CASE STUDIES IN THE HISTORY OF MATHEMATICS

Turin 15-16 October 2018

Organizers: *Revue d'histoire des mathématiques*
Clara Silvia Roero (University of Turin), Frédéric Brechenmacher (École polytechnique); Erika Luciano (University of Turin).

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Program

15 October University Palace, via Po 17-via Verdi 8, Biblioteca Graf, 2nd floor, **Sala A. Graf**

9.00-10.00 **Tom Archibald** (Simon Fraser University, Canada) What is the best way to found integration theory ? An examination of arguments, 1930-1950

10.00-11.00 **Chiara Pizzarelli** (University of Turin, Italy): Quintino Sella's role in cristallography: a mathematical approach for practitioners, 1847-1861

11.00-11.30 Discussion and Coffee break

11.30-12.30 **Sandra Bella** (University of Nantes, France) Le manuscrit *Instruction du calcul différentiel et des méthodes générales de trouver les tangentes aux lignes courbes* de Pierre Varignon : un moment inédit de la réception française du calcul leibnizien

12.30-14.00 Discussion and Lunch

14.00-15.00 **Alberto Cogliati** (University of Milan, Italy) For a history of curvature before Gauss's *Disquisitiones*

15.00-16.00 **Maria Giulia Lugaresi** (University of Ferrara, Italy) Mathematics and hydraulics between Turin and Ferrara: the works by F. D. Michelotti (1710-1787) and T. Bonati (1726-1820)

16.00-16.30 Discussion and Coffee break

16.30-17.30 **Charles Braverman** (University of Lorraine, France) Paul Tannery and Kant as protagonists of the relation between mathematics and philosophy. A case study on the writings in French academic journals at the end of the 19th century

Discussion

16 October: Department of Mathematics G. Peano, via Carlo Alberto 10 – **Sala Orsi**

9.00-10.00 **Maria Anna Raspanti** (University of Turin, Italy) From quadratic transformations to Cremona transformations (19th century)

10.00-11.00 **Antonietta Demuro** (University of Lille, France) Mathematicians, measuring instruments and photographic techniques in ballistics. An interesting interaction around Kampé de Fériet's experimental works (1915-1925)

11.00-11.30 Discussion and Coffee break

11.30-12.30 **Dominique Tournès** (University of La Réunion, France)The German School of Nomography in the Interwar Period

12.30 Discussion and Lunch

Case Studies in the History of Mathematics
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ABSTRACTS

What is the best way to found integration theory ? An examination of arguments, 1930-1950

Tom Archibald (Simon Fraser University, Canada)

Lebesgue's theory of measure provided one route toward the founding of integration theory, and the developments of measure theory in the first decades of the twentieth century often have the spe- cific aim of building integration. Beginning in the thirties, this approach was contested by the so-called functional theory of integration. Adher-ents of the two approaches, including P. Halmos and J. Dieudonné, put forward arguments comparing the strengths and weaknesses of the two approaches. The components of the arguments include discussions of the suitability of one approach over another in areas of application; and of the ways in which different approaches yield certain canonical results. In this paper we examine this complicated terrain in a preliminary way. We begin some discussion of the pleas of the proponents of a measure- theoretic foundation, considering its advantages for ergodic theory and probability. We will then look at the approach of various writers to de- composition theorems for functions and functionals, centering our view on the work of F. Riesz at the Bologna congress of 1928 and looking at its antecedents and consequences.

Le manuscrit « *Instruction du calcul différentiel et des méthodes générales de trouver les tangentes aux lignes courbes* » de Pierre Varignon :
un moment inédit de la réception française du calcul leibnizien.

