was an astronomer and mathematician, born in Modena in 1633. He covered the chair of Mathematics at the University of Bologna and, subsequently, the chair of Astronomy and Meteors at the University of Padua. In his treatise "*L'astrologia convinta di falso*"[139] *(Astrology convinced of false),* Montanari reports his experiment on horoscopes, demonstrating the total randomness of the correspondence between astrological predictions and actual events. He created false horoscopes, with random events that came to his mind, distributed them, and checked their veracity later, verifying that the predictions that were found true were just in the same proportion as the ones made by astrologers who studied the influences of stars.

In the second part of the dissertation, Belgrado talks about the real principle that governs the phenomena described, citing experiments and data that demonstrate that the influence of the Moon on Earth is negligible with respect to the influence that celestial bodies have on each other. Calculations are based on the gravitational theory enunciated by Isaac Newton.

It is interesting to notice that, despite Belgrado pointed out, at the beginning of the dissertation, that the proofs against the influences of

138 Belgrado, Jacopo. *Del ruolo del caso nelle invenzioni,* Stamperia del Seminario, Padova, 1757. ("anche il celebre Montanari è d' opinione, che Galeno abbia composto quel libro importunato da' suoi amici, per conciliare autorità, e credito a loro errori coll'opera d'un Medico sì valente.")

139 Montanari, Geminiano. *L'Astrologia convinta di falso col mezzo di nuove esperienze e ragioni fisico-astronomiche,... o'sia la caccia del frugnuolo, etc*. 1685

celestial bodies were not sufficient at that time, he admitted the possibility to find some others in the following years, and most of the arguments he cited are the same that nowadays are used to disprove astrology. Scientific improvements and more precise measurements have taken place, and it is also clear that scientific instruction and communication are more diffused than they were in the eighteenth century. However, the same superstitions and beliefs are still diffused. This fact is linked with the reflection that Belgrado makes in the last paragraph of the dissertation, in which he reflects on the reason for the credulity of people, regardless of their level of education. As he reported in the chapters about medicine and about comets, in fact, diseases and other misfortunes happen even without the presence of a comet, an eclipse, or a certain planetary alignment: these are facts that people can notice even without a precise data base or scientific instruction. The reason why those beliefs are so hard to remove, according to Belgrado, is that humans are in search of something to persuade themselves that suffering and hard times will be over soon, trying to predict the end of them.

"The uncouth men, there [in the motion of the stars] seek their end, where their elders have sought it, and sometimes by adventure have found it, that is, in the phases of the Moon. We soon seem to be less miserable, seeing ourselves close to one of them, as one who, in the new climate and in the native air, hopes to improve his health, or by approaching the shore believes to free himself from shipwreck. Take away the power of the Moon over the seasons or times, and they will think they have lost a flattering comfort that tempered the bitterness of their lives".[140]

140 Belgrado, Jacopo. *Dell'Influsso degli Astri ne' Corpi Terrestri,* Stamperia del Seminario, Padova, 1757. ("Gli uomini rozzi, colà [nel moto degli astri] ne cercano il termine, ove l'han cercato i lor maggiori, e qualche volta per avventura l'han ritrovato, cioè ne' punti di Luna. Ci pare tosto d'essere men miseri, veggendoci vicini a un di loro, come chi nel nuovo clima, e nell'aere nativo spera di migliorare salute, o accostandosi al

People research comfort to pain in a predictive mechanism in which they want to believe, despite evidence. This can be one of the reasons why, even if the kind of studies conducted by Belgrado, Montanari, Nollet and all the Enlightenment scientists have been communicated and kept on in the following three centuries, superstitions are still rooted in the mind of people. This also makes the second dissertation of Belgrado particularly interesting today and adapted to the current way of thinking about science.

This dissertation by Belgrado is cited in the paper written by Biagio Rossi, "*Historical notes on the astronomical observatory of the Royal University of Parma"* and described by the author as "An erudite exposition, solidly argued and elegantly styled, published by the typography of the Seminary of Padua, was the one that added popularity to its glory, thanks to its practical conclusions." [141]

The two dissertations and science popularization in the eighteenth century

The content of the two dissertations not only appear as very topical, though they were written almost three hundred years ago, but they are alos totally in line with the scientific communication activity that Enlightenment scientists were carrying out.

lido crede di liberarsi dal naufragio. Si tolga a costoro il poter della Luna sulle stagioni, o su i tempi, penseranno d'aver perduto un lusinghiero conforto, che temperava l'amaro della loro vita.")

