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Galilean Science in Jesuit Classes of the 17th Century

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On November 5th 1614 the provincial Congregation of the Jesuits convened in Parma, Italy.[1] Parma was then a flourishing university town and the capital of the rich and successful state of Rannucio I Farnese. In 1600, the Jesuits had been invited by the Farnese family to assist in building up a system of higher education in their state. Eventually, the Jesuits controlled three inter-related prestigious institutions in the city of Parma. First, the old university had been reopened after a long period of stagnation. There, law and medicine, in addition to natural philosophy were taught under the supervision of the Jesuits. Second, a Jesuit college had been newly established, in which lower classes of grammar and rhetoric as well as higher courses in philosophy and theology had been taught. Last, the Jesuits in Parma were called to provide for the education of noble families' sons from all over Europe in the ***Collegio dei Nobili*** of the city.[2] There they used to spend a few years in a boarding school, where their formation as the future serving elite of many Catholic states was meticulously planned and taken care of.

The opening day of the Congregation - the 5th of November 1614 - was carefully chosen by the Jesuits after consultation with the Duke (or his representatives). All of them believed that the city would be full of scholars and citizens at this time, namely the beginning of the academic year. ("…tempo quando La Citta', e le Cittadine, e le Scolari suole essere ripiena"). In preparation, the Jesuit Church was decorated "from

[1] All quotations are from ms. In archivio di stato , parma
[2] All historiography on the Jesuits in the Farnese state: Brizzi two books and Miriam Torrini

top to bottom with its rich drapery". The Duke ordered to send over from his own "guardarobba" beds, tables, chairs, and other paraphernalia necessary for the hospitality of a large number of guests from the Province. He endowed the Jesuits with a large sum of money "buona soma di danaro" for buying generous quantities of food and other useful equipment. ("coltelli, forcine, cuchiari, boccali, bichieri, Lucerne, cattini, per Le mani, vasi per l'acqua benedetta, insino la carta, penne, calamari, temperini, forbicette, et altro. Segno evidente dell'isquisitissima sua providenza.") On the opening day, his highness, "Sua altezza Serenissma", came to the Jesuit church to take part in mass. As mass was over, he called the Fathers and gave his speech, "speaking with a lot of affection, showing how much respect he held for the Society, and the love with which he cared for them". As the Father Provincial expressed his wish to pay tribute to the Duke before the Congregation began, the Duke sent two coaches and received a small group of Jesuits in his palace. He welcomed them with the same kind of majesty that he paid to great personalities, with torches and candles in the halls and rooms that "equaled the clarity of day". On top of the scale stood the Swiss guard, with their weapons ready, and as the Jesuits entered the palace they saw that the rooms were full of "Signori e titolati". The congregation started in the evening, in presence of the Duke, who took part in almost all of the sessions. It lasted for ten days during which some of the Jesuits were invited to a ceremonious meal in the palace. One of the lucky Jesuits who were chosen to take part in the event – probably a secretary who later dictated a memo about it – described the splendid kinds of food, wine and decorations in memorable details, which I shall spare you for the sake of brevity and focus. Instead, I shall concentrate on the afternoon routine during the ten days of the congregation:

"After lunch, they took part in the disputations that were four in Theology and one in Philosophy (one had been put off for a reason which I shall explain later on), frequented by "literati", scholars and religious people, many of them coming from other cities in the surroundings in order to participate and argue. Also, two most "curious" problems in mathematics were demonstrated. One: Why, when a ray of sun passes through a hole of whatever figure, it nevertheless shows the image of the sun in a circular (form) on the "terminus ad quem" [the place where it arrives]; and the other: how - or in what way – someone [concerned with] a certain object made of various metals [a mixture of metals]: gold, silver, bronze or others, can know how much of each metal is inside. And they were successful, with the grace of God, to the great satisfaction of all those who were present."

The rich documentation of the event surviving in manuscript form in the Archivio di Stato di Parma, from which I have quoted just a few lines above, testifies to two major aspects of the Jesuit involvement in the mathematical sciences of their age. These will serve as a convenient point of departure to talk about the role of the "problem" in Jesuit education. First, in probing into the contents of the specific problems chosen to be recited, and actually "performed' in public, one may be able to place the problems in their proper scientific context and learn from them something about the peculiar style of Jesuit mathematical teaching in the seventeenth century. Second, it is manifest that "problems" had a "performative" dimension that calls for clarification and should challenge our reflection on the subject.

