

WHEN
MATHEMATICS &
COMPUTER SCIENCES
MEET



*Opportunities for academic research
and graduate education
at the East of Paris*

Labex
BÉZOUT

Models and algorithms:
from the discrete to the continuous



La Cité Descartes à Champs-sur-Marne © Bnamme - Photo: Eric Wiverno, 11/2011

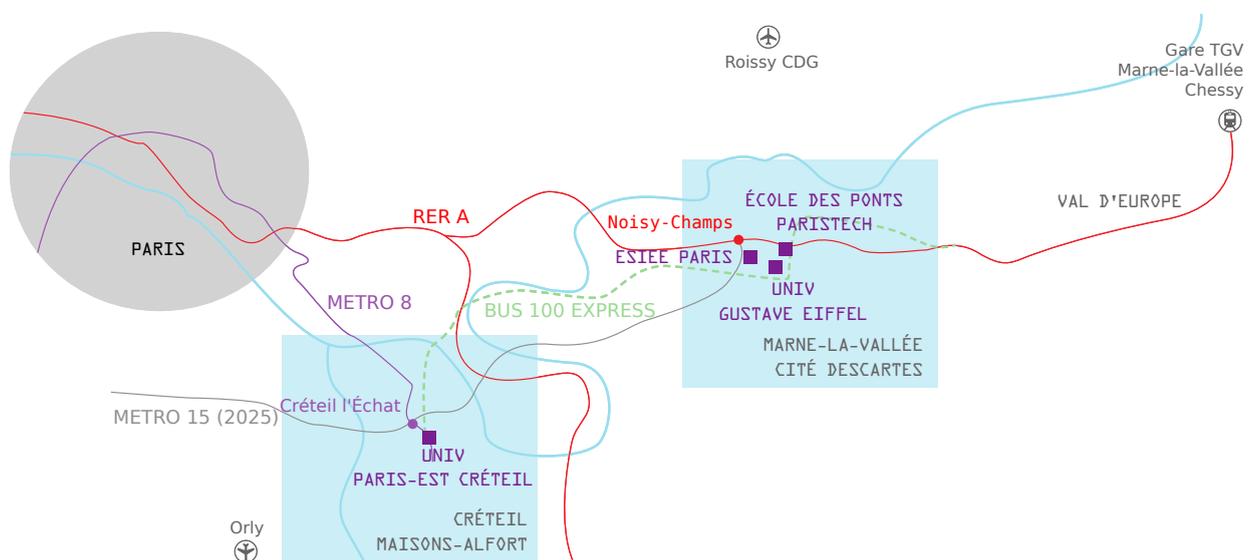
AN EXCEPTIONAL ACADEMIC ENVIRONMENT

Less than 30 minutes from the center of Paris

The Bézout Labex is part of the pole of research and higher education **Université Paris-Est** (UPE, also called Paris-Est Sup), which brings together two universities, four prestigious engineering schools, including **École des Ponts ParisTech** and **ESIEE Paris**, three schools in architecture, one national veterinary school, five research and development institutes, four operating agencies, one competitiveness cluster, and over 70 research laboratories.

UPE was built in 2007 and is a major international campus offering multi-disciplinary libraries and student housing. Convenient public transport is available between the different sites. The campus also offers student support services. Students and researchers alike can get involved in various campus organizations and enjoy cultural life in the area. UPE also has partnerships with sport centers, events venues, and local authorities to offer a truly dynamic place to live and work.

In 2020, a new milestone was reached with the creation of **Université Gustave Eiffel**, merging many of the above institutions, and becoming a major actor in the Parisian academic landscape.



Who was Bézout?

Étienne Bézout (1730-1783) was a famous French mathematician and academic during the Age of Enlightenment. Considered as one of the founders of algorithmics, he also played a key role in the development of science and the teaching of mathematics in France. Both algebra and algorithmics find some of their common fundamental principles in the seminal work of Étienne Bézout.

What does "Labex" stand for?

In 2010, the French government launched the "Investing for the Future" program and began investing heavily in research. This program led to the development of several projects including the creation of what are now called "Laboratories of Excellence." The goal of the Labex project is to select renowned French research laboratories and offer them additional resources so they can become more competitive in the international arena. The laboratories that have been selected use an integrated approach that combines research, training and concrete applications for industry.