141 Rossi, Biagio. *Note storiche sull'osservatorio astronomico della R. Università di Parma*, Rapporto annuale dell'osservatorio metereologico VIII, 1922 ("L'opera poi "Dell'Influsso degli astri nei corpi terrestri", erudita esposizione fatta con solidità di argomenti e con fine eleganza di stile, edita dalla tipografia del Seminario di Padova, fu quella che alla sua gloria aggiunse anche la popolarità, in grazia delle sue conclusioni pratiche.")

From the beginning of the eighteenth century, new lectures in experimental physics started to be diffused in Europe, starting from the universities of Cambridge and Oxford. Those "lecture demonstrations' ' were characterized by an experimental approach: the principal part of the lecture was, in fact, the experience and the observations of the physical laws in actions, and only after that, the mathematical demonstration that explained the fact was exposed. This approach shows a crucial difference from the one followed by natural philosophers before the Scientific Revolution, that was mainly based on the studies of ancient books, written by esteemed philosophers such as Aristotele. Starting from Galileo Galilei, less credit was given by the scientific community to the authority of a character and more to the observations and experimental results that were supposed to be repeatable and objectively observed by anyone. This new form of authority is clearly seen in Belgrado's approach in his dissertation "*On the influence of stars on terrestrial bodies",* when he openly criticizes works by accredited authors such as the *De diebus decretoriis* of Galeno, in chapter VII, or the "*De partibus animalium, o earum cassius"* written by Aristotele, in chapter V, highlighting the shortcomings of the way they exposed their theories, characterized by a lack of evidence and objective explanations. Belgrado, instead, proposes experiments that could be made in order to study the same phenomena, that are more in line with the scientific method.

He specified that "I have chosen to use the whole of Aristotle's text faithfully, because I have considered it necessary in order to make very just reasoning on it, and to draw from it those corollaries which are either favorable, indifferent, or contrary to the opinion of the influences. I do not pretend to sit on the bench and call upon the great Master of those who do, to explain all the errors that are contained in the text alone. [...] Although this criticism does not seem to belong directly to my theme, it does teach us that the great philosopher does not always deserve faith, and that the known errors of an author are like those rocks rising from the sea, which, discovered from afar, cause fear to sailors and suspicion to other blind men who hide around them."[142]

Belgrado does not claim to have a higher credibility than those authors, but to shed light, through logical deductions, on the mistakes of the reasoning exposed, which, as it is logically incorrect or incomplete, does not depend on the authority of the writer or the reader. These authors can actually constitute obstacles to those who are carrying out research, whose sight can be obscured by the impossibility of contradicting such knowledge.

Another revolutionary characteristic of eighteenth-century lecture-demonstrations was the fact that they not only involved university students, but a generic public as well. Most of the first English lecturers were members of the Royal Society of London, which, from 1703, was directed by Isaac Newton. The lectures dealt with topics that had been previously discussed at the Royal Society.[143] The first of these public lectures was given by James Hodgson in 1705.

142 Belgrado, Jacopo. *Dell'azione del caso nelle invenzioni e Dell'influsso degli astri nei corpi terrestri, Stamperia* del Seminario, Padova, 1757 ("Ho voluto fedelmente il testo intero d'Aristotele addurre, perché ho stimato ciò necessario a farvi sopra de' raziocini assai giusti, e a trarne que' corollari, che sono o favorevoli, o indifferenti, o contrari all'opinion degli influssi. Io non pretendo di sedere a scranna, e di chiamare il gran Maestro di color che fanno, a render ragione di tutti gli errori, che solo nel testo addotto contengonsi. [...] Benchè questa critica non sembri direttamente appartenere al mio tema; con tutto ciò ella c'insegna, che il gran Filosofo non merita sempre Fede; e che gli errori già noti d'un autore sono a guisa di quegli scogli risaltanti dal mare, i quali scoperti da lungi destan timore a' naviganti, e sospetto di altri chiechi, che si nascondono intorno a loro.")