The problems chosen for the Provincial Congregation were both very ancient, and at the same time acquired new solutions and new meanings in the decade that preceded

1614. While the origins of the first problem – the image of the sun reflected through a pinhole - were rooted in the tradition of the Aristotelian *Problemata*,[3] it was extensively discussed by all great figures of the medieval optical tradition – including Alhacen, Witelo, Bacon, Pecham – as well as by the great Renaissance artists – especially Leonardo - and mathematicians – especially Maurolico. However, it was not until Kepler that the problem was given its fully fledged geometrical solution and espitemological meaning. In his 1604 *Paralipomena ad Vitellionem* – written as a commentary to Witelo, but meant to serve as an introduction to the science of astronomy - Kepler was the first to dismiss the discourse on visual rays and on "species" emanating from sensible objects. Instead, he showed how an image of an external object is produced on a screen, but also on the human retina, by considering rays as geometrical entities and by developing a theory of vision and an epistemology of geometrical entities that justified his solution.[4] Kepler's solution had implications for understanding the way images of distant objects were formed through the telescope's lenses, as is testified by his *Dioptrice* from 1611.[5] This problem was of high interest to Jesuits[6] who claimed that one of them – Lembo - actually built a telescope before hearing of Galileo's.[7] Thus, the Jesuits were able to construct their own telescope a few months after the publication of the *Sidereus nuncius* which they used to confirm most of Galileo's celestial observations and to promote their own

[3] Book 15, chs. 6, 11. See Lindberg article from Exact Sciences, and Ann Blair on Problems
[4] Raz
[5] Dictionary of the History of Ideas (on internet)
[6] Scheiner included discussion of the intersection of lightrays in a small opening and their straight path on pp. 75-8 of the *Disquisitiones mathematicae*; It is a dissertation written by Georg Loscher under Scheiner's supervision. The full title: Johann Georg Locher, Christopher Scheiner *Disquisitiones mathematicae, de controversiis et novitatibus astronomicis*, Ingoldstadt, 1614 (F. Daxecher, pp. 11-116); Also in his *Oculus hoc est: Fundamentum opticum*, Insbruck 1619 Scheiner included a chapter on: Intersection of rays caused by a pinhole, camera obscura, pp. 32-34; Schiener proves that light rays intersect in a pinhole and that the rays run in straight lines, according to the principles of light and intersect at all time behind the small opening. (Daxecher, p. 121). He also refers to Guercke 1992b, 144-6. Locher theses were defended in public on September 5th 1614. It may also be the case that in Ingolstadt and other places the problem was recited. After the text appeared in print Scheiner got a letter of admonition from Aquaviva (see Daxecher letters to Scheiner). The oculum is in MP;
[7] Lattis, 185, Grineberger's and Guldin's letters; More on Jesuits and the telescope

research in the field of astronomy.[8] Moreover, the Jesuits soon developed an insatiable appetite for optical instruments which they used not only for research and teaching purposes, but mainly for missionary propaganda outside Europe, and for buttressing their status as intellectual elite. These instruments, however, certainly exhibited the Jesuits' expertise in the fields of optics and catoptrics. Thus, in the diffusion of a variety of practices the Jesuits became defenders of the telescope and other optical instruments against attacks on their epistemological credibility. The decision to perform the problem of the sunray passing through a pinhole could function as an emblem, smacking of traditional respectability but also invoking all the connotations that accompanied the most recent scientific and epistemological debates and controversies of the age.[9]

The second problem chosen for public performance in Parma dates back to the legend of Archimedes and the crown of Hiero, King of Syracuse. Thus, it enjoyed the same aura of tradition and respectability as the pinhole camera problem. It also had a long history in the Society of Jesus, as far as I can tell. Already in 1603 the young mathematician Marino Ghetaldi – a frequent visitor to Clavius's academy but no Jesuit - published a treatise entitled *Archimedes Promotus* and dedicated to the Crown problem. Ghetaldi was concerned with comparisons between the gravity and magnitude of various kinds of bodies, as testified by the subtitle of his treatise: *DE VARIIS CORPORVM GENERIBVS, gravitate & magnitudine comparatis*. The treatise

[8] Biagioli new book – on telescope

[9] More on the use of optical instruments by Jesuits. Gorman's dissertation, chapter on Grienberger: Describes an experiment to show that the study of perspective furnishes the causes of appearances that would otherwise remain a mystery; a trick picture, possibly an anamorphosis which he had heard of, in which forest landscape seen from one position is transformed into a picture of the Emperor with his brother when he looks through a specially constructed hole] Testimonies about the use of optical instruments – in particular the camera obscura – by Jesuits in China – optical instruments in the Jesuit gardens in Pecking – source on internet site - and in Kirscher's museum