Sandra Bella (University of Nantes, France)

En juin 1696, Guillaume de l'Hospital publie le premier ouvrage de calcul différentiel intitulé *Analyse des infiniment petits pour l'intelligence des lignes courbes*. Ce traité est l'aboutissement d'un travail d'apprentissage, débuté en décembre 1691, en grande partie grâce aux cours de son professeur Jean Bernoulli. L'Hospital abandonne les méthodes d'étude des courbes pour adhérer complètement au nouveau calcul.
Peu après la publication du traité de l'Hospital, l'enseignant Pierre Varignon rédige un cours dans lequel il récapitule les principales méthodes de recherche de tangentes depuis Descartes jusqu'à Leibniz. Ce cours, jamais publié, est conservé à la BNF, sous le titre « Instruction du calcul différentiel et des méthodes générales de trouver les tangentes aux lignes courbes ». Le dessein de Varignon est de comparer ces méthodes de tangentes à celle qui résulte du calcul leibnizien. C'est l'occasion pour lui de fournir des éclaircissements sur les nouvelles notions impliquées dans le calcul différentiel, et de relativiser l'imminence de l'utilisation de ce

dernier. Pourtant, avec Guillaume de l'Hospital, Pierre Varignon est le principal diffuseur du calcul leibnizien en France.
Dans cette communication, nous analysons ce manuscrit comme étant une lecture du calcul différentiel qui répond et s'articule à d'autres textes mathématiques. En cela, il est un témoignage privilégié et inédit de la réception française du calcul de Leibniz.

Paul Tannery and Kant as protagonists of the relation between mathematics and philosophy. A case study on the writings in French academic journals at the end of the 19th century.

Charles Braverman (University of Lorraine, France)

During the 19th century in France, philosophy became an academic discipline with a strong identity. The side effect of that institutionalisation of philosophy was that the academic cursus (through high school, *École normale supérieure*, University, *agrégation*, Ph.D.) did not involve a great deal of mathematics teaching. This raises the question of the possible interaction between mathematics and philosophy. However, it is now very common to mention the development of the reflexion on non-Euclidean geometry at that time. One may ask how that reflexion took roots in France from a material and intellectual point of view. Several studies show that the academic journals of philosophy were - at the end of the 19th century - fundamental places for philosophy and sciences to meet. The difficulty is then to describe how they met. Thousands of papers have been published by hundreds of thinkers during the last quarter of the 19th century. Among them, which ones are aimed at the philosophy of mathematics? Who wrote them? What are their subjects? In order to give some answers, I will use a case study justified by its exemplarity. That case study will focus on Paul Tannery's writings. My point will be to describe some aspects of the bridge between philosophy and mathematics that Tannery contributed to construct around strategical references to Kant.

For a history of curvature before Gauss's *Disquisitiones*

Alberto Cogliati (University of Milan)

The publication by Euler of the memoir "Sur la courbure des surfaces" (1767) led to the emergence of a widespread interest in the notion of curvature for surfaces. In France, the community of geometers linked in various ways to the figure of Gaspard Monge was particularly active in realm of research.
The intervention aims at describing and analysing some contributions on the subject by Monge himself, Meusnier, Rodrigues and Dupin. Our intent is to propose a reconstruction of the history of curvature of surfaces that, while recognizing the extraordinary uniqueness of Gauss's achievements, looks at work done prior to the publication of the *Disquisitiones* as something both valuable and interesting in itself and not just as mere precursor of Gaussian theory, as is sometimes asserted.

Mathematicians, measuring instruments and photographic techniques in ballistics.
An interesting interaction around Kampé de Fériet's experimental works (1915-1925)

Antonietta Demuro (LDAR - université *Paris Diderot*, ESPE LNF)

The aim of this talk is to investigate Kampé de Fériet's experimental research on how to apply photography to the study of projectile motion. In 1915, after completing his doctoral thesis under the supervision of Paul Appell, Kampé de Fériet was mobilized - together with other mathematicians such as Arnaud Denjoy, Ernest Esclangon and Jules Haag -to the « Commission de Gâvre », a military institution attached to the Navy Ministry, which used to conduct firing tests and ballistic studies. Here, not only he used his mathematical knowledge to apply analytical and numerical methods to problems of war, but he also developed a passionate interest in experimental issues. In fact, in collaboration with the physicist Gabriel Foex, he built an instrument and performed a method that would allow photographic recording of velocities of a projectile.