143 Talas, Sofia. *La Fisica nel Settecento: Nuove lezioni, spettacolo, meraviglia*, Il Nuovo Saggiatore, Vol. 27, NO 5-6, 2011

Among those lecturers, there were John Theophilus Desaguliers, Willem Jacob ‘s Gravesande Pieter van Musschenbroeck, and Jean Antoine Nollet. In Italy, Giovanni Poleni himself played a central role by creating a “Theatre of Experimental Philosophy” in Padua, in which he showed various experiments carried out with sophisticated instruments, most of which were built by Italian craftsmen.

According to the available sources, it is possible that Jacopo Belgrado also gave some “lecture demonstrations” in Parma, where, from 1738 and 1750, he held the chair of physics and mathematics at the *Studium Parmens*. He acquired, in fact, various experimental instruments, about which he talked a lot with Poleni. Moreover, according to a letter not part of the catalogue to which this thesis refers, quoted in the article “*New Light on the Cabinet of Physics of Padua”*[144], written by Sofia Talas, it seems that he himself was willing to give some public lectures. He wrote: ”I try through public activities and some private experiments to stimulate the good taste in a city, where I certainly could not find it”.[145]

In the letters written before 1750, when Belgrado became confessor and theologist of Filippo di Borbone, giving up his didactics activity and dedicating himself to writing and building the Astronomical Observatory, a lot of instruments that he wanted to buy, or that he built, are mentioned, though the intent to use them for lectures is not explicit. What is certain is that he carried on his communication activity by publishing a great number of books and dissertations concerning the main scientific topics that were studied in the eighteenth century.

144 Talas, Sofia, *New Light on the Cabinet of Physics of Padua*, 2013

145 Belgrado to Poleni, Carteggio Poleni, vol 7, 7/08/1742 (”Io m’ingegno con pubbliche funzioni, e con qualche privato sperimento d’eccitare il buon gusto in una città, in cui certo non ho saputo trovarlo”)

The book containing the dissertations “On the action of the case on inventions” and “On the influence of stars in terrestrial bodies” is not a collection of experiments or theories, but it is clearly aimed at communicating the correct scientific approach that is necessary to question nature.

Some experiments made by other scientists are mentioned in his book, as well as some ideas of methods to conduct experiments, but not experiments that were conducted by Belgrado himself. In the dissertations, the accent is posed on the method. Belgrado often comes back to reflections about the importance of rigorous and objective data analysis, and the need of going beyond unfounded beliefs, giving more credit to rational reasoning, though this requires discussing and sometimes abandoning comfortable ideas.

The two dissertations can be seen as a meta-analysis of the scientific, but also social revolution that was taking place in the years of Enlightenment. While the scientific books published by his colleagues, such as the “*Lectures on Experimental Physics”* by Nollet, or “*A Course of Experimental Philosophy”* by Desaguliers presented experiments in detail, followed by the physics theory and mathematical demonstrations, with the specific purpose of teaching scientific concepts and their applications, Belgrado, in this book, while citing experiments and theories, analyses the mechanisms by which the scientific thought was diffusing and the obstacles that it encountered. His reflections went deep into the reasons why unfounded beliefs are rooted into the human mind, as well as the misconceptions that an inadequately trained and attentive person may encounter when confronted with a phenomenon he or she does not fully understand.

What is surprising is the topicality of these reflections, that could be applied to l today’s society as well as to the society of eighteenth-century Europe. The first dissertation is more an analysis of the mechanisms that are beyond a scientific discovery, shedding light on the complexity of the trials, the studies, the information exchange between scientists, besides the role of a lucky event. It is still a common opinion that a scientific discovery or invention is made thanks to the geniality of a single mind, and often the sum of all other people who contributed, the failed experiments that lead to new awareness, the minor steps and the time that occurred between an idea and a structured theory is disregarded. Almost three centuries ago, Belgrado went deep into this complexity, and tried to communicate it.