included numerical tables representing the specific weights of a long list of metals and other materials discovered through experimentation.[10] It also contained an explanation of buoyancy in terms of the difference between the specific weights of the body and the medium, written in a strict Archimedean spirit.[11] Hence, Ghetaldi's book became relevant as the controversy on floating bodies between Galileo and a number of Aristotelian philosophers at the university of Pisa heated up between 1611-1614. In his written discourse on *Bodies That Stay atop Water or Move in It*, published in April 1612 at the explicit request of the Duke of Toscany Cosimo II de Medici, Galileo chose to sharpen his disagreements with his Aristotelian interlocutors by emphasizing his Archimedean solution to the problem of buoyancy and by presenting it as anti-Aristotelian. In fact, however, right at the beginning of his text Galileo declared that he will present an Archimedean solution by other means. These means consisted of principles which he borrowed from the mechanical tradition of the pseudo-Aristotelian *Problemata*.[12] It is within this context that one should understand the inclination of many Jesuit mathematicians to support Galileo's position against his Aristotelian opponents. The Jesuit mathematicians were committed to follow Aristotle in physics, but took active part in the revival of Archimedes' work of the 16th century. Their strategy, however, was diametrically opposite to that of Galileo. Instead of claiming the superiority of the Archimedean solution over the Aristotelian one, the Jesuits chose to show the continuity between Archimedean and pseudo-Aristotelian elements in

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[10] Letter to the reader: mentions Clavius and the good will he showed him. Also, the book was published by the same shop as the books of the Jesuits. "Etenim cum Clauium, quod tam diu cupiebam, vidissem [...] minorem tanta scientia, & fama viri benignitatem [...] perissem"

[11] Ghetaldi, 28, 16th proposition of the seventh theorem

[12] Shea; Ceglia

[13] OG XII, 78, Francesco Stelluti a Galileo; OG, xii, 76-7; 112 In the second letter Bardi explains the motivation to publish in Latin, so that the book will be read all over Europe, and not only by Italians.

[14] Ref. in IV 195

explaining various hydrostatic phenomena. Thus, when G. Bardi, a former student of Galileo who was studying mathematics with Christoph Grienberger at the Collegio Romano in 1614 expressed his wish to recite the problem of buoyancy in public, his teacher Grienberger, an old correspondent of Galileo, willingly wrote the problem for him. The problem was presented as an interpretation of a chapter in *De Caelo*, but basically glorified Galileo's discourse and justified its conclusions, among other things by performing experiments designed by Grienberger. The problem was performed in Rome on 23 June 1614, in presence of "il ditto Sig. Principe [Cesi], con Mons. Suo fratello [Bartolemeto Cesi] et altri Prelati et signori letterati, con il Sig. Valerii [Luca Valerio] et Sig. Fabri [Giovanni Faber]"[13]. Thus the young Prince Cesi, the head of the illustrious academia dei Lincei, his brother together with other prelates of very high status in the Church hierarchy, some other Roman intellectuals, the well - known Jesuit mathematician Luca Valerio – were all present at the event, inspiring it with their authority and brilliance. Stelluti – a Roman correspondent of Galileo who was also present reported to Galileo from Rome, emphasizing how much Galileo's opinion was favored and defended ["favorite et diffesa l'opinione di V.S."] during that evening. One last detail should not be omitted: a few days later the problem saw light in the form of a text published with Zanetti, the publishing company that the Jesuits favored and made their own, and where Ghetaldi too had published his *Archimedes promotus*..[14] Nevertheless, when Josephus Blancanus - another former student of Clavius now posted in the Venetian province – attempted to include a treatise on hydrostatics in his *Aristotelis loca mathematica* – the Jesuit internal censors prevented him from doing so. The book, published in 1615 was dedicated to extracts from Aristotle's corpus reinterpreted in the light of new scientific developments. After the censure all that remained of the planned treatise on hydrostatics was the name of the chapter:

"On things that sink in water, along with a new demonstration of that problem of Archimedes, where he investigated a mixture of metals by an insoluble crown"[15] and one sentence: "in this place a commentary is required a commentary in the last chapter of *De caelo*, meanwhile, in its place the reader should approach Galileo's Italian discourse on bodies that move in water".[16] Now, Blancanus signed the dedicatory letter to his *Loca* (check!) in1614 in Parma. The catalogue of Jesuit teachers of mathematics in Italy shows that he held the chair of mathematics in Parma that year. It is very likely, then, that he wrote the problem performed in front of the Congregation, and that he either used Grienberger's problem performed by Bardi at the Collegio Romano at the beginning of summer 1614, or he wrote his own version. It is even possible that he actually recited it. Be it as it may, when Blancanus finally attempted to work this problem through into a treatise and insert it in his book, he was not allowed to do so. His book saw light in 1615 with the name of the omitted treatise on the index, and the curious reference to Galileo's discourse on things that float or move in water in the body of the text.