RESEARCH AT THE CROSSROADS OF MATHEMATICS & COMPUTER SCIENCES

The Bézout Labex specializes in research on the cutting edge between mathematics and computer science. It includes **three laboratories** located East of Paris in Marne-la-Vallée and Créteil – CERMICS and LAMA, which specialize in mathematics, and LIGM, which specializes in computer science. These laboratories bring together about 300 active researchers, including PhD students.

Several research groups within these laboratories are leaders in France in their areas of specialization, and some of their members have received prestigious awards, e.g., Hajer Bahouri (Doisteau-Blutet prize from the French Academy of Sciences, 2016), Éric Cancès (ERC Synergy co-PI, 2019), and Philippe Loubaton (Valori prize from the French Academy of Sciences, 2018). By fostering the **cross-fertilization of ideas** between mathematicians and computer scientists, the Bézout Labex serves as an international center developing new research topics at the interfaces between mathematics and computer sciences, at the interplay between the discrete and the continuous.

Every year, **prestigious foreign scientists** are selected to share the Bézout Research Chair. Each comes for up to three months to work on a specific scientific topic and participate to the numerous conferences, seminars, and working groups that take place. The Labex also promotes the application of its research within industry and services, in areas such as health, imaging, telecommunications, networks, and finance.

The **CNRS Bézout research federation** makes the perimeter of the Labex visible at the **regional and national levels**, in particular via the DIM Math Innov, which it co-founded.

CERMICS - cermics-lab.enpc.fr
The Centre d'Enseignement et de Recherche en Mathématiques et Calcul Scientifique

is the laboratory of applied mathematics and scientific computing of the École des Ponts ParisTech.



LAMA - lama.u-pem.fr
The Laboratoire d'Analyse et de Mathématiques Appliquées

is a research unit associated with the Centre National de la Recherche Scientifique (CNRS), the Université Gustave Eiffel, and the Université Paris-Est Créteil-Val-de-Marne.



LIGM - ligm.u-pem.fr
The Laboratoire d'Informatique Gaspard-Monge

is a research unit associated with the CNRS, the Université Gustave Eiffel, and the engineering schools École des Ponts ParisTech and ESIEE Paris.

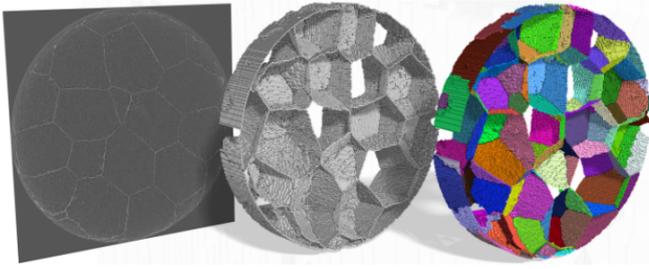


The Bézout Labex regularly offers invited professor positions, post-doctoral positions, and PhD fellowships

For more information and to apply online: bezout.univ-paris-est.fr



IMAGES AND GEOMETRY



Computer imagery and geometry are closely related, cross-fertilizing domains. Applications that range from scientific computing to data visualisation and medical imagery demand computational tools to analyze and manipulate images. Numerous challenging problems coming from this experimental field are tackled with a myriad of ideas coming from geometric analysis, topology, and combinatorics. Beyond the creation of these tools, we analyze their algorithmic complexity by combining discrete and continuous structures which are leveraged upon to revisit classical problems in convexity, minimal surfaces, and quantitative topology.

FIVE STRATEGIC AREAS OF RESEARCH

HIGH-DIMENSIONAL PHENOMENA

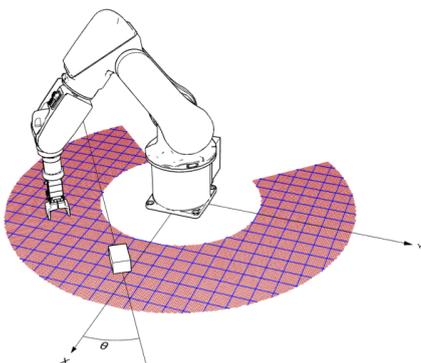
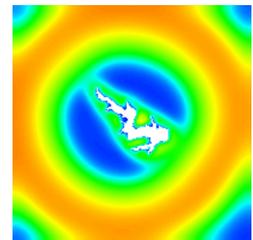
High-dimensional phenomena are ubiquitous in modern applications. The mathematical and algorithmic analyses underlying these models involve deep tools from asymptotic geometric analysis, random matrices, and combinatorics. We develop geometric, functional, and probabilistic tools to describe the phenomena of concentration of measure in various settings, continuous and discrete. We have particular interest in the study of high-dimensional convex bodies, transport-entropy and functional inequalities. The expertise in random matrix theory is both theoretical and applied; the focus lies on the spectral analysis of matrix models used in applications such as high-dimensional statistics, electrical engineering, and theoretical ecology.