In this presentation, his experimental work on ballistics will be examined from two different perspectives. On the one hand, we will analyze his work with regard to the impact that the mathematicians' scientific and institutional commitment had on the reconfiguration of the modern mathematical landscape; as this gained a stronger focus on applied issues and stronger links between universities, industry and military institutions. On the other hand, understanding the instrument developed by Kampé de Fériet and Foex will bring to light new elements about how the knowledge in photography and cinema could be translated to produce devices able to visualize projectile movements. Meanwhile, it will highlight how these applications have progressively revolutionized the experimental practices of military officers in the 20th century.

So here we raise the question of how we can interpret the adoption of Kampé de Fériet's photographic techniques in a domain like ballistics, where actors coming from different backgrounds manage to create an interesting interaction between measuring instruments, analytical theories, numerical methods as well as laboratory and ground research.

Mathematics and hydraulics between Turin and Ferrara:
the works by F. D. Michelotti (1710-1787) and T. Bonati (1726-1820)

Maria Giulia Lugaresi (University of Ferrara)

During the 18th century mathematical studies devoted to hydraulic and hydrodynamics applications become relevant. As far as studies on fluvial hydraulics, Italy has led the field since 17th century, thanks particularly to the works by Galileo and his school: Benedetto Castelli, *Della misura dell'acque correnti* (1628), Evangelista Torricelli, *Opera geometrica* (1644). The importance of such kind of studies both from a theoretical and a practical point of view is well documented by a remarkable increase of papers about the motion of waters. A lot of mathematicians are involved in this research field. They are asked to describe the motion of waters by means of mathematical formulas. In the middle of 18th century fluid mechanics is organized as an autonomous discipline with the works by Daniel and Johann Bernoulli, D'Alembert and Euler. The motion of water, however, can't be described by Euler's equations because they refer ideal conditions and do not consider whirling motions and frictional forces of the water in the river bed. That's why in this period many practical experiments are conducted in order to find the better description of the motion of water in rivers and streams.

In Piedmont, the King Carlo Emanuele III financially support the construction of a laboratory for hydraulics experiments. The so-called "Stabilimento della Parella" has been created in Turin in 1763 with the aim of carrying out experiments on the flux, the fall and the speed of water. The main referee in the Piedmontese scientific and cultural milieu for these kind of studies is Francesco Domenico Michelotti (1710-1787), professor of hydraulics at the University of Turin.

In the same period another mathematician from Ferrara, Teodoro Bonati (1726-1820), is involved in similar studies and experiments on behalf of the Papal State. Among 1762 and 1763 he realizes some experiments on artificial canals first in Ferrara, then in Rome.

The scientific relationship between Michelotti and Bonati will be presented in this talk, starting from the exam of the correspondence between the two mathematicians in the period 1768-1772, soon after the publication of the first volume of the *Sperimenti idraulici principalmente diretti a confermare la teorica, e facilitare la pratica del misurare le acque correnti* by Michelotti.

Quintino Sella's role in Crystallography: a mathematical approach for practitioners, 1847-1861

Chiara Pizzarelli (University of Torino)

Quintino Sella (1827-1884) was internationally renowned for his mineralogy studies. Nevertheless, investigations about his most original contribution, the application of elementary and sophisticated Mathematics to Crystallography, are definitely few.

After graduating in Mathematics at the Turin University (1847) and studying at the *École des mines* in Paris (1847-1852) with Pierre A. Dufrénoy (1792-1857) and Henri H. de Sénarmont (1808-1862), Sella published three important articles about Mathematical Crystallography.

By distancing himself from the classical approach and avoiding the use of methods pertaining to Analytical Geometry and Spherical Trigonometry, Sella took advantage of the Millerian notation and demonstrated the most important theorems and properties of Crystallography just by using Elementary Geometry, determinants and – for an advanced crystallographic problem – also the quadratic residues. By applying these mathematical tools to classic crystallographic methods of counting crystals angles, Sella's first aim was to facilitate the practical work of crystallographers.

In this talk I firstly intend to illustrate the influences Sella received during his education and through his international contacts, by studying his Mineralogy notebook from the *École des mines* and his library, and by analyzing his collaboration with the crystallographer William H. Miller (1801-1880) and – as regards the application of quadratic residues to crystallography – with the Italian mathematicians Felice Chiò (1813-1871) and Angelo Genocchi (1817-1889).