As for the second dissertation, it deals with the mechanisms that obstruct the diffusion of scientific thought among people, also caused by the misunderstandings about what is scientific and what is not, and by people who are or are known as scientists, who spread incorrect beliefs among people. The conclusions Belgrado wrote in this dissertation focus, however, on an analysis of the human mind that today would be classified as psychological. The reason it is hard to abandonn incorrect beliefs such as the influence of celestial bodies on Earth, according to him, is that people are looking for comfort to their troubles and prefer to be deceived by their own mind than accepting that every event depends on the consequences of immutable physical laws and their own free will. He concludes with an anecdote:

"The story of that Citizen of Argos is well known, who imagined himself from morning till night hearing wonderful Tragedies, and locking himself up alone in a Theatre, putting on an attitude of admiration and applause for the Actors. The relatives, who were suffering from such a strange and bizarre illness in one of their closest relatives, wanted to treat and cure him, whatever the cost to them, which happily happened with the use of Hellebore, which dispelled the bile of the Sick man, the only source of such an illness. But when he was restored to health and sanity, here is the beautiful thanks he gave them. You have not cured me, but rather you have killed me, depriving me of a delight that was so dear to me, and violently depriving me of a sweet error that made me think the days of my life blissful and happy."[146]

This characteristic of human thought is currently present in most of the population, and, in fact, false theories, pseudo sciences and irrational beliefs are still diffused.

It is also interesting to notice that Belgrado, in spite of the critical spirit that he directs to irrational beliefs, and his insisting on the importance of proofs, often talks about "God, that does all the things and see all the things"[147], considering in fact religious faith different from an unfounded belief. One of the examples of this though is the sentence:

"This is the one true reason why mankind finds it so hard to abandon such an opinion, which is a valuable part of their happiness. Whoever takes it out of the world would be sinning against the Laws of the Common Good and would decrease the pleasure which each one experiences in flattering himself to be near the end of what he considers to be true misery."[148]

146 Belgrado, Jacopo. *Dell'influsso degli astri ne' corpi terrestri,* Stamperia del Seminario, Padova, 1757 ("è nota la Storia di quel Cittadino d'Argo, il quale s'immaginava dalla mattina alla sera d'udire Tragedie meravigliose, e chiudendosi solo in un Teatro si metteva, e continuava in un atteggiamento di chi ammira, e fa applauso agli Attori. I Parenti, che mal soffrivano sì strana, e bizzarra malattia in uno de' lor più stretti congiunti, vollero medicarlo, e guarirlo, qualunque prezzo costasse loro; ciò che felicemente avvenne coll'uso dell'Elleboro, che dissipò la bile dell'Infermo, unica sorgente d'un tal male. Ma ristabilito ch'egli fu, e rimesso in senno, ecco il bel ringraziamento ch'egli lor fece. Voi non m'avete guarito, ma piuttosto m'avete morto, privandomi d'un piacere che m'era sì caro, e violentemente togliendomi un dolce errore, che mi faceva parere beati, e lieti i giorni del viver mio.")

147 Belgrado, Jacopo. *Dell'influsso degli astri ne' corpi terrestri,* Stamperia del Seminario, Padova, 1757 ("Dio, che tutto fa, e tutto vede")

148 Belgrado, Jacopo. *Dell'Influsso degli Astri ne' Corpi Terrestri*, Stamperia del Seminario, Padova, 1757. ("Ecco l'unica, e vera cagione, per cui gli Uomini duran fatica ad abbandonare

On this subject, in fact, he published, in 1777, a book titled "*On the existence of God by geometrical theorems*"[149], that, from the title, evidence that he did not see any contradiction between the religious and scientific field.

una tale opinione, ch'è benemerita in parte della loro felicità. Chi volesse torla affatto dal mondo, peccherebbe contro le Leggi del ben comune, diminuendo il piacere che sperimenta ciascuno di lusingarsi vicino al fine di ciò che si reputa miseria vera.")

149 Belgrado, Jacopo. *Dell'esistenza di Dio da' teoremi geometrici*, Belgrado, Jacopo. Udine, 1777

Chapter 7

The astronomical observatory of Parma

There is currently little available information about the astronomical observatory of Parma, founded by Jacopo Belgrado. Some details are provided in the letter exchange between him and Giovanni Poleni that took place in those years.