Moving now to the "performative" side of problems I would first like to draw your attention to the fact that recitation of problems in the halls of Jesuit colleges and in special public events was one activity among similar ceremonious practices that colored Jesuit educational routines with elements of drama and ritual. More

[15] De ijs, quæ aquæ insident, vnà cum noua demonstratione problematis illius Archimedis, quo metallorum mixtionem indissoluta Corona, explorauit. in additione. ante num"
[16] "Hoc loco desideratur commentarius in cap. vlt. de Cœlo. cuius loco ìnterim Lector adeat Discursum Italicum Galilæi Galilæi, de his, quæ in aqua mouentur"

accurately, I would like to argue that the "problems" – like the inaugural lectures at the beginning of the academic year - constituted a discursive space that mediated between the closed world of students and boarders and the wider circles of the city, its dignitaries and rulers. In a text of Christopher Clavius, written in preparation of the first *Ratio studiorum* of 1586, the architect of Jesuit mathematical studies pointed out to the cultural thirst for hearing a public lecture in mathematics in many cities. By this he meant to convince his colleagues and superiors that the Society will acquire much prestige by training its scholars to develop their talent to talk about mathematics in public.: "..an effort must be made so that, just like the other disciplines (facultates), mathematics also may flourish in our schools (gymansiis), so that from this also Ours will become more suited for serving the various interests of the Church; especially since it is not a little unseemly that we lack professors who are capable of presenting a lecture about mathematical topics, longed for in so many, such famous, cities."[17] (my emphasis, R.F.) True, the last version of the *Ratio studiorum* from 1599 did not grant the mathematicians of the Society all the resources that they required. Nevertheless, mathematics did become part of the three years course in philosophy, to be studied by all during the whole of the second year, parallel to the reading in natural philosophy. In addition, an "academy of mathematical topics" – namely an advanced seminar[18] for Jesuit graduates with a talent in mathematics – was created in some of the colleges and universities run by the Jesuits. According to the second version of the *Ratio* from 1591, the academy was designed especially for Jesuit graduates in the interim between the courses of philosophy and theology. Full commitment was the "sine qua non" for the "academicians": "…they are strictly forbidden to be involved in that time

[17] Dennis C. Smolarski, S. J., "Historical Documents, Part I: Sections on Mathematics from the Various Editions of the Ratio Studiorum" in *Science in Context* 15(3), 459-464 (2002), p. 460

[18] Baldini, in Archimedes

in any other studies, but they are to give themselves entirely to listening to, repeating and discussing mathematics…" Simultaneously, the academicians were expected to fulfill a public role by speaking on mathematical subjects whenever a special occasion came about: "let them be set apart for this study as much by frequently expanding on it in the private academies, as by speaking about it publicly when there will be an occasion for it".[19] Finally, the last version of the *Ratio* from 1599 explicitly mentions the practice of "problems" in the following words: "And let him arrange that every month or every other month" some one of the students before a large gathering of students of philosophy and theology has some famous mathematical problem to work out and afterwards, if it seems well, to defend his solution".[20]

The text of the *Ratio*, then, confirms for the modern scholar the testimony emerging from the Parma *Relazione* and from the letters of Bardi and Stelluti to Galileo: the recitation of problems was a regular event in Jesuit colleges. It found its pedagogical justification in the necessity to stimulate not only intellectual capacity but also the capacity for presentation and interaction. Jesuit education put an enormous emphasis on the development of rhetorical skills that accompanied many of the common activities in the college such as repetitions, disputations, public defense of theses and theatrical productions.[21] Ignatius' preliminary justification, according to which: "The purpose is that the intellectual powers may be exercised more, and that difficult matters occurring in these branches may be clarified, unto the glory of God our Lord" was, indeed, developed by the Jesuits into a complete educational philosophy which I

[19] Ibid, p. 463: Ratio Studiorum – 1591. Rules for the Provincial Superior. On Mathematics. See also rules of the academies in the last version of the Ratio, 1599.
[20] Ibid. p. 464
[21] Article fro Jesuits

cannot probe into here.[22] What should be further emphasized, however, is that the Society also hoped to gain some advantages in the public sphere from such activities, as Clavius explicitly states in his text. No less than training students in presenting their work to their fellow students as well as to wider circles of dignitaries and intellectuals, the recitation of problems was meant to attract visitors to the College and to contribute to the cultural life of the city. The fusion of educational purposes with more general cultural- political goals found its ultimate expression in the *Ratio*'s rules for the professor of rhetoric that captures the dramatic, baroque spirit of Jesuit education in the following words:

"Nothing, in fact, so develops resourcefulness of talent as frequent individual practice in speaking from the platform in the lecture hall, in church, and in school…as well as in the refectory."[23]

The lecture hall, the Church, the school tribune and the spaces allocated for public disputations, mathematical problems and defenses of theses emerge in the text of the *Ratio* itself as meeting places between novices and externs. Simultaneously they should be seen as "trading zones" that were used in a process of mediation between the controlled spaces of the Jesuits enclosed behind the gates of the college and the less regulated, sometimes chaotic space of the city bursting in so many different rhythms and a plurality of cultural forms.