Secondly, I'll focus on the reception of Sella's scientific work both internationally and locally and on his attempt to introduce his 'mathematical approach' in Crystallography at the *Scuola di Applicazione per gli ingegneri* in Turin.

Archival sources

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From quadratic transformations to Cremona transformations (19th century)

Maria Anna Raspanti (University of Torino)

In the first half of the 19th century, transformations were used in an increasingly systematic way as research tools in geometry, since the possibility of mutating one figure into another, according to a determined law, makes it possible to deduce the properties of one figure from those of another already known or easier to be analysed. As a result, transformations themselves gradually became the object of study.

The aim of my research is to analyse the development of the theory of geometric transformations in the second half of the 19th century, trying to trace the genesis of Cremona's ideas.

Starting from the first studies on quadratic transformations in Europe, I look at Italy, where Giusto Bellavitis (1803-1880) was the first to actively devote himself to study modern geometric theories that were spreading among the transalpine geometers. In his work *Saggio di geometria derivata* (1838) he anticipated results that would be obtained about twenty years later, even if they remained little known.

It was the contribution of the Italian astronomer Giovanni Virginio Schiaparelli (1835-1910) that marked a decisive stage in the development of the theory of transformations; his results

were published in 1864 in a paper entitled *Sulla trasformazione geometrica delle figure ed in particolare sulla trasformazione iperbolica*. The historiographical analysis of archival sources such as unpublished manuscripts by the same author and published (but not studied in mathematical details) or unpublished correspondence, which he kept up with other scientists (such as G. Bellavitis, L. Cremona and Q. Sella), has made it possible to define the role of Schiaparelli, who first posed the problem of classification in the study of transformations.
The classification of Schiaparelli – although incomplete - is the one that offered the initial idea for the reflections that led Luigi Cremona (1830 – 1903) to the decisive generalization introduced with the study of geometric transformations of higher order of the plane figures in his work of 1863, *Sulle trasformazioni geometriche delle figure piane. Nota I.*, which – together with those of the space which he later dealt with – took the name of Cremona transformations.
Cremona wrote a second paper on the same subject in 1865, *Sulle trasformazioni geometriche delle figure piane. Nota II*, in which he made explicit reference to the transformations studied by Ernest de Jonquières (1820-1901). The correspondence between Cremona and De Jonquières and further information obtained from the correspondence between Thomas. A. Hirst (1830-1892) and Cremona, reveal a close connection between the work of Cremona and that of De Jonquières (*De la transformation géométrique des figures planes, et d'un mode de génération de certaines courbes à double courbure de tous les orders*, 1864), as I try to show.
Finally, I mention some of the successive developments of geometric research to which the work of Cremona provided new fundamental ideas and which are part of a broader research project concerning a survey conducted from the historical, mathematical and historiographical point of view on the birth and development of Birational Geometry, from the origins of the theory of birational transformations to studies on continuous groups of Cremona transformations.

See RASPANTI, M. A., *Dalle trasformazioni quadratiche al gruppo delle trasformazioni cremoniane*, Tesi Dottorato, Università di Torino a.a. 2017-2018 (Prof. L. Giacardi, A. Brigaglia).

The German School of Nomography in the Interwar Period

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Nomography, the science of graphical tables, was established in France at the end of the 19th century in the milieu of French engineers from the Ecole polytechnique in response to the huge calculation needs arising from civil engineering problems. This new discipline, associated above all with the name of Maurice d'Ocagne and, to a lesser extent, Rodolphe Soreau, spread throughout Europe and beyond during the first half of the 20th century. The inventory of nomography articles published in mathematics and engineering journals shows that it is mainly around a Berlin-Leipzig-Prague-Vienna axis that the discipline circulates and is enriched between the two world wars. We will look at the new actors involved in this field and how they free themselves from the "founding fathers" d'Ocagne and Soreau to create new knowledge and new methods. We will study to what extent we can speak of a "German school of nomography" and how this school could have contributed to the economic development of Germany before the Second World War.