When, in 1768, the Jesuits were expelled from the College, they were forced to leave all their belongings: amongst them there was all the scientific equipment that belonged to Belgrado. The observatory, which saw alternate periods of intense research and inactivity, was converted into a meteorological observatory in 1891. Currently it is no more in use, and the building belongs to the University of Parma. These are the reasons why the sources about that part of his life and scientific activity are fragmentary.

Despite this, from a reconstruction of the work that Belgrado did, we see that it was admirable and ingenious. It must also be remarked that, in his correspondence with Giovanni Poleni, some discussions about the instrumentation built emerge; this is another example of the mutual collaboration between the two scientists, and the interest they had in the scientific activities of each other.

The importance of the foundation of the observatory also lies in the fact that, though it does not exist anymore, it was only the third astronomical observatory of Italy. This is a sign of the enterprising and innovative spirit that characterized Jacopo Belgrado.

The foundation of the Specola Parmense and its first activities

In 1757, Belgrado founded in Parma the *Specola Parmense*, the third Italian astronomical observatory, after the one of the University of Bologna and the University of Pisa. After that, there came the observatory of the University of Turin, in 1759, thanks to G. B. Beccaria, the one of Brera (Milan) founded in 1764 by the confrere of Belgrado, Ruggero Boscovich, with whom he was in strict correspondence contact, as well as Poleni,, and the observatory of Padua, founded by Giuseppe Toaldo in 1767.

Belgrado was already active in astronomical observations. From the western tower of the University Palace, the same where the Specola was placed, Belgrado made observations on his own.[150] The tower has a thirty square meters terrace and a smaller tower of 2,8-meter diameter, from which it is possible to have a good view of the city. In an epoque when light pollution was not a problem yet, it was a perfect location for the sky observations.

In 1738, Belgrado observed from there an Aurora Borealis appearing in the sky over Parma and wrote down a document containing all the observations and his reflections about the unknown phenomena. He affirmed that the only study of the events observed until that time would not be enough to reveal the nature of the Aurora Borealis.[151] Again, we see the reluctance that Belgrado had in formulating hypotheses without a complete database and a theoretical structure.

He also observed a solar eclipse on the 25th of June 1748, and a lunar eclipse on the 8th of August of the same year.

150 Rossi, Biagio. *Note storiche sull'osservatorio astronomico della R. Università di Parma*, Rapporto annuale dell'osservatorio metereologico VIII, 1922

151 Belgrado, Carlo, *Commentario della vita e delle opere dell'Abbate Conte Jacopo Belgrado*, Reale Tipografia Parmense, 1795.

The observatory, however, was officially inaugurated years later, when, after leaving the teaching of mathematics at the Collegio di San Rocco, and becoming mathematician and theologist at the Court for Filippo di Borbone, Belgrado had more time to dedicate to astronomical research. The official foundation of the *Specola Parmense* is traced back to the year 1757, when Belgrado published the *Observatio defectus Lunae habitae Parmaee in novo observatorio patrum Societatis Jesu die 30 julii 1757,* a text, difficult to trace,that described the lunar eclipse observed by Belgrado in 1757 thanks to the astronomical dial built by the Stefano Droghi (1711-1797) and Pietro Ballarini[152]. The two men, two years later, determined the meridian of Parma. In their honor, Belgrado had an inscription placed in the Observatory saying:

COELORUM – SCIENTIAE – ACQUIRENDAE

ASTRONOMICAM – TURRIM – CONDIDERE

P. P. SOC. IES.

LINEAM

A BOREA AD ASTRUM

DUXERE

STEPH. DROGUS ET PETRUS BALLARINUS

PARTITH PARMENSIS

ANNO MDCCLIX

The correspondence between Poleni and Belgrado shows that three copies of the book had also been sent to Poleni in the same year, and two of them were delivered by him to P. Colombo, Astronomy professor, and to Dr. Durer, defined by Poleni as “amateur of astronomical things”[153]. In the

152 Comi, Antonio. *Jacopo Belgrado e la specola dello Studium parmense*, Archivio storico per le provincie parmensi, quarta serie, Vol XLIX, 1997