The *Relazione* of Parma with which I opened this lecture testify to the interpretation of the "refectory" and the city even though they do not specify the location of the after-lunch disputations and problems conducted during the Provincial Congregation

[22] Scan Villoslada for: disputations, public lectures, defenses, theses, etc and refer to books on Jesuit paedagogy.

[23] Ratio, Farrel, Rules for Teachers of Rhetoric, 20 (last passage) See also G. Baffetti, Retorica e Scienza: Cultura Gesuitica e Seicento Italiano

of 1614. However, later dated descriptions of the concrete spaces built by the Jesuits for their public intellectual activities exist and demonstrate a growing tendency towards refinement and grandeur. One example is a description accompanied by a series of aquarelles of the great hall first called "sala d'armi" at the Collegio dei Nobili of Parma. A series of allegorical representations of music, geography, philosophy, military architecture, jurisprudence and poetry situated in historical scenes that derived from classical and contemporary sources decorated the hall [24] that came to be known as "il salone". Another smaller hall built for weekly philosophical disputations and called "la saletta" was also used by the fathers to convene around the fire in the evenings. In addition, the complex of the college also included two theatres, "grande" and "piccolo". In fact the plan of the ground level of the complex[25] that survived the buildings to the present day testifies to the ways in which the complex of the college was divided between public spaces designed for the mixing of insiders and outsiders on special occasions, and the internal spaces where everyday scholarly routine was taking place. Thus the whole southern part of the complex seems to have been built especially for the special events: it contained the great "salone", the "saletta", the two theatres and a "foresteria" with a special kitchen and other services for visitors. This part had its own gate and entrance on the south, and was separated from the refectory in the north by a large court. Such architectonic structure testifies to the complex cultural messages embodied in the material culture within which Jesuits scholars and students were living their life. The college was supposed to provide a closed space, tightly regulated, that allowed for the protection of the students and boarders from the influences and noise of the general culture around. At the same time it contained well demarcated arenas for monitored exchanges which pointed out the desire for cultural

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[24] Descrizione della sala e roproduzione acquarellata degli affreschi che la ornavano in BBP, Ms. Parm. 1250, Turrini p. 43.
[25] Ibid. Figure 2

hegemony but also betrayed the impact left by the surrounding culture on the norms that guided Jesuit activities.[26]

The performative dimension of the "mathematical problems" is not exhausted, however, by pointing out the material location where such public events were situated. The academic preparation for reciting a problem was deeply rooted in the pedagogic traditions of the Jesuits. Starting from the lower classrooms, contests with allocated "roles" were frequently practiced in order to intensify the appetite for learning: "Class contests are to be highly valued and are to be held whenever time permits, so that honorable rivalry which is a powerful incentive to studies may be fostered. It is customary in these contests to have the teacher ask the questions and the rivals correct the errors or to have the rivals question one another. Individuals or groups from opposite camps, particularly from among the officers, may be pitted against each other, or one pupil may engage several opponents."[27] Second, practices of public disputations were constitutive for the philosophical and theological curriculum: "On Saturday or any other day dictated by local custom, disputations should be held in the classes for two hours, or longer where there are many extern students.. . Other professors of the Society, though they belong to different faculties, should attend the disputations whenever possible. To enliven the discussions, they should press the objections that are proposed…The same privilege may be extended to extern doctors, who may even be invited expressly to take part in the argument…[28]. Thus, discussion and exchange of ideas between students and professors, and among professors of the different disciplines were regularly celebrated

[26] More about the material culture in the book: the invitations the publications etc. Rice, broadshits of thesis as an art genre; Gorman – consuming Jesuit culture
[27] Ratio studiorum, p. 95
[28] Ibid. 50-51

in special events and provided an opportunity for outsiders to take part and express their criticisms and opinions. These well-imprinted habits culminated, however, in the various "academies" that grew up in Jesuit colleges already in the 16th century: literary academies, as well as academies of philosophers and theologians, and finally also the mathematical academy mentioned above: "By the word “academy” we mean a group of students chosen from the entire student body on the basis of their devotion to learning who will meet under a Jesuit moderator to take part in special exercises connected with their studies."[29] Moreover, these advanced seminars called "academies" were always partly open to scholars who did not necessarily belong to the students body or professorial staff, but were somehow closely associated with the local college: "Besides, where custom sanctions it, the rector may approve the admission of others who are not members of the sodality or even students in our school."[30] It was especially in the context of the academies that private teaching was done, and it was precisely at the academies, to a large extent structured around disputations, defense of theses, or solution of difficult problems that interpenetration between the inside and the outside of the college took place.