DISCRETE MATHEMATICS AND ALGORITHMS

Several lines of research are related to the interaction between discrete mathematics and algorithms. One of these lines relies on discrete optimization, with questions ranging from graph coloring to optimization of transportation systems. Another focus is on limits of combinatorial structures, e.g., graphon-type objects in discrete geometry, graphons in statistics, etc. Random discrete structures, especially random polytopes, also form an active area of research.

STOCHASTIC AND DETERMINISTIC MODELS

We have a renowned expertise in the study of mathematical models, deterministic or random, relevant to a wide range of applications including banking and insurance, material sciences, fluid mechanics, condensed matter physics, and molecular modeling. The relevant mathematical fields are extremely diverse, ranging from jump processes, Malliavin calculus, Markovian dynamics to linear and nonlinear partial differential equations and homogenization. The implementation of the research conducted in mathematical finance (option pricing and risk evaluation) is disseminated in banks and insurance. Research on computational methods leads to numerous collaborations with the industry, e.g., CEA, EADS, EDF, and various other partners.



SMART CITIES

This area is a major application domain of the Bézout Labex, in line with our connection with the I-SITE FUTURE project in Paris-Est. Preparing the city of tomorrow requires expertise in a number of research areas in mathematics and computer science. We apply our expertise to digital construction, maintenance, and urban modeling, using computer vision and machine learning; to architectural geometry and structural mechanics, using discrete differential geometry; to urban data analysis, using multifractal techniques; to urban networks, using tools from mobile networks and IoT.





AN INTERNATIONAL MASTER'S PROGRAM

The Bézout Labex offers, each year, **7 scholarships** for outstanding students from foreign academic institutions who wish to study at the master's level in University Paris-Est in an integrated program combining mathematics and computer science: the **"Bézout excellence program."** This offers the opportunity to acquire sought-after skills in both mathematics and computer science, which can be used in academia or industry.

This program is based on the master's programs in mathematics and computer science (second year, a.k.a. "M2"). Each Bézout scholar can enroll in the **mathematics and computer science track**, co-founded by the Bézout Labex and common to both master's programs, which offers an innovative way to focus on the interactions between both disciplines; each course of this track is taught in English, jointly by a mathematician and a computer scientist. Alternatively, the student can register in another track of these two master's programs, and additionally follow one or two courses from the other master. The tracks in mathematics focus on **mathematics of finance and data; probability theory and statistics of new data; and analysis and applications (images, compressed sensing)**. Those in computer science concern **imaging sciences; software; systems and services for the Internet of Things; and smart systems and applications**. Lectures are given either in English or in French.

The best students at the end of the program will be invited to start a PhD in the Bézout Labex. A joint supervision with the student's national doctoral framework, leading to both PhD grades, is possible.

Peng Tian completed his master's in 2015. His PhD thesis, co-advised by two professors in the Bézout Labex, one from LAMA and the other from LIGM, was on large random matrices. He is currently a post-doctoral fellow in statistics at Hong-Kong University.

“ My two years of master's courses in Labex Bézout were very important for me. The first year was for consolidating a wide range of fundamental knowledge and having a first taste of research, and the second year was a connection between school level studies and real research works. Thanks to the excellent faculty, my vision was widened. A mixture of experiences of studying in China and in France has modified my style of thinking and solving problems. My confidence has been strengthened. I also saw that combining probability and other deterministic mathematics was more and more in fashion, and that there were more and more applications of probability and statistics in the world. ”

Kacper Pluta completed his master's in 2014. His PhD thesis, also co-advised by two professors of the Bézout Labex, was on digital geometry. He is currently a postdoctoral fellow at the Technion, Israel Institute of Technology.

“ During my studies in Poland I became interested in digital geometry and I heard about researchers from Paris-Est working in this field of science. The university has a very good reputation, which I found very attractive and convincing. Classes were very interesting and well-prepared, and met the newest state of the art level in my fields of interest. I also appreciate the easiness of communication with professors and their open-mindedness to discuss topics even after classes. This program is a very interesting opportunity for students who aspire achieving a master's degree of high quality. ”





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