153 Poleni to Belgrado, letter of the 27 August 1757, Venice, Biblioteca Marciana, It.X,135 (=6713) f° 217 (“delle cose astronomiche dilettante”)

collection of letters regarding those years, only the copies of the ones written by Poleni are present, while the ones from Belgrado are missing. It is clear, anyway, that Belgrado described the work he did in the observatory with Droghi and Ballarini, because, in the letter of the 16th of April 1757, Poleni wrote:

"I rejoice that you have so well planned your Observatory: I do not have one, but I have seen it in fact and in my books; I have sometimes observed the Sky, and I was a professor of Astronomy. You will have much merit with this illustrious City, or rather with the whole of Italy."[154]

He was referring to the chair of Astronomy and Meteor he had at the University of Padua from 1709.

This note shows that not only Belgrado held Poleni in high esteem, but that Poleni highly appreciated Belgrado as well

Belgrado, at his own expense, had provided the observatory of a Gregorian telescope, a Parisian one, twenty-five feet long, two other smaller telescopes, a meridian, two pendulums and an astronomical dial of three-feet radius[155]. For the construction of the observatory and when it was functioning, Belgradocollaborated with the astronomer Giuseppe Bolsi-Marchese, who returnied to Parma in 1750, after carrying out for forty years his astronomical career in Bologna together with Eustachio Manfredi.

154 Poleni to Belgrado, letter of the 16 April 1757, Biblioteca Civica, Verona, It.X,135 (=6713) f° 167 ("Mi rallegro che abbiate così bene architettata la vostra Specola: io non ne ho, ma ne ho vedute in fatto, e su miei Libri; ho alle volte osservato in Cielo, e fui Professore d'Astronomia; onde mi credo in istato di poter ben giudicare. Voi avrete molto merito con cotesta illustre Città, anzi con l'Italia tutta ancora.")

155 Rossi, Biagio *Note storiche sull'osservatorio astronomico della R. Università di Parma*, Rapporto annuale dell'osservatorio metereologico VIII, 1922

From the article “*News about latitude and longitude in Parma”*[156], published in the Journal of Parma, it appears that the latitude and longitude of the city of Parma were determined by Jacopo Belgrado himself, in the year 1761. The results of the measurements that he conducted were of 44° 44’ 50’’ of latitude and 27° 35’ 0’’ of longitude, calculated with respect to the Meridian of El Hierro Island, placed at the west of the Canary Islands, and nicknamed Meridian Island. Already in 1823, it was clear that those measurements required more precise instruments and calculous methods, which Belgrado did not have less than a century before. In 1808, the astronomers in Milano, in charge of latitude and longitude measurements in Austrian Lombardy, made new measurements from the belltower of San Giovanni of Parma, and corrected the values found by Belgrado of 3’ in latitude and 25’ in longitude.

The observatory was equipped in the following years with several other instruments:

- A telescope from Gregory
- A Parisian telescope of twenty-five feet length, with a tin tube and a wooden support
- A telescope of twelve feet length, covered in leather
- A telescope of fifteen feet length, covered in marbled paper
- Two pendulum astronomical clocks
- A meridian
- A mobile astronomical dial of three feet ray
- A binocular
- Two telescope lenses
- Four star-maps representing constellations

156 F.B., *Notizie sulla Latitudine e Longitudine a Parma*, Gazzetta di Parma, N° 6, 21st of January 1823

In Blegrado's office, there were also:

- A Newtonian brass telescope
- A spyglass
- A spyglass with five orders of carton tubes
- A brass solar clock
- A small spyglass with a wooden case
- A bronze platform for making lenses
- Three small ivory microscopes

This list of instruments is contained in a catalog written when Belgrado, together with the other Jesuits, was expelled from the College of San Rocco and forced to leave Parma, for the will of the minister of Filippo di Borbone, Du Tillot, the night of the 8th of February 1768. When they expelled Belgrado and the other priests and friars, the men commissioned by Du Tillot drew up a complete inventory of all the goods they found in their rooms. That catalog is now kept in the Historical Archive of Parma, and twenty-five pages of it are dedicated to Belgrado's belongings. Besides astronomical materials, books, objects of daily use and physics instruments are also listed, so that the catalog also contains all the information about the Physics cabinet.