With all this, however, one should never forget that the inter-penetration of college life and city life was always well monitored and regulated. The rector of the college was required to frequently take part in great public events. "He shall frequently attend the private and public disputations in theology and philosophy ".[31] The prefect of studies was expected to preside the most solemn disputations: "He shall preside at all disputations which the professors of theology or philosophy attend ".[32] The poems

[29] Ibid. 132
[30] Ibid.
[31] Ibid. p. 37
[32] Ibid. p. 42

and texts recited and discussed, the theses defended and the problems chosen had to be repeated in front a superior or even written beforehand and scrutinized by the teachers. And before publication as in the case of Bardi [and Loscher] – the supervision was done by the professors and the perfect of studies under the explicit regulations that had been codified in the *Ratio* for such practices.[33]

The node between the intellectual and performative dimensions of the writing and recitation of the problem will serve me as a clue for its understanding as a cultural form. We have seen above how the space of performace was used as a mediating cultural ground between interns and externs, between insiders and outsiders, between refectory and city. The complexity of the cultural messages imbuing those spaces, often implicit rather than explicit, was certainly clear to participants but felt by the visitors as well, even though perhaps not transparent. Simultaneously, the problem was a textual space that mediated different – and often contradictory - educational goals such as the desire to cultivate the intellect and the need to control it. Problems considered worth of demonstration and debate were very "ancient" problems, as the *Ratio* explicitly stated. However, these problems were not necessarily part of text-book materials designed to be taught in the classrooms. Thus, usually they did not fall within the well defined disciplinary boundaries that monitored the intellectual contents discussed in the colleges. Problems thus became the ideal form to allow for engagement in a plurality of conceptual frameworks, as you will immediately see in my example. By definition, problems represented zones of multiple possibilities, some of them might have been innovative, and hence officially considered unworthy

[33] see especially regulations of the prefect of studies] [develop the ritualistic elements of the problems and the defenses – the order of sitting, the time allocated, the numbers etc. and compare it to the ritualistic elements in the Parma text

by the Jesuit establishment. But nobody could deny the excitement they were bound to create in the space of performance, so well expressed in the Parmense manuscripts, describing those "due Problemi curiossisimi" that were demonstrated in front of the big audience of "religiosi" and "literati" gathered around the Congregation in 1614. Michael Gorman, writing about the role of experiments and instruments in ceremonial visits to Jesuit colleges – close in kind to problems performed in other ceremonial events – has lately remarked that" "experiments and instruments could occupy the politically charged middle-ground between the Jesuit mathematician and the princely visitor, constituting an apparently neutral site for courtly "conversazione" while multiplying the points of contact between the Jesuit college and other centers of political power and authority". This, however, is not the main story for me. I look at the Jesuit mathematicians in their role as teachers who purported to transmit scientific traditions and cultivate intellectual and moral norms within the rules of the game they legislated for themselves: namely within the boundaries of the tradition. The problems, I contend, allowed them to transgress those very rules without betraying their goals. But of course, they complicate the stories we have been used to tell ourselves about "Jesuit science". This is how I suggest to read Paolo Guldin's *Dissertatio de motu terrae*, a text published in 1635, that grew out of two events in which a "problem" had been recited in two different colleges: first in Rome, around 1614, and later on in Vienna around 1622.

Paulus Guldin (1577-1643)

Paulus Guldin was a disciple of the Jesuit Christopher Clavius, the most prominent European mathematician between Copernicus and Galileo, and the person responsible for instituting mathematical studies as an obligatory part of the philosophical curriculum in all Jesuit universities. More important yet, Guldin was also a member of the academy of mathematics instituted by Clavius at the Collegio Romano. A mathematician in the Archimedean tradition, Guldin engaged himself in many of the scientific polemics of the time. In 1635 he published the first volume of his *Centrobaryca* [The science of centers of gravity] , the fourth and last volume of which was published in Vienna in 1641.[34] To the first volume of the *Centrobaryca* Guldin attached his *Dissertatio physico mathematica de motu terrae* – a physical-mathematical treatise on the motion of the earth, where he defined his problem in the following words: "To move the earth - gathered in a spherical form by its gravitational tendencies - from its place at the center of the universe" – namely to move the heavy globe of the earth. Guldin considered this as a possible version of the problem formulated by Archimdes' followers, namely: "To move by any power whatever any weight whatever" [Quavis potentiam quodvis pondus movere] or, as he explains: "given any, even minimal power, [and] given any weight, it [the power] agitates the weight with maximal [force]".[35]