After the expulsion of the Jesuits, the College of San Rocco hosted the University of Parma, and the objects that belonged to Belgrado were sold or used for other purposes. The University of Parma, nowadays, does not own any of the original instruments that belonged to Belgrado, nor letters or lessons that he kept at the College. In order to find such materials, more in-depth research would be needed.

The scarcity of information about the astronomical observatory of Parma is also due to the fact that, after the appointment of the director of the observatory Pietro Pigorini, in 1857, it was gradually converted to a meteorological observatory. After his death, in 1891, under the guidance of the director G. Valle the activity of the observatory was fully dedicated to the hourly service and meteorological observations. That was also due to the fact that the tower was not suitable anymore for the scientific evolution required by scientific progress.

The meteorological observatory is not in use nowadays either, the tower is property of the University of Parma, and it is hard to know where the instruments that were collected and used in it are now kept.

Before becoming a meteorological observatory, the Specola founded by Jacopo Belgrado had moments of intense research activities that could not have been possible without his dedication and hard work. During all the periods in which he was able to conduct his research, he kept on providing instruments. In a letter written to him by Poleni in 1759, the purchase of other instruments is mentioned:

"The telescope and the clock, which will come to you from Paris, will undoubtedly be two precious pieces, and of great use to your observatory. The value of Mt. Rey is well known to me: he is the Maker of the kind of those who know how to add to a perfect execution, where necessary, what needs to be invented. It will be known to him that the Pendulum must serve your Observatory, so I do not doubt that you are about to have a masterpiece.

Regarding the Comet, I know that it was discovered in Paris on 21 January of this year by Mr. Messier, and that in progress it disappeared because it entered under the rays of the Sun, and that it was discovered again at the beginning of April."[157]

157 Poleni to Belgrado, letter of the 19 May 1759, Biblioteca Marciana, Venice, It.X,136 (=6714) f° 20 ("Il Cannocchiale, e l'Orologio, che a Voi giungeranno da Parigi, saranno senza dubbio due Pezzi preziosi, e di grande utilità alla Specola vostra. Il valore di Mt. Rey mi è

Even without having access to the letter written by Belgrado, to which Poleni replied, it can be seen that an intense astronomical and technical activity was carried out in those years.

The activity of the Astronomical Observatory after the expulsion of Belgrado

After Belgrado was expelled from the College, his collaborators Droghi and Ballarini carried on the activities of the observatory and kept the instruments. The mathematics chair was given to Professor Tortosa, and the physics chair to Professor Andrea Bina, to whom the invention of the seismic pendulum is attributed.

When Professor Pietro Cossali got the physics chair, in 1768, and the astronomy, meteorology and hydraulic chair in 1790, astronomical activity started again at the observatory. Between 1791 and 1797, he published astronomical treatises about ephemerides, in which he explained in a simple language astronomical phenomenon, as well as pure scientific topics, in order to make the books accessible for a non-scientific audience. This can be seen as a continuation of the popularization activity of the Enlightenment scientists, which Belgrado was involved in. Cossali also managed to provide the observatory with modern instruments, though he was not able to see the results of his work, because in 1804 he moved to Padua and held the sublime calculus chair at the University of Padua.

molto noto: Egli è l'Artefice del genere di quelli, che ad una perfetta esecuzione sanno aggiungere, dove occorra, quel che fa d'uopo che sia inventato. Gli sarà noto che il Pendolo dee servire per la Specola vostra, onde non dubito che non siate per avere un capo d'opera. Circa la Cometa, io so che fu scoperta a Parigi lì 21 Gennajo di quest'anno da Mr. Messier, e che in progresso essa disparve perché entrata sotto i raggi del Sole, e che fu di nuovo scoperta ai primi d'Aprile.")

His chair in Parma passed to Professor Antonio Colla, who found a collection of instruments that was reduced to two mobile astronomical dials, both equipped with a telescope, a planetary machine that represented the movement of some planets of the Solar System, a Gregorian telescope and three spy glasses.[158] The purpose of Professor Colla was to conquer the same innovation level of the other Italian observatories and he did it by providing a collection of astronomical and meteorological memories, corresponding with Italian and foreign astronomers, and activating observations of astronomical phenomenon. In 1845, a lot of comets appeared in the sky above Parma, and from the Specola it was possible to observe them and to collect data. Colla himself discovered some of them and studied them in detail.