In his dissertation, Guldin chose as his object the real, physical globe of the earth, and set out to prove physically and geometrically its real motion. The motion of the earth, he argued, is an effect of its heterogeneous nature and of motions on its surface that result in small trepidations, always forcing its center of gravity back to its place in the center of the universe. This doctrine Guldin related to a passage from Aristotle’s second book ***On the Heavens*** (Book II, Ch. XIV), where Aristotle stated that the earth as a whole – like all other heavy bodies on it – “tends” towards the center of the

[34] P. Guldin, ***Centrobaryca***, Vienna 1635-1641
[35] Bring in all the dimensions of the Aristotelian problems, of nature and machine, of the magical effects of machines, etc.. From the next sentence it is clear that he could find justification in Hero's text on machines but also in Galileo's mechanics, where Galileo formulates, and perhaps even tries to prove the law of minimal force. Go to all the old literature of Wholwill etc. that relate this to the problem of inertia,. Deal with Festa and Roux about the cosmological significance of this problem. Show how the dissertation attempts to connect all the different aspects of the science of mechanics gathered from the different traditions.

universe: “if, then, a weight many times that of the earth were added to one hemisphere, the center of the earth and of the whole [namely the center of the universe] will no longer be coincident. So that either the earth will not stay still at the centre, or if it does, it will be at rest without having its center at the place to which it is still its nature to move.” ((297a: 32-297b:2) Aristotle further deliberated about the way parts of the earth arrange themselves around the center after fall, contending that: while moving towards the center of the universe a heavy body on earth will continue its motion “until it occupies the center equally every way”. (297b:13) Guldin – following in the footsteps of earlier commentators (from Buridan to Guidobaldo del Monte) argued that it was by now clear that the distribution of weight on the earth is not even, and is in fact in constant change. Hence the earth has to perform small trepidations to keep its center of gravity in its place. Guldin thus presented the different aspects of Aristotle’s argument as a theory about the motion of the earth. He named his treatise physico-mathematical and he divided its argument into two clear parts: first, he attempted to support the theory by “experience” as well as by the authority of Aristotle, and then he offered a geometrical proof, which he deemed as his original contribution to the discussion. It is quite clear, however, that the empirical support was drawn from the literature on the subject that testified, so he claimed, that the material globe of the earth was heterogeneous, showing that everywhere earth and water were interpenetrating each other. It was indeed Christopher Clavius who had previously inserted the thesis about the "terraquaeous" globe into Jesuit discourse, although Clavius insisted that its inequality or difformity was negligible compared to the huge mass of the globe. Therefore, Clavius thought that the description of the globe as round and spherical was justified, after all, and he confirmed that its center of magnitude and center of gravity coincided. Guldin, on the other hand, drew other conclusions from Clavius's theses. Taking seriously the heterogeneity of the globe it seemed to him reasonable to state that since the center of gravity of the earth and its center of magnitude do not coincide, the globe must be constantly performing small motions in order to keep its center of gravity at the center of the universe.

Now Guldin wanted to measure this motion. In order to be able to treat the motion mathematically – something that was of no interest to his predecessors - Guldin first *imagined* the globe of the earth as a mechanical object. No wonder that he sought to represent changes in the equilibrium of the system by transferring one portion of the earth (section DFCH) from one side of the globe to the other. He thus created a cone on one side of the hemisphere (G) while truncating the hemisphere on the other side (D). According to Luca Valerio, he continued: "In each heavy body the center of gravity is ***removed*** from its place in the figure, if the same weight is added or subtracted or its parts are differently constituted". Applying then Archimedes' basic rule of the inverse ratio between weight and distance from the fulchrum, Guldin found that as a result of the change of equilibrium the center of gravity of the whole system must move from E to L. And he understood the distance LE between the two centers of gravity on the globe's diameter (that of the old system and that of the new) as a measure of the motion of the earth. Hence he came to his conclusion: Demonstravi, ut opinor, centrum mutari, & consequenter Terram moveri posse". (I have demonstrated so that I believe that the center mutates; and consequently the earth can move".)[36]

The tradition in which Guldin wrote was rooted in medieval questions on ***De caelo,*** concerning the natural place of the elements and the position of the earth in the center of the universe.[37] However, he aimed to transform such a question into a physico-mathematical problem. Careful reading of Guldin's strategies may throw light on the particularities of his treatise, which exemplify the "Jesuit way" in science.

36

37 Following Aristotle, John Buridan (ca 1300-ca1358) developed his theory about the difference of weight between the earth's terrestrial part and the part covered by water. This difference of weight, he argued results in slight trepidation as it strives to achieve equilibrium at the center of the universe. The idea was taken up by Albert of Saxony (1316-1390) and transmitted through him, John Major and Nicholas Oresme, to the seventeenth century via Guidobaldo del Monte, Paolo Sarpi, the Coimbrans and Paulus Guldin.