His activity was carried on by Pietro Pigorini, who after studying astronomy in Paris, provided the Specola with modern scientific instruments. He visited observatories in France and England, and, thanks to the information he collected, he introduced important improvements to the equipment and quality of Parma astronomical observatory. He bought for instance a meridian circle built by Pistor and Martins, an astronomical pendulum built by Tiede, and a telescope built by Lerebours and Secretan, placed under a turning dome.

The astronomer Schiapparelli proposed to combine the activity of the observatory of Parma with the one of Milan, in order to determine the longitude gap between the two towers, the latitude of Parma and the absolute azimuth. The Specuoa of Parma became a part of the web of the European Degree and used for geodetic operation as a new trigonometric point. The activity of Pigorini was rewarded: he became a member of the

158 Catalogue of the Royal Archive of Parma, High Schools from 1739 to 1817, folder 567, cyted in Rossi, Biagio *Note storiche sull'osservatorio astronomico della R. Università di Parma*, Rapporto annuale dell'osservatorio metereologico VIII, 1922

Astronomical Association of Heidelberg and of the Academy of Sciences of Lyon, besides various scientific journals.

Conclusions

The analysis of the correspondence between Belgrado and Poleni, allowed to widen the network of research, teaching and instruments of which the figure of Giovanni Poleni constitutes a central point. For some instruments and experiments described in Poleni's catalog, such as the fire-extinguishing machine and the pyrometer, it was possible to trace the origin and the history of the objects before the acquisition. Moreover, the contacts with other scientists were explored, and this shed light on the contactswith Jean Antoine Nollet, and with Charles Marie de la Condamine.

All those reconstructions were possible thanks to the precise dedication of Poleni to update his correspondent Jacopo Belgrado with his personal and working news.

As it has been said in the introduction, the analysis brought into light a secondary character, Jacopo Belgrado.

The correspondence and the careful study of Jacopo Belgrado show a polyhedric scientist, capable of carrying out different kinds of projects and with enough enterprising spirit to create a new scientific environment in Parma.

As well as Poleni, he was in touch with personalities such as Jean Antoine Nollet, Charles Marie de la Condamine and Ruggero Giuseppe Boscovich, with whom he exchanged knowledge and opinions.

Within the letters, not only the admiration that he felt for Poleni emerged, but also the reciprocity of that feeling. Poleni, in fact, more than once asked Belgrado’s advice and opinion.

Unfortunately, because of the expulsion of the Jesuits from Parma, most of the instrumentation that Belgrado purchased was lost, sold or reused.

The notes of his lessons are now kept by the descendants of the noble families that had attended them at the *Collegio dei Nobili*, where he used to teach mathematics.

Besides teaching, the research carried out by Belgrado, dealt with the cutting-edge themes of his time.

His style of reasoning, that strongly emerges from the dissertation "*On the action of chance on terrestrial bodies",* was in line with Newtonian philosophy. His both humanistic and scientific attitude allowed Belgrado to make a meta-analysis of the contraposition not only between the new scientific method, based on objective and repeatable observations, with the old method, based on the writings of philosophers, but also between the rational thought and the irrational, biased, superstitious thought that characterized people of the eighteenth century as well as it characterizes people nowadays.

Well-known scientists have characterized the Scientific Revolution with discoveries, inventions and the foundation of institutions that persist until today, but, at their side, a lot of other scientists contributed to the diffusion of the scientific method that made possible the scientific progress that we have today.

Though quantum mechanics would deny it, a metaphor could be proposed by using the Law of Continuity, often cited by Belgrado in *Dell'azione del caso nelle invenzioni*: "nature does not operate by leaps and bounds". Neither scientific progress operates by leaps and bounds, thanks to the fortuity chance of an apple falling on the head of a genius, but a continuous process is necessary, made of information exchange, improvements, collaboration and mistakes.

Amongst the exponents of the Enlightenment, several characters like Jacopo Belgrado have contributed to creating the continuity between great discoveries that maybe, without their support, would not have been possible.

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