1) In deviation from the tradition, Guldin uprooted his theme from its natural context in the commentaries on Aristotle's ***De caelo*** and appropriated it into an independent, physico-mathematical treatise on the motion of the earth. Thus, the motion of the earth, an object of recurring Inquisitorial prohibition became a legitimate discursive entity, though still a very controversial one. True, this discourse on the mobility of the earth is part of traditional cosmology. The earth remains at the center of the starry system and its motion is explained in terms of a "tendency" towards the center of the universe. However, Guldin's move consisted in an actual attempt to touch upon the rules of the game that used to govern the field of arguments about the motion of the earth in a scholastic environment.
2) In an Aristotelian framework of thought the concept of ***gravity***, or more specifically the ***gravity*** of the earth, is the most substantial argument against its motion. The ***center of gravity*** is the center of the ***universe***, the place towards which all heavy bodies move in their desire to rest. In a very subtle gesture Guldin suggests ***equilibrium*** on the earth's ***center of gravity*** in the Archimedean sense as a condition of possibility of the earth's ***immobility***. Guldin's discussion of the ***actual*** physical conditions on the surface of the earth leave no doubt in the mind of an intelligent reader, however, that such equilibrium is very unlikely indeed, a rare - if ever actually fulfilled - condition of possibility. Thus, from something close to logical and physical ***impossibility*** the motion of the earth becomes a most commonsensical ***probability***. This is a point of departure that requires at least the problematization of the very concept of motion in general, and the motion of the earth in particular.
3) At this point Guldin submits his object – the change in center of gravity which he interprets as the motion of the earth - to the rigor of geometrical proof and recruits the power of mathematics to exclude doubt and to gain credibility for his thesis. On its own terms, and within the boundaries set by Guldin, a calculation of the distance through which the earth's center of gravity is displaced seems reasonable and even respectable.
4) Still, it seems to me that Guldin's most interesting step concerns his claim that one is able to apply statical considerations to dynamical situations and infer a strong physical conclusion about natural motion from developing such methods. In other words, by inserting the Archimedean notion of a quantitative center of gravity into the Aristotelian context Guldin thought he could re-interpret the rules of the game that did

not open the discourse on motion to mathematicians in his institutional environment. However, it soon transpired that he had gone too far. The last pages of the *Dissertatio de motu terrae* are dedicated to an *Annotation* in which Guldin tells his readers that his treatise had been criticized by Niccolo Cabeo - a Jesuit philosopher and mathematician known for his opus *Philosophia magnetica*. A glance at the text of the opponent shows that according to him Guldin had maintained the idea that any minimal power changing the equilibrium of the earth on its center of gravity – even a bird or a flea – in fact constitutes a cause for its motion. The affinity to Galileo's conceptual world thus becomes clear.[38] No wonder that Guldin was censored here by none other than his own fellow Jesuits. As a result, Guldin committed an act of self censure and decided to retreat from his thesis that the earth moved physically. In the Annotation of 1635 he already claimed that the motion he was speaking of was basically mathematical and not physical. I leave open the question whether this was the price Guldin had to pay for publishing his "radical" ideas, and whether, moreover, this points to the real constraints that inhibited Jesuit science, especially immediately after Galileo's trial in 1633.

In conclusion, I would like to reflect about the question: What can we possibly learn about Jesuit science from reading the problems in their performative and intellectual context?

Both the contents and the form of the examples I bought here seem to point out the peculiar nature of problems, which allowed for transgression of the tradition without actually breaking the rules of the game. Starting from the intellectual aspect, both Blancanus and Guldin invested great efforts in presenting their problems within a very traditional context: namely, questions on *De Caelo*. Both inserted new Archimedean concepts into this context: Blancanus used the Archimedean concept of "specific gravity" to investigate bodies of different specific gravities in their medium; Guldin looked into the motion of the earth from the point of view of its center of gravity. Both Blancanus and Guldin offered innovative theses that were hard to settle with their commitment to the common Aristotelian conceptual framework. Both showed their affinity with Galileo's work. Both were at the front of cutting edge research of the period. And both were in some ways harshly criticized or censored, but managed

[38] See De motu, on rotational motion

to survive without real damage. All this was made possible, I would like to argue, precisely because of the performative aspect of the problems. Much as the problem was performed in special Architectonic spaces that mediated between the closed environment of the college and its public arenas, so the problem offered a textual space in which the boundaries between physics and mathematics could be mediated and negotiated. It was in the context of problems that the Jesuit dilemma between adhering to past traditions and striving for scientific relevancy became most conspicuous. But it was precisely the public context of the problem that allowed for transcending the boundaries of the commentary and the textbook under the spell of the desire for sophisticated audiences and societal brilliance.

Apppendix (